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

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ABSTRACT

Field experiment was conducted under irrigation at Bayero University Kano, during 2011/2012 dry season to investigate the effects of different nitrogen levels and harvest interval on growth and leaf yield of Moringa (Moringa oleifera (Lam)). The treatments consisted of four levels of nitrogen (0, 50, 100 and 150kg N ha^{-1}) and three times of harvest interval (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 interval allocated to the sub plots and replicated four times. The data collected were subjected to analysis of variance (ANOVA) using the general linear model of GenStat and significant different means were separated using DMRT. The result shows that applications of nitrogen significantly increased plant height, number of leaflets per plant, plant stem diameter, number of branches per plant, fresh and dry weights per plant. Generally, 150kg N ha^{-1} level gave highest values for all the growth and yield characters assessed. The highest fresh and dry total leaf yields were also obtained with 150kg N ha^{-1} level. Increase in harvest interval significantly increased fresh and dry leaf yields of Moringa with the highest yields obtained from 4 weeks harvest interval. Nitrogen and harvest interval interaction was found to be significant on fresh and dry leaf yields of Moringa, which indicated that high yields were supported by 150kg N ha^{-1} at 4 weeks harvest interval.

Keywords: Moringa, harvest interval, Nitrogen level, yield

INTRODUCTION

Moringa is a small tree with sparse foliage often planted in compound and farmlands (Keay, 1959) 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 to as Zogale, or Bagaruwar Makka in Hausa, in Fulfulde it is called Kabije, Gawara or Konamarade. 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 as Ruwag, Alim, Halim, Shagara and 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 which meets the estimated amino acid requirement for children between the age of 2 – 5 years (Kalb and Kuo, 2002). Leaves of *Moringa* are the most nutritious part of the plant, and have been used to combat malnutrition especially among infants and nursing mothers. The leaves are also good sources of protein, vitamins A, B and C and minerals such as calcium and iron. The leaf contains 22-35% protein together with all essential amino acids and is high in the sulphur containing amino acids, methionine and cystene, and it also contains carbohydrates 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* leaves is an excellent source of vitamins, minerals and protein perhaps more than any other tropical vegetable (Anonymous, 2008).

Moringa is propagated both sexually and asexually and it has low nutrients demand and management requirements. In Nigeria, *Moringa* is often grown as a live fence or a backyard tree. To put more land under cultivation as a means of increasing production to meet the growing demands of the crop will be expensive, difficult and damaging to the environment. Growers therefore need to increase their production by adopting appropriate strategies and techniques which will lead to sufficient and reliable yields without depleting the natural resource base.

It is therefore essential to establish the best agronomic practices for cultivation and utilization of the crop. Thus, the aims of this research was to determine the optimum level of Nitrogen required for the growth and yield of the *Moringa* plant and also to determine the most appropriate harvest interval required for sustainable utilization of the plant.

MATERIALS AND METHODS

The experiment was conducted during the 2011/2012 dry season at 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 treatments combination consisted of four levels of Nitrogen (0, 50, 100 and 150 kg ha^{-1}) and three levels of harvest interval (2, 3 and 4 weeks). The experiment was laid out in a complete randomized block design at the growth stage but at 12 weeks after sowing (i.e. at harvesting stage) a split plot design was adopted with nitrogen levels allocated to the main plots while harvest interval 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 2 cm 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 interval of 2, 3 and 4 weeks treatments were introduced and lasted for three months. Observations were recorded on some growth, yield and yield components and the data collected were subjected to analysis of variance (ANOVA) using the general linear model of GenStat (2011). Significant treatment means were separated using DMRT (Duncan 1955).

RESULTS

Effect of nitrogen levels on vegetative growth of *Moringa* during the first 12 weeks.

The mean plant height, stem diameter and number of branches $plant^{-1}$ increased with time, showing significant differences (P<0.05) from the 4^{th} WAS (Table 1). The highest nitrogen level (150 kg ha^{-1}) gave the highest increase 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 $plant^{-1}$. The leaflets number $plant^{-1}$ fresh and dry weight $plant^{-1}$ increased with time in all treatments and were significantly different (P<0.05) 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 for the control (Table 2). At 4^{th} WAS 150 kg N ha^{-1} treatment gave highest fresh weight $plant^{-1}$ while 100, 50kg N ha^{-1} and the control were found to be statistically at par. During at same period 150 and 100 kg N ha^{-1} produced plant that were statistically the same in terms of dry weight $plant^{-1}$, followed by 50 and 0 kg N ha^{-1}.

Total Fresh and Dry Leaf Yields of *Moringa*

Table 3 shows the effects of nitrogen levels and harvest interval on the total fresh and dry leaf yields (t ha^{-1}) of *Moringa*. The result revealed that the higher the level of nitrogen the higher the fresh and dry leaf yields throughout the harvest period. The highest total fresh leaf yield of 38.06 t ha^{-1} and total dry leaf yield of 10.21 t ha^{-1} were obtained with 150 Kg N ha^{-1} during the harvests recorded after the initial general harvest at 12 WAS. On application of harvest interval treatment which lasted for three month, when nitrogen was held constant at 150 kg ha^{-1} each increase in number of weeks in harvest interval significantly increased leaf yields with maximum estimated yields of 46.029 t ha^{-1} and 12.317 t ha^{-1} fresh and dry leaf respectively obtained with 4 weeks harvest interval (Table 3).

Table 4 shows the interaction between nitrogen levels and harvest interval on total fresh and dry yields of *Moringa* leaf at BUK, the result indicated that there was positive and highly significant interaction between nitrogen levels and harvest interval on the total fresh and dry leaf yields and the best combination that produced the highest leaf yields was between 150 kg N ha^{-1} and 4 weeks harvest interval.

Discussion

The result of this study showed a significant difference of nitrogen level applied for all the growth and yield characters of *Moringa* measured. 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). Considering the low nutrient status of the soil of the experimental sites it is to be expected that application of nitrogen will increase the growth performance of the crop. Increase in nitrogen levels from 0 to 150 kg ha^{-1} led to successive increase in growth characters such as plant height, stem diameter, fresh weight $plant^{-1}$, dry weights $plant^{-1}$, leaflets number $plant^{-1}$ and number of branches $plant^{-1}$ all were significantly affected by level of nitrogen application.

This is in line with the findings of Oliver (2009) who recorded similar result in which best performance was obtained with NPK fertilizer (27-7-20) at 32 – 43 Kg week $^{-1}$ ha^{-1} in *Moringa* production. The result is also similar to what was obtained by Dash and Gupta (2009) who reported to have obtained significant increase in growth characters of *Moringa* such as shoot height, leaves number, plant fresh and dry biomass when treated with NPK/Urea (5g pot^{-1}) and SSP respectively. The result was still similar to that of Matallawa (2012) who reported to have obtained significant increase in plant height; stem diameter, leaflets number plant^{-1}, fresh and dry weight plant $^{-1}$ in *Moringa* treated with NPK at different levels of 0, 50, 100 and 150 Kg ha^{-1}.

Application of nitrogen was found to significantly increase fresh and dry leaf yields of *Moringa* throughout the harvesting period which lasted for three months and this could be attributed to the good responce of the plant to the N applied at the site. However, the result indicated that there was corresponding increase in *Moringa* yield with increase in nitrogen level application. The highest level (150 Kg N ha^{-1}) produced higher fresh and dry leaf yields, as compared to 100 and 50 Kg N ha^{-1} levels which also significantly produced higher yields compared to the untreated control (0 Kg ha^{-1}) and this was in line with what was obtained by Matallawa (2012) and Radovich (2009) who reported positive yield responses of *Moringa* at fertilization rates of 350 Kg N ha^{-1}. Fuglie and Sireeja (2010) supported this in their report which stated that nitrogen application increase the yield of *Moringa* leaf of up to three folds.

The harvest interval significantly increase the fresh and dry leaf yields of *Moringa* (t ha^{-1}) with highest means of 46.03 and 12.32 t ha^{-1} fresh and dry leaf yields respectively obtained with 4 weeks harvest interval. The result was similar to that of Amaglo *et al.* (2006) who reported significant yield of *Moringa* leaf when harvested at 4-5 weeks harvest interval, after the initial harvest at 60 days after sowing. This indicated that leafy vegetables harvest interval plays a vital role in their yields. Though, the highest yields were obtained with 4 weeks harvest interval which could be due to more time allowed for leaves growth and development the finding agreed with Palada and Chang, (2003) who reported that harvesting of *Moringa* young edible shoots is possible at every two to three weeks harvest interval in *Moringa* plantation with nitrogen fertilization.

CONCLUSION

The study showed that nitrogen and harvest interval significantly affected the leaf yield of *Moringa*, when nitrogen level was held constant at 50,100 and 150 Kg ha^{-1}, 4 weeks harvest interval produced significantly higher yield values throughout the harvesting periods with the highest values of 47.91 and 12.09 t ha^{-1}fresh and dry leaf yield respectively obtained with 150 Kg N ha^{-1}, whereas the lowest fresh and dry yields of 5.03 and 2.84 t ha^{-1} were obtained with the untreated control and 2 weeks harvest interval. Based on this study it can be concluded that farmers in the area of study should apply 150kg N ha^{-1} and harvest interval of 4 weeks after the initial general harvest at 12 WAS for high yield and good quality of *Moringa* leaf.

Table 1: 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			Stem diameter_			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 2: Effects of Nitrogen levels on leaflets number plant^{-1}, fresh and dry weights plant^{-1} of *Moringa* during 2011/2012 dry season at BUK

	Number of leaflet plant^{-1}			Fresh weight (g) plant^{-1}_			Dry weight (g) 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 DMR

Table 3: Effects of Nitrogen levels and harvest Interval on total fresh and dry leaf yields (t ha–^{1}) of *Moringa* at BUK

Treatments	Fresh harvest	Dry harvest
Nitrogen (kgha^{-1})		
0	11.708d	3.448d
50	21.738c	6.795c
100	31.879b	8.320b
150	38.057a	10.211a
S.E±	1.0020	0.2222
Harvest Interval (weeks)		
2	9.931c	3.590c
3	21.576b	6.426b
4	46.029a	12.317a
S.E±	0.8679	0.1925
Interaction		
N x HI	**	**

Means followed by the same letter are not significantly different at 5% level of significance using DMRT, **Significant at 1%.

Table 4: Interaction between nitrogen levels and harvest interval on total fresh and dry leaf yield (t ha^{-1}) of *Moringa* at BUK

	Fresh			Dry		
Harvest interval (weeks)	2	3	4	2	3	4
Nitrogen (kgha^{-1})						
0	5.030j	8.636h	15.848e	2.835k	4.467h	5.952f
50	6.940i	11.060g	23.652c	3.382j	5.405g	7.828c
100	9.610h	18.035d	30.850b	4.070i	6.692e	9.075b
150	13.683f	23.503c	47.918a	4.443h	7.395d	12.090a
SE±			0.9974			0.7422

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

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