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RESPONSE OF MAIZE (*Zea mays* L.) TO AQUEOUS EXTRACT OF MORINGA (*Moringa oleifera* LAM.) AND NITROGEN RATES. PART II

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Abstract

Maize (Zea mays L.), the major staple crop in Nigeria is recording low yield ha^{-1} in farmer's field. The low yield is attributed to inadequate application of fertilizers more especially the nitrogen type. Fertilizer is a scarcest and expensive commodity to small scale farmers who constitute major maize producers. Moringa (Moringa oleifera Lam.) a common plant in Nigeria were earlier reported to improve crop growth and yield. Thus, field experiments were conducted in 2009 and 2010 rainy seasons at the Teaching and Research Farm, Faculty of Agriculture, Bayero University, Kano, Nigeria to study the response of Maize to Aqueous Extract of Moringa and Nitrogen rates. Treatments consist of four concentrations of moringa shoots extract (0%, 3%, 4% and 5%) and three Nitrogen rates (0, 60, 120 kg N ha^{-1}). These treatments in a factorial combination were laid out in a Randomized Complete Block Design with three replications. Foliar spray of moringa extract on maize started at 2 weeks after sowing and continued fortnightly until 8 weeks after sowing. Nitrogen rates were applied in two doses at land preparation and at 5 weeks after sowing. Data were collected on Leaf area index, Crop growth rate, Net assimilation rate and Grain yield ha^{-1} and were subjected to Analysis of Variance. Results showed significant effects of moringa extract and Nitrogen rates with interactions on the parameters. Based on the results, it was concluded that moringa extract can compliment nitrogen fertilizer on the growth and yield of maize. Therefore, 120 kg N ha^{-1} with 5 % moringa extract which manifested highest effect on the parameters should be adopted to improve yield per unit area.

Keywords: *Maize, Aqueous Extract of Moringa, Nitrogen rates, improve yield ha^{-1}.*

INTRODUCTION

Maize is the major staple crop in Nigeria. It is also a source of raw materials for industries. However, its average yield per hectare is very low (IITA, 2007), more especially under small scale farm farming families who constitute the major producers in the developing countries. Low yield per hectare under small scale farming is attributed to low input supply more especially inorganic fertilizers. Maize is known to be a heavy feeder of nitrogen (N) fertilizer. Hardly can a farmer apply half of the recommended rate because of its scarcity and where available it's high in cost. The application of 120 kg N ha^{-1} was reported to increase maize grain yield up to 213% (Adesoji et al., 2007). This report was in agreement with one earlier made by Ado et al., (2005) that maize yield increased with increased N application up to 150 kg ha^{-1}. Moringa (*Moringa oleifera* Lam.), a common plant in Nigeria was reported to improve soil fertility, crop growth and yield. The extract from the Moringa is use as plant growth hormone (PGH), which enhances crop growth and yield (Foidl et al., 2001). Moringa leaf extract at 2% concentration influenced leaf area index (LAI) of Kalmegh (*Andrographis paniculata*) (Prabhu et al., 2009). Leaf area index increased from 0.419 to 0.456 at 60 days after planting (DAP) and 0.978 to 1.034 at 90 DAP were recorded. Similar report on wheat, showed an increase in LAI from 3.62 to 4.66, and 5.41 with 0.28 kg ha^{-1} ethephon and 2.2 kg ha^{-1} chlormequat, respectively (Shekoofa and Emam, 2008). Contrastingly, garlic LAI of 0.82, 0.77 and 0.73 were obtained with gibberrelic acid (GA) at 0, 100, and 200 ppm, respectively (Rahman et al., 2004). These authors reported similar trend in crop growth rate (CGR) at 45 – 60 DAP, where CGR of 0.27, 0.22 and 0.18 g d^{-1} were obtained with GA at 0, 100, 200 ppm, respectively. Also, Net Assimilation Rate (NAR) at 30 – 45 and 60 – 75 DAP were 4.96, 4.41 and 4.11 g m^{-2}wk^{-1} and 10.19, 9.57 and 8.61 g m^{-2}wk^{-1} with 0, 100 and 200 ppm, respectively (Rahman et al., 2004). Interaction between N with PGH were also reported to influence plant growth. Leaf area index of rice (*Oryza sativa* L.) increased significantly with foliar application of NAA at 100 and 200 mg l^{-1} along with N rates at 0, 60, 90 and 120 kg N ha^{-1}

(Grewal and Gill, 1986). The results further indicated that rice grain yield was enhanced with foliar application of NAA under low level of N (0 and 60 kg ha^{-1}). There was interaction between N with PGH on grain yield of wheat (Shekoofa and Emam, 2008).

This research was therefore, carried out to determine if moringa extract can improve maize growth and yield as well as compliment N fertilizer to improve yield per unit area.

MATERIALS AND METHODS

Field experiments were conducted in 2009 and 2010 rainy seasons at the Teaching and Research Farm, Faculty of Agriculture, Bayero University, Kano, Nigeria (Latitude 11^{o} 58' N and Longitude 8^{o} 25' E at an altitude of 458 m), to study the response of maize to aqueous extract of moringa (AEM) and N rates. Moringa shoots of about 40 days were crushed with water (10 kg of fresh material in 1 litre of water) and filtered out. Liquid extract obtained were diluted with water in the following concentrations: 0%, 3%, 4% and 5%. These treatments with three N rates (0, 60, 120 kg N ha^{-1}) in a factorial combination were tested on maize in an experiment laid out in a randomized complete block design with three replications. Foliar spray started at 2 weeks after sowing (WAS) and continued fortnightly until 8 WAS. At land preparation half of the N in form of urea and 26.4 P – 49.8 K in form of single super phosphate and murate of potash, respectively were applied. At 5 WAS the remaining half of N in form of urea was side dressed. Samples of soils from the experimental sites were collected and their physico - chemical properties determined. Weeds were controlled by the application of pre – emergence herbicides (Primextra (290 g/liter S – metolachlor and 370 g/litre atrazine) at 4 L ha^{-1}) on the sowing dates. Application was done using CP 20 knapsack sprayer. Thereafter, supplementary weeding was done at 3 and 7 WAS. The following parameters were then measured and recorded: LAI at 5 and 7 WAS and at harvest. This was determined using the equation: LAI = LA/GA where LA = leaf area and GA = ground area covered by the plant. Crop growth rate, CGR (g wk^{-1}) was determined as follows: CGR = $(W_2 – W_1)/ (T_2 – T_1)$; where W_1 and W_2 are shoot dry weights taken at two consecutive harvests over time intervals T_1 and T_2. Net assimilation rate (g cm^{-2} wk^{-1}) was determined by the relation: NAR = $(W_2 – W_1) (Log_e\ L_2 – Log_e\ L_1)/(t_2 - t_1)(L_2 - L_1)$; where W_2 and W_1 are shoot dry weights taken at two consecutive harvests over time t_1 and t_2 when the corresponding leaf area was L_2 and L_1, respectively. Grain yield ha^{-1}: Net plots were harvested and grain weights were converted to yield in kg ha^{-1}. Data collected were subjected to analysis of variance using SAS system for windows (SAS v8, 2000).

RESULTS AND DISCUSSIONS

The results of the composite soil samples for the two cropping seasons are presented in Table 1. Soils of the experimental sites were silty clay and slightly acidic; total N was moderately high. Organic carbon was also high. Table 2 shows the effects of N rates with AEM on LAI per plant of maize in 2009 and 2010 rainy seasons and the combined. There was a significant effect of N in 2009 rainy season at 5 WAS and highly significant effect in the seasons and combined at 5 and 7 WAS and at harvest; 60 kg N ha^{-1} had the highest effect, except in 2010 rainy season at harvest where 120 kg N ha^{-1} had the highest effect. In all seasons 0 kg N ha^{-1} gave the least LAI. The significant effect of N on LAI might be due to the role of N in promoting vegetative growth; this might have influenced number of leaves and leaf area, consequently, LAI. There was no significant effect of AEM on LAI in 2009 rainy season and combined at 5 WAS, and in the two seasons and combined at 7 WAS (Table 2). Highly significant effects in 2009 and combined as well as a significant effect in 2010 rainy season were recorded. In 2010 rainy season at 5 WAS and at harvest, 4% AEM produced the highest effect. Lowest effect was associated with 0% AEM. In 2009 rainy season and combined at harvest, 3% and 5% AEM had the highest and lowest effects, respectively. The significant effect of AEM on LAI might be due to the role of plant growth hormone in promoting rapid cell division, cell enlargement and the over all plant growth. The result of this study agreed with the earlier report of Prabhu et al. (2009) and Shekoofa and Emam (2008) who reported significant increased in LAI of crops with PGH. There were no interaction between N with AEM on LAI in 2009 rainy season at 5 and 7 WAS, and in 2010 rainy season at harvest (Table 2).

Table 1. Soil physical and chemical properties of the field experiments in 2009 and 2010 rainy seasons

Soil properties	**2009**		**2010**	
	0 – 15 cm	**15 – 30 cm**	**0 -15 cm**	**15 – 30 cm**
Soil pH (H_2O)	6.70	5.90	5.60	5.51
Organic carbon (g kg^{-1})	3.90	1.00	9.70	8.90
Organic matter (g kg^{-1})	6.72	1.72	16.72	15.34
Total N (g kg^{-1})	0.98	1.26	1.90	1.40
Available P (mg kg^{-1})	5.13	5.02	6.01	6.05
C.E.C (cmol kg^{-1})	9.67	5.94	6.92	4.30
Exchangeable K (cmol kg^{-1})	0.96	1.26	4.40	4.6
Exchangeable Na (cmol kg^{-1})	0.32	0.35	0.30	0.35
Exchangeable Ca (cmol kg^{-1})	0.04	0.05	0.28	0.73
Exchangeable Mg (cmol kg^{-1})	0.35	0.28	0.27	0. 27
Textural class	Silty clay	Silty clay	Silty clay	Silty clay

Table 2. Effect of aqueous extract of moringa and nitrogen rates on leaf area index of maize in 2009 and 2010 rainy seasons and combined

Treatments	**5 weeks after sowing**			**7 weeks after sowing**			**Harvest**		
	2009	**2010**	**CMBD**	**2009**	**2010**	**CMBD**	**2009**	**2010**	**CMBD**
Nitrogen (kg ha^{-1})									
0	0.88b	1.73b	1.31b	1.38b	2.14b	1.76b	1.05c	1.15b	1.10b
60	1.60a	3.75a	2.67a	2.36a	3.63a	2.99a	2.51a	2.67a	2.59a
120	1.51a	3.65a	2.58a	2.26a	3.63a	2.95a	2.25b	2.78a	2.51a
Level of probability	*	**	**	**	**	**	**	**	**
SE (±)	0.18	0.1	0.15	0.18	0.12	0.16	0.08	0.12	0.10
AE M (% conc.)									
0	1.57	2.70b	2.14	1.93	2.84	2.39	2.10b	1.84b	1.97b
3	1.43	3.09a	2.26	2.27	3.36	2.82	2.67a	2.25a	2.46a
4	1.18	3.32a	2.25	2.00	3.16	2.58	1.49c	2.38a	1.93a
5	1.13	3.08a	2.11	1.79	3.18	2.49	1.50c	2.31a	1.91b
Level of probability	NS	*	NS	NS	NS	NS	**	*	**
SE (±)	0.21	0.12	0.17	0.21	0.14	0.24	0.09	0.14	0.12
Interactions	NS	**	**	NS	**	**	**	NS	**

Means in the same column followed by the same letter (s) are not significantly different at 5 % level of probability. NS = not significant at 5 % level of probability. * = significant at 5% level of probability using LSD ** = highly significant at 1% level of probability using LSD. AEM = aqueous extract of moringa. CMBD = combined.

Table 3. Interaction between aqueous extract of moringa and nitrogen rates on leaf area index of maize in 2009 and 2010 rainy seasons and combined

	Aqueous extract of moringa (%)							
	5 WAS 2010 rainy season				**Combined**			
Nitrogen(kg ha^{-1})	0	3	4	5	0	3	4	5
0	0.71c	2.68e	1.76f	1.78f	0.72c	1.94b	1.27c	1.30c
60	3.33cd	3.18de	4.61a	3.97abc	2.67a	2.43ab	3.06a	2.54ab
120	4.05ab	3.42bcd	3.58bcd	3.59bcd	3.02a	2.41ab	2.42ab	2.48ab
SE (±)	0.21				0.30			
	7 WAS 2010 rainy season				Combined			
0	1.62c	3.17b	1.83c	1.93c	0.99c	2.66ab	1.70bc	1.67bc
60	3.19b	3.41ab	3.87ab	4.04a	2.93ab	2.88ab	3.20a	2.96ab
120	3.71ab	3.50ab	3.77ab	3.57ab	3.23a	2.91ab	2.84ab	2.82ab
SE (±)	0.24				0.31			
	Harvest 2009 rainy season				Combined			
0	0.91g	5.19a	1.67der	1.84cd	0.34e	1.85c	1.07d	1.13d
60	1.97cd	2.82b	1.32efg	1.72cde	3.20a	2.38b	2.51b	2.27bc
120	1.16fg	2.20c	0.83g	1.30efg	2.38b	3.14a	2.22bc	2.32b
SE (±)	0.16				0.20			

Means in the same column followed by the same letter (s) are not significantly different at 5 % level of probability using LSD. WAS = weeks after sowing.

Highly significant interaction between N rates with` AEM on LAI were recorded in 2009 rainy season at harvest, 2010 rainy season at 5 and 7 WAS and the combined at 5 and 7 WAS and at harvest. In Table 3 the highest interactions in 2010 rainy season and combined at 5 WAS was with 60 kg N ha^{-1} and 4 % AEM. The least interaction was with 0 kg N ha^{-1} and 0 % AEM. At 7 WAS the interaction that had the highest LAI in 2010 rainy season was 60 kg N ha^{-1} coupled with 5 % AEM, while 120 kg N ha^{-1} with 0 % AEM had the highest LAI in the combined. Least interaction at 7 WAS were with 0 kg N ha^{-1} and 0 % AEM (Table 3). Also in Table 3, the highest LAI in 2009 rainy season at harvest was 0 kg N ha^{-1} with 3 % AEM and 60 kg N ha^{-1} with 0 % AEM in the combined. The least effect was with 0 kg N ha^{-1} and 0 % AEM.

There was a highly significant effect of N rates on CGR at 7 WAS and at harvest; 120 kg N ha^{-1} produced the highest effect in all seasons and combined except in 2009 rainy season at 7 WAS where 60 kg N ha^{-1} had the highest effect (Table 4). Nitrogen at 0 kg ha^{-1} had the least CGR in all seasons and combined. The significant effect of N on CGR might be related to the significant effect of N on LAI, which might have influenced the photosynthetic ability of the plant thereby, increasing dry matter production. AEM had no significant effect on CGR in 2009 rainy season and combined at 7 WAS (Table 4). Highly significant effects in 2010 rainy season at 7 WAS, and the seasons and combined at harvest were observed. In 2010 rainy season at 7 WAS, 3% AEM gave the highest effect and the least effect was with 4% AEM. At harvest, 5% AEM produced the highest CGR in the seasons and the combined while the least CGR where obtained with 4% AEM (Table 4). There was no significant interaction between N and AEM on CGR in 2009 rainy season and combined at 7 WAS (Table 4). The non – significant interaction might be due to the non – significant effect of AEM in the seasons. There was interaction in 2010 rainy season at 7 WAS and at harvest and highly significant interaction in 2009 rainy season and combined at harvest. In Table 5, the highest interaction in 2009 rainy season was obtained when 120 kg N ha^{-1} was combined with 0% AEM while the lowest interaction occurred with 0 kg N ha^{-1} and 0% AEM. 1n 2010 rainy season and at 7 WAS, the best interaction was with 120 kg N ha^{-1} and 3% AEM while the least was with 0 kg N ha^{-1} and 4% AEM. At harvest; 120 kg N ha^{-1} with5% AEM had the best effect in all seasons and combined. Least CGR was obtained when 0 kg N ha^{-1} and 0 % AEM (Table 5) were applied.

There was no significant effect of N rates on NAR of maize in the seasons and combined at 7 WAS and in 2010 rainy season at harvest (Table 4). Highly significant effect in 2009 rainy season and combined at harvest was observed. In 2009 rainy season, 60 kg N ha^{-1} and 120 kg N ha^{-1} had same effect with higher magnitudes while in the combined; 120 kg N ha^{-1} had the highest effect. Aqueous extract of moringa (Table 4) significantly affect NAR in 2009 rainy season at 7 WAS and at harvest, 4 and 5% AEM had the same effect in 2009 rainy season with highest NAR while 0 and 3% AEM had same effect and turned out to be the lowest. In 2009 rainy season at harvest, 5% AEM had the highest effect. There was a highly significant AEM effect in the combined. The 5% AEM had higher effect than all other concentrations that showed same effects. The significant effect of AEM on NAR might be due to the ability of the AEM to increase and maintain chlorophyll contents of plants which could help in photosynthesis partitioning and consequent increase in dry matter accumulation. There was no interaction between N rates with AEM in 2009 rainy season at 7 WAS and at harvest; in 2010 rainy season at harvest and combined at 7 WAS. There was interaction in 2010 rainy season at 7 WAS and combined at harvest (Table 4). The least interaction was found with 0 kg N ha^{-1} and 4% AEM and 60 kg N ha^{-1} with 5% AEM which were similar (Table 5).

Significant effects of N rates on grain yield of maize in 2009 rainy season and highly significant effect in 2010 rainy season and combined were observed. Nitrogen at 120 kg ha^{-1} had higher grain yield in the seasons while the lowest yield was obtained by 0 kg N ha^{-1} (Table 6). There was no significant effect of AEM on grain yield of maize in the seasons and combined. This might be due to the fact that AEM influenced the growth parameters more than grain yield. There was no interaction between N and AEM in 2009 rainy season and combined (Table 6). Significant interaction was recorded in 2010 rainy season, where 120 kg N ha^{-1} and 0 % AEM had the highest effect. Least interaction was obtained with 0 kg N ha^{-1} and 0 % AEM (Table 5).

Table 4. Effect of aqueous extract of moringa and nitrogen rates on crop growth rate (gwk^{-1}) and net assimilation rate ($gm^{-2}wk^{-1}$) of maize in 2009 and 2010 rainy seasons and combined

Treatments	Crop growth rate						Net Assimilation Rate						Grain yield		
	7 weeks after sowing			Harvest			7 weeks after sowing			Harvest					
	2009	2010	CMBD	2009	2010	CMBD	2009	2010	CMBD	2009	2010	CMBD	2009	2010	CMBD
Nitrogen (kg ha^{-1})															
0	50.71b	16.83b	33.77b	11.78b	72.49c	42.14c	0.03	0.01	0.02	0.01b	0.03	0.016c	719.7b	1369.3c	1044.5c
60	99.28a	34.35a	68.81a	81.59a	134.81b	108.20b	0.03	0.01	0.02	0.02a	0.02	0.021b	2065.6a	3277.2b	2671.4b
120	97.91a	43.15a	70.53a	93.08a	179.32a	136.20a	0.03	0.01	0.02	0.02a	003	0.026a	2137.0a	4649.5a	3393.3a
Level of probability	**	**	**	**	**	**	NS	NS	NS	**	NS	**	*	**	**
SE (±)	6.38	3.35	5.09	5.60	6.00	5.81	0.003	0.001	0.003	0.003	0.003	0.003	413.12	200.94	324.84
AE M (% Conc.)															
0	80.66	34.00b	57.33	65.71a	116.54bc	91.13b	0,02b	0.007	0.02	0.013b	0.03	0.02b	2391.0	2992.6	2691.8
3	79.54	45.80a	62.67	73.32a	135.33b	104.32ab	0.02b	0.008	0.02	0.014b	0.03	0.02b	1610.7	3085.4	2348.0
4	86.80	22.70b	54.75	35.43b	105.83c	70.63c	0.03a	0.003	0.02	0.011b	0.02	0.02b	1285.1	3290.7	2287.9
5	83.53	28.61b	56.07	74.16a	157.79a	115.97a	0.03a	0.004	0.02	0.022a	0.03	0.03a	1276.2	3026.1	2151.2
Level of probability	NS	**	NS	**	**	**	*	NS	NS	*	NS	**	NS	NS	NS
SE (±)	7.36	3.86	5.88	6.46	6.93	6.70	0.003	0.001	0.003	0.003	0.003	0.003	476.47	231.75	374.65
Interactions	NS	*	NS	**	*	**	NS	*	NS	NS	NS	*	NS	*	NS

Means in the same column followed by the same letter (s) are not significantly different at 5 % level of probability using LSD. NS = not significant at 5% level of probability.
* = significant at 5% level of probability using LSD. ** = highly significant at 1% level of probability using LSD. AEM = aqueous extract of moringa.

Table 5. Interactions between aqueous extract of moringa and nitrogen rates on crop growth rate (gwk^{-1}), net assimilation rate ($gm^{-2}wk^{-1}$) and grain yield ($kg\ ha^{-1}$) of maize in 2009 and 2010 rainy seasons and combined

	Aqueous extract of moringa (%)											
	Crop growth rate											
	7 WAS 2009 rainy season				**7 WAS 2010 rainy season**							
Nitrogen ($kg\ ha^{-1}$)	0	3	4	5	0	3	4	5	0	3	4	5
0	18.04d	60.12c	63.51c	61.19abc	26.22bcd	16.72de	3.72e	20.67cde				
60	94.06abc	97.83abc	116.57ab	88.66abc	40.50bc	46.89b	35.66bcd	30.34bcd				
120	129.89a	80.67bc	80.33bc	100.73abc	35.28bcd	73.78a	28.72bcd	34.83bcd				
SE (±)	12.76				6.70							
	Harvest 2009 rainy season				Harvest 2010 rainy season				Combined			
0	2.79f	15.41f	13.75f	15.17f	38.25e	89.08d	75.92d	86.72d	20.52e	52.25d	44.84d	50.95d
60	113.95ab	94.73abc	37.37ef	80.33bcd	143.80bc	134.69c	83.03d	177.70ab	128.88bc	114.71c	60.20d	129.01bc
120	60.40cde	109.81ab	55.15de	126.97a	167.56bc	182.22ab	158.56bc	208.94a	123.98bc	146.02ab	106.86c	167.96a
SE (±)	11.21				12.01				11.62			
	Relative growth rate								Grain yield			
	7 WAS 2009 rainy season				Combined				2010 rainy season			
0	0.010a	0.003bc	0.0001c	0.007ab	0.02bc	0.01c	0.02bc	0.02bc	685.71f	1318.52ef	1164.02ef	2308.99de
60	0.007ab	0.010a	0.007ab	0.0001c	0.02bc	0.03ab	0.01c	0.03ab	3061.37cd	3022.22cd	3835.98bc	3189.42cd
120	0.003bc	0.010a	0.003bc	0.007ab	0.02bc	0.03ab	0.02bc	0.04a	5230.69a	4915.34ab	4871.96ab	3579.90cd
SE (±)	0.002				0.01				401.88			

Means in the same column followed by the same letter (s) are not significantly different at 5 % level of probability using LSD. WAS = weeks after sowing.

The significant interaction between N and AEM in 2010 rainy season on maize grain yield might be due to the season, whose effect could not manifest clearly but with the application of N. The presence of interaction is an indication of differential response to the different rates of the factors employed (Hussaini et al., 2004).

CONCLUSION

From the results, it was obvious that AEM had significant effects on the growth and grain yield of maize and it can complement the crop's N fertilizer requirement. Conclusively, 120 kg N ha^{-1} with 5% AEM, which had the highest effects on the parameters studied, should be adopted to maximize production and economic benefits. Modern method of extraction of moringa should be explored to reduce drudgery.

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