INFLUENCE OF AQUEOUS EXTRACT OF MORINGA (*MORINGA OLEIFERA* LAM) AND NITROGEN RATES ON YIELD AND YIELD COMPONENTS OF TOMATO (*LYCOPERSICON ESCULENTUM* (L.) MILL) II

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Abstract: Production of tomato (*Lycopersicon esculentum* (L.) Mill) the most important vegetable crop in Nigeria is constraint by many factors, most importantly low yield per hectare. Earlier, Moringa (*Moringa oleifera* LAM.) were reported to improve crops growth and yield. Field experiments were therefore, carried out in 2009 and 2010 rain fed cropping seasons at the Teaching and Research Farm, Faculty of Agriculture, Bayero University, Kano, Nigeria to study the effects of aqueous extract of moringa and nitrogen rates on yield and yield components of tomato. Moringa shoots were crushed with water (10 kg of fresh material in 1 liter of water) and filtered out. Liquid extract were then diluted with water in the following concentrations; 0 %, 3 %, 4 % and 5 %. These concentrations with 3 Nitrogen rates: 0, 40, 80 kg N ha^{-1} in a factorial combination were tested on tomato in an experiments laid out in a randomized complete block design with three replications. Foliar spray of moringa started at 2 weeks after transplanting and continued fortnightly until 8 weeks after transplanting. Data were collected on number of branches per plant, number of fruits per plant, fruit weight and fruit yield per hectare and were subjected to analysis of variance. Results showed significant effect of treatments on the characters with significant interactions. Based on the result it was concluded that aqueous extract of moringa can compliment nitrogen fertilizer on the production of tomato. Effects were more apparent in the interactions of 40 kg N ha^{-1} with 3 %, and it was therefore, recommended for adopted to improve tomato yield per hectare.

Keywords: Aqueous extract of moringa, nitrogen rates, tomato, yield per hectare.

Introduction: Production of tomato (*Lycopersicon esculentum* (L.) Mill), the most important vegetable crop in Nigeria is constraint by many factors most importantly low yield per hectare. Tomato is considered most important for its rich source of vitamins and minerals with various culinary uses either in its fresh form as salad or as puree in stew and soups. One of the methods in improving crop yield is the application of adequate fertilizer per hectare. However, fertilizer is the scarcest farm input among small scale farmers who constitute the bulk of tomato producers in Nigeria and where it is available it is too cost to a poor resource farmer. Another strategy to achieve yield increase is the use of plant growth regulators (PGR). Moringa (*Moringa oleifera* LAM.) extract a common plant in most households were earlier reported to enhance crops growth and yield as a PGR [1], [2], [3], [4], [5].

This research therefore, was aimed at revalidating the previous findings on the use of moringa by determining if it can improve tomato yield and compliment N fertilizer. Thus, recommends its use to improve tomato production and yield.

Materials and Methods: Field studies were conducted in 2009 and 2010 rainy seasons at the Teaching and Research Farm, Faculty of Agriculture, Bayero University, Kano, Sudan Savanna agro - ecological zone of Nigeria (Latitude 11^{o} 58' N and Longitude 8^{o} 25' E at an altitude of 458 m) to study the influence of aqueous extract of moringa (AEM) and nitrogen rates on yield and yield components of tomato. 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 concentrations with three N rates (0, 40, 80 kg N ha^{-1}) in a factorial combination were tested on tomato (Variety: ROMA VF) in an experiments laid out in a randomized complete block design with 3 replications. Foliar spray started at 2 WAT (weeks after transplanting) and continued fortnightly until 8 WAT. Half dose of N in form of urea and 60 kg ha^{-1} P_2O_5 and K_2O fertilizers in form of single super phosphate (SSP) and muriate of potash (K_2O), respectively were applied at transplanting. The remaining half of N was applied at 5 WAT. Land for the experiments were prepared by harrowing and ridging at a spacing of 0.75 m between rows, thereafter were marked into plots with a gross plot sizes of 13.5 m^2 and net plot sizes of 3.15 m^2. Soil samples were collected in the seasons randomly at a depth of 0 - 15 cm and 15 – 30 cm using soil auger its physical and chemical properties determined (Table I). One plant from seedlings earlier raised in the nursery was transplanted per stand to give a plant population of 26667 plants ha^{-1}. Transplanting was on 3rd September, 2009 and 11th July, 2010. Weeds were controlled by spraying Pendimethalin (500 EC) at 1.5 L ha^{-1} using CP 20 knapsack sprayer and were supplemented by hoe weeding at 3 and 7 WAT.

Insects pest were controlled using BEST ACTION (cypermethrin 30 gm/l plus dimethoate 25 gm/l) at 1L ha^{-1} at flowering and fruiting using the above sprayer. Data were collected on number of branches per plant at 5 and 7 WAS, and at harvest: Five plants in each plot were selected at random and tagged, their branches were counted, means computed and recorded. Number of fruits per plant: fruits of the five tagged plants in each plot were counted, mean determined and recorded. Fresh fruit weight: ten fruits were randomly taken from each plot their fresh weight measured using electrical balance model AAA//60 L, average taken and recorded. Fruit yield ha^{-1}: net plot fruits were harvested and the fresh fruit yield determined, and were converted to fruit yield per hectare. All the collected data were subjected to analysis of variance using SAS system for windows [6].

Results and Discussion: Table 1 shows the results of the physical and chemical properties of the composite soil samples of the experimental sites in the two cropping seasons of the experiments. Soils were silty clay and slightly acid; total N was moderately high. Organic carbon was also high. This may be due to the residual soil nutrient of previous cultivations. In Table 2, with the exception of 2009 rainy season at 5 WAT where there was a significant effect of N rates on tomato number of branches per plant. And in 2009 rainy season at 7 WAT, and 2010 rainy season at harvest where there was no significant effect of N rates on number of branches per plant. Highly significant effects of N was recorded in 2009 rainy season at harvest; 2010 rainy season at 5 WAT and combined at 5 and 7 WAT and at harvest. At 5 WAT, 40 kg N ha^{-1} had highest effect with 6.01 branches per plant in 2009 rainy season; 3.8 branches per plant in 2010 rainy season and 4.93 in the combined; while least number of branches was in 0 kg N ha^{-1}. Similarly, at harvest 40 kg N ha^{-1} had higher number branches per plant (10.76) in 2009 rainy season and 12.56 branches per plant in the combined. At 7 WAT on the other hand, 80 kg N ha^{-1}gave more branches while 0 kg N ha^{-1} had the lowest. The significant effect of N on number of branches per plant might be connected with the role of N in promoting growth and development in plants. On the other hand the non – significant effect of N in 2009 rainy season at 7 WAS might be connected with the season with unstable rainfall which might have affected crop growth, since tomato is very sensitive to short periods of water deficiency. At harvest in 2010 rainy season crops might have attained physiological maturity and growth might have ceased. Highly significant effect of AEM was recorded in the seasons and combined on number of branches per plant of tomato (Table 2). Except in 2010 rainy season where 4 % had higher branches per plant (4.39); 3% had higher branches per plant in all seasons; 8.19, 10.29 and 12.39 in 2009 rainy season at 5 and 7 WAT and at harvest, respectively; 15.67 and 26.67 at 7 WAT and at harvest, respectively; 5.70, 12.98 and 19.53 in the combined at 5 and 7 WAT and at harvest, respectively. Aqueous extract of moringa at 0 % had lower branches. In 2010 rainy season at 7 WAT, 4 % had the lower branches per plant (Table 2). The significant effect of AEM on number of branches per plant might be connected with the effect on plant height as the plant increases in height terminal buds away from the shoot apex develop into branches [7]. Highly significant interaction between N rates with AEM was recorded in the two seasons and combined at 5 and 7 WAT and at harvest (Table 2). Interaction with higher number of branches per plant in 2009 rainy season and combined was 0 kg N ha^{-1} with 3 % AEM; 10.22 and 7.03, respectively. In 2010 rainy season was 0 kg N ha^{-1} with 4 % AEM (6.67). And in combined at 5 WAT, was in 0 kg N ha^{-1} with 3 % (7.03); at 7 WAT higher branches per plant was in 0 kg N ha^{-1} with 3 % AEM (12.32) in 2009 rainy season; 40 kg N ha^{-1} with 3 % AEM (22.45) in 2010 rainy season and 40 kg N ha^{-1} with 3 % AEM (16.05) in the combined. At harvest higher branches per plant was in 40 kg N ha^{-1} with 3 % AEM (12.65) in 2009 rainy season; 0 kg N ha^{-1} with 4 % (34.41) in 2010 rainy season and 40 kg N ha^{-1} with 3 % AEM (22.49) in the combined. Except in 2009 rainy season and combined at harvest where least number of branches was in 0 kg N ha^{-1} with 3 % and 40 kg N ha^{-1} with 5 % AEM, respectively; least branches in the seasons was in 0 kg N ha^{-1} with 0 % moringa (Table 3). The effect of N rates and AEM on number of fruits per plant in 2009 and 2010 rainy season and combined is presented in Table 4. Highly significant effect of N rates was recorded with 80 kg N ha^{-1} produced more fruits in the seasons; 44.17, 73.61 and 58.89, respectively. And lower fruits with 0 kg N ha^{-1}. The highly significant effect of N on number of fruits per plant might be due to the role of N in promoting crop growth which will in turn increased the photosynthetic ability of a plant resulting to more dry matter. The result is in line with the report that higher fruits yield of tomato were obtained with N application up to 110 kg ha^{-1}[8]. Also recorded in Table 4 was a highly significant effect of AEM on number of fruits per plant. Aqueous extract of moringa at 4 % had highest fruits per plant; 60.89 in 2009 rainy season; 101.48 in 2010 rainy season and 81.19 in the combined. Lower fruits was with 0 % in the seasons. The significant effect of AEM on number of fruits per plant might be connected to the significant effect of AEM on number of branches per plant, increase in the number of branches may support more flowers resulting in more fruits.

Similarly, a highly significant interaction between N rates with AEM in the seasons and combined were recorded on number of fruits per plant (Table 4). Number of fruit per plant was higher in 40 kg N ha^{-1} with 4 % AEM; 79.33 in 2009 rainy season; 132.22 in 2010 rainy season and 105.78 in the combined. Least number of fruits per plant was in 0 kg N ha^{-1} with 0 % AEM (Table 5). Also shown in Table 4; the effect of N rates and AEM on tomato fruit weight in 2009 and 2010 rainy season and combined. Highly significant effect of N rates in 2009 rainy season was recorded. There was no significant effect of N rates in 2010 rainy season and combined. In 2009 rainy season fruit weight was higher with 80 kg N ha^{-1} (34.85 g) and lower with 0 kg N ha^{-1} (25.86 g). The non – significant effect of N on tomato fruit weight in 2010 rainy season which might have resulted to the non - significant effect in the combined might be due to the favourable nature of the season. Highly significant effect of AEM in 2009 rainy season and significant effect in the combined was recorded. Aqueous extract of moringa at 3 % had higher fruit weights; 42.02 g in 2009 rainy season and 39.00 g in the combined. Least fruit weight was with 4 % in 2009 rainy season and 5 % in the combined (Table 4). The significant effect of AEM on fruit weight in 2009 rainy which might have resulted to significant effect in the combined might be due to the response of tomato to PGR as was earlier reported that PGR increased tomato fresh weight [9]. The non – significant effect of AEM on tomato fruit weight in 2010 rainy season might be due to the season. Highly significant interaction between N rates with AEM in 2009 rainy season and significant interaction in the combined was recorded (Table 5). Higher fruit weight was in 40 kg N ha^{-1} with 3 % AEM (65.55 g) in 2009 rainy season; 0 kg N ha^{-1} with 3 % AEM (39.92 g) in the combined (Table 4). Least fruit weight was in 0 kg N ha^{-1} with 0 % AEM. The effect of N rates and AEM on fruit yield per hectre in the seasons is presented in Table 4. There was no significant effect of N rates. The non – significant effect of N on fruit yield in the seasons might be due to the role of N in vegetative growth at the expense of yield. There was no significant effect of AEM in 2010 rainy season and combined. Significant effect was recorded in 2009 rainy season; 3 % had higher fruits yield (9276.7 kg ha^{-1}) and lower yield was with 5 % (8716.4 kg ha^{-1}) (Table 4). The significant effect of AEM in 2009 rainy season on tomato fruit yield per hectare might be due to the role of PGR in improving crop growth and yield. Highly significant interaction between N with AEM on fruit yield was recorded in 2009 rainy season. No interaction in 2010 rainy season and combined. Higher fruit yield was in 0 kg N ha^{-1} with 4 % AEM (9052.38 kg ha^{-1}) and lower in 80 kg N ha^{-1} with 4 % (Table 5).

Conclusion and Recommendation: Moringa extract was found to affect tomato performance. And it can compliment N fertilizer; from the result moringa along had a significant effect on yield and yield components. However, for better result the combination of the two is most desired. In this experiment effects were more apparent in the interactions of 40 kg N ha^{-1} with 3 %, and it was therefore, recommended for adopted to improve tomato yield per hectare.

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Table 1. The soil physical and chemical properti Table 1. The soil physical and chemical properties of the experimental site 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 number of branches per plant of tomato in 2009 and 2010 rainy seasons and combined.

Treatments	5 weeks after transplanting			7 weeks after transplanting			Harvest		
	2009	2010	Combined	2009	2010	Combined	2009	2010	Combined
Nitrogen (kg ha^{-1})									
0	5.27b	2.80b	3.86b	7.74	3.00c	5.37c	8.89b	13.08	10.99b
40	6.01a	3.80a	4.93a	6.80	8.5b	7.65b	10.76 a	14.38	12.56a
80	5.75ab	2.46b	4.29b	7.29a	9.72a	8.51a	9.39b	14.00	11.70b
Level of probability	*	**	**	NS	*	**	**	NS	**
SE (±)	0.18	0.25	0.22	0.29	0.29	0.29	0.32	0.45	0.39
Aqueous extract of M (% concentration)									
0	4.41c	1.94c	3.18c	5.84b	5.50b	5.67b	9.16b	8,92c	9.04c
3	8.19a	3.22b	5.70a	10.29a	15.67a	12.98a	12.39 a	26.67a	19.53a
4	4.61c	4.39a	4.50b	6.56b	3.50c	5.03b	8.66b	15.08b	11.87b
5	5.50b	2.61b c	4.06b	6.41b	3.63c	5.02b	8.51b	4.61d	6.56d
Level of probability	**	**	**	**	**	**	**	**	**
SE (±)	0.20	0.29	0.25	0.33	0.34	0.34	0.36	0.52	0.45
Interaction	**	**	**	**	**	**	**	**	**

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

- = significant at 5% level of probability using LSD. ** = highly significant at 1 % level of probability using LSD. NS = not significant using LSD. M = moringa

Table 4. Effect of Aqueous extract of moringa and nitrogen rates on number of fruits per plant, fruit weight (g) and fruit yield (kg ha^{-1}) of tomato in 2009 and 2010 rainy seasons and combined.

Treatments	Number of fruits per plant			Fruit weight			Fruit yield		
Nitrogen (kg ha^{-1})	2009	2010	CMBD	2009	2010	CMBD	2009	2010	CMBD
0	36.28b	60.46b	48.37b	25.86b	23.32	24.59	9649.0	8312.0	8980.15
40	42.50a	70.83a	56.67a	26.16b	21.88	24.02	9909.5	8317.0	9113.25
80	44.17a	73.61a	58.89a	34.85a	25.63	25.90	9186.6	9689.0	9438.0
Level of probability	**	**	**	**	NS	NS	NS	NS	NS
SE (±)	1.63	2.72	2.25	2.09	6.35	4.73	314.97	452.96	201.18
Aqueous extract of M (% concentration)									
0	25.11d	41.85d	33.48d	25.35bc	34.76	30.06a	9109.5a	9562.0	9336.0
3	34.00c	56.67c	45.33c	42.02a	37.96	39.00a	9276.7a	9871.0	9573.9
4	60.89a	101.48a	81.19a	19.93c	10.09	15.01b	8978.9ab	9892.0	9435.5
5	43.93a	73.21b	58.57b	28.54b	18.31	23.42ab	8716.4b	9943.4	9329.9
Level of probability	**	**	**	**	NS	*	*	NS	NS
SE (±)	1.88	3.14	2.59	2.41	7.33	5.45	121.08	327.91	232.08
Interactions	**	**	**.	**	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.

*= significant at 5% level of probability using LSD.
** = highly significant at 1 % level of probability using LSD.
NS = not significant using LSD. CMBD = combined. M = moringa.

Table 5. Interaction between Aqueous extract of moringa and nitrogen rates on number of fruits per plant, fruit weight (g) and fruit yield (kg ha^{-1}) of tomato in 2009 and 2010 rainy seasons and combined.

	Aqueous extract of moringa (%)											
Nitrogen (kg ha^{-1})	Number of fruit per plant											
	2009 rainy season				2010 rainy season				Combined			
	0	3	4	5	0	3	4	5	0	3	4	5
o	19.33f	49.33bc	52.67b	55.33b	32.22f	82.22bc	87.78b	92.22b	25.78f	65.78b	70.22b	73.78b
40	28.00ef	28.00ef	79.33a	34.67de	46.66ef	46.67ef	132.22a	57.78bd	37.33de	37.33de	105.78a	46.33d
80	28.00ef	24.67ef	50.67bc	41.77cd	46.67ef	41.11ef	84.45bc	69.63cd	37.33de	32.89ef	65.56b	55.71c
SE (±)	3.27				5.45				4.49			

	Fruit weight								Fruit yield			
	2009 rainy season				Combined				2009 rainy season			
0	13.45e	44.95b	16.45de	28.60cd	15.25cd	39.92a	17.67bcd	25.52abcd	7640.74e	8517.46abc	9052.38a	7535.98e
40	39.65bc	65.55a	20.45de	16.75de	35.78abc	31.28abcd	10.25d	16.16cd	8047.67bcde	8339.68bcd	7476.19e	7774.60de
80	22.95de	18.55de	22.90de	40.25bc	39.13ab	18.76abcd	17.11bcd	28.50abcd	8640.21ab	7973.02bcde	7407.94e	7838.62cde
SE (±)	4.17				9.46				209.97			

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

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