



Growth and Yield Response of Maize (*Zea mays* L.) to *Moringa oleifera* Leaf Extract and Boost Extra foliar fertilizers on Sandy Loam Soils of the Northern Guinea Savannah Zone of Nigeria

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ABSTRACT

A field experiment was conducted in 2012 and 2013 rainy seasons at the Teaching and Research Farm of the Department of Crop Science, Adamawa State University, Mubi to assess the growth and yield response of maize plant to *Moringa* leaf extract and Boost extra foliar fertilizers on sandy loam soils. The study comprised of 13 treatments viz; T₁ (control), T₂ (Boost extra, 3 lit ha⁻¹), T₃ (Boost extra, 2 lit ha⁻¹), T₄ (*Moringa* leaf extract, 1:32), T₅ (*Moringa* leaf extract, 1:36), T₆ (*Moringa* leaf extract, 1:40), T₇ (*Moringa* leaf extract, 1:40), T₈ (*Moringa* leaf extract, 1:36), T₉ (*Moringa* leaf extract, 1:32), T₁₀ (*Moringa* leaf extract, 1:32 plus Boost extra, 3 lit. ha⁻¹), T₁₁ (*Moringa* leaf extract, 1:32 plus Boost extra, 2 lit. ha⁻¹), T₁₂ (*Moringa* leaf extract, 1:36 plus Boost extra, 2 lit. ha⁻¹) and T₁₃ (*Moringa* leaf extract, 1:40 plus Boost extra, 2 lit. ha⁻¹). T₂ was sprayed twice, T₃, T₄, T₅, T₆, T₁₀, T₁₁, T₁₂ and T₁₃ were sprayed once while T₇, T₈ and T₉ were sprayed at 2, 4 and 6 weeks after sowing (WAS). All treatments except T₂ received NPK (120:60:60). The experiment was laid out in a randomized complete block design (RCBD) with 3 replications. Results showed that application of *Moringa* leaf extract (1:32 v/v) at 2, 4 and 6 WAS significantly increased yield components of maize. The highest grain yield (4.9 t ha⁻¹) and stover yield (7.7 t ha⁻¹) were obtained from T₉ while the lowest grain yield (2.6 t ha⁻¹) and stover yield (4.9 t ha⁻¹) were obtained with Boost extra applied at 3 lit ha⁻¹ (T₂). The concentration of *Moringa* leaf extract had a significant influence on grain and stover yields of maize where dilution ratios of *Moringa* leaf extract to distilled water of 1:32 and 1:36 increased grain yield by 35.2 and 9.5%, respectively. Therefore, for better growth and yield performance of maize, Boost extra should be applied in combination with NPK while *Moringa* leaf extract (1:32) should be sprayed at 2, 4 and 6 weeks after sawing in addition to soil application of NPK (120:60:60).

Keywords: *Moringa* leaf extract, Boost extra, NPK, Maize, Growth, Yield

INTRODUCTION

Maize is an important staple food crop not only in Nigeria but even in Africa (Olakojo *et al.*, 2005) and mainly as an energy giving food with a total production of 7.3 million tons (FAO, 2007). Being a versatile crop, constituting about fifty percent in the poultry feed ingredients; it is widely cultivated for its economic value in all the agro-ecological zones in Nigeria. Application of inorganic fertilizer to increase crop growth and yield is well known since the nutrients are readily available for plant use but continuous and inappropriate use of inorganic fertilizer is harmful both to the soil and the environment (Afe *et al.*, 2015). It increases soil acidity, and nutrient imbalance and pollution of underground water. The well documented detrimental effects of inorganic fertilizer, its cost and unavailability has limited its use among poor farmers in Nigeria (Taminu *et al.*, 2007). The dependency on the use of inorganic fertilizers as a source of plant nutrients by farmers and their high cost is further associated with land and soil degradation and environmental pollution (Phiri, 2010). For this reason, there is need to search for alternative safe natural sources of plant nutrients. The practice of applying liquid fertilizer to plant leaves is recently done in Nigeria, and it is gradually gaining popularity among peasant farmers in many cultivated crops (Afe *et al.*, 2015). Research on foliar fertilizer application has been reported to increase the growth, yield and quality of crops such as

soybean (Barge, 2001), tomato (Alexander *et al.*, 2004) and okra (Selvi and Rani, 2000) among others. Philips (2004) demonstrated that this technique apart from supplying the micronutrients it also acts as a catalyst in the uptake and use of certain macronutrients.

Boost extra, is a foliar fertilizer that is commonly used by farmers in Nigeria. It contains both the macro and micro nutrients with 20% N, P and K, 0.075% Zn, Cu and Mg, 1.5% Fe, 0.35% Mn, 0.035% Bo and 0.012% Mo with pH range of 4.0-4.5 (Omex, 2007). Its application in combination with poultry manure and inorganic fertilizer for early maturing maize production in Southern Guinea Savannah ecological zone of Nigeria has been found to be beneficial (Afe *et al.*, 2015).

Moringa oleifera is one of such alternative, being investigated to ascertain its effect on growth and yield of crops and thus can be promoted among farmers as a possible supplement or substitute to inorganic fertilizers (Phiri, 2010). Moreover, several re-searches have indicated that *M. oleifera* L. is a highly valued plant with multipurpose effects (Fugile, 2000; Yang *et al.*, 2006; Anwar and Rashid, 2007; Adebayo *et al.*, 2011). Increase in grain yield of maize and common beans has been reported by Mvumi *et al.* (2013) and Mehboob (2011). Therefore, the present study was planned to evaluate the growth and yield of maize (Sammaz 20) in response to combined application of NPK, Boost extra and Moringa leaf extract.

MATERIALS AND METHODS

The experiment was carried out in 2012 and 2013 rainy seasons at the Teaching and Research Farm of the Department of Crop Science, Adamawa State University, Mubi to study the response of maize to *Moringa* leaf extract and Boost extra foliar fertilizers applications. The experimental site falls within the northern guinea savannah zone of Nigeria. The soil was sandy loam, total nitrogen was 0.17 g kg⁻¹, available phosphorus, 6.68 mg kg⁻¹, potassium, 0.45 [Cmol (+)kg⁻¹], organic carbon, 3.70 g kg⁻¹ while CEC was 3.32 [Cmol (+)kg⁻¹] as shown in Table 1. Mineral composition of *Moringa* leaf extract and Boost extra are presented in Tables 2 and 3, respectively. *Moringa* leaf extract was prepared as described by Fugile (2000).

Treatments and experimental design

There were 13 treatments as follows;

T₁ = Control NPK (120:60:60)

T₂ = Boost extra (3 lit ha⁻¹) sprayed twice

T₃ = Boost extra (2 lit ha⁻¹) sprayed once

T₄ = *Moringa* leaf extract (1:32) sprayed once

T₅ = *Moringa* leaf extract (1:36) sprayed once

T₆ = *Moringa* leaf extract (1:40) sprayed once

T₇ = *Moringa* leaf extract (1:40) sprayed at 2, 4 and 6 weeks after sawing (WAS)

T₈ = *Moringa* leaf extract (1:36) sprayed at 2, 4 and 6 WAS

T₉ = *Moringa* leaf extract (1:32) sprayed at 2, 4 and 6 WAS

T₁₀ = *Moringa* leaf extract (1:32) plus Boost extra (3 lit ha⁻¹) sprayed once

T₁₁ = *Moringa* leaf extract (1:32) plus Boost extra (2 lit ha⁻¹) sprayed once

T₁₂ = *Moringa* leaf extract (1:36) plus Boost extra (2 lit ha⁻¹) sprayed once

T₁₃ = *Moringa* leaf extract (1:40) plus Boost extra (2 lit ha⁻¹) sprayed once.

The experiment was laid out in a randomized complete block design (RCBD) with 3 replications. Maize variety was Sammaz 20 released by Institute of Agricultural Research, Samaru, Zaria. The land was cleared, ploughed and harrowed and marked out into 4 m x 3 m. The distance maintained between 2 units plot is 0.50 m and between blocks was 1 m. Two seeds were sown at a spacing of 75 cm x 25 cm and were thinned to 1 plant per hill 2 WAS. Split application of the inorganic fertilizer was adopted. Data collected were on stem height, number of leaves, leaf area, number of plants with 2 cobs, number of column cob⁻¹, grain cob⁻¹, shelling percentage, harvest index, grain and stover yields. Parameters measured were subjected to analysis of variance using SAS (2010) and means were separated using Duncan's multiple range test.

RESULTS AND DISCUSSION

The data regarding plant height, leaf area, number of leaves, number of plants with 2 cobs, number of column cob⁻¹ and grain weight cob⁻¹ are presented in Table 4. Results shows that there were no significant difference (P=0.05) between the years in all the parameters measured. Statistical analysis

of the data shows that there was no significant difference in plant height between soils applied NPK alone, Boost extra and *Moringa* leaf extract applied in combination or separately. Number of leaves was highest (11.44 plant⁻¹) with *Moringa* leaf extract (1:36). This was at par with number of leaves produced at T₁, T₂, T₇, T₈, T₉ and T₁₃. However, the lowest (10.26) was recorded at T₁₂. Soils applied NPK, Boost extra and *Moringa* leaf extract had significant effect on leaf area of maize. Foliar application of *Moringa* leaf extract of 1:40 sprayed once had the highest leaf area of 746.06 cm² (T₆). This was at par with leaf area obtained with T₁, T₃, T₅, T₉ and T₁₃. The lowest was recorded with foliar application of *Moringa* leaf extract (1:32) + Boost extra (2 lit ha⁻¹) of 636.37 cm² (T₁₁). Number of plants with 2 cobs expressed in percentage shows that *Moringa* leaf extract (1:40) had the highest with 21.1 % while the lowest (9.9) was recorded with Boost extra (3 lit ha⁻¹) sprayed twice without NPK (T₂). This was not significantly different (P=0.05) from T₃, T₄, T₅, and T₇. The finding in this work corroborates with few previous reports of Chattha *et al.* (2015), Abbas *et al.* (2013) and Ali *et al.* (2011) who suggested that application of *Moringa* leaf extract can enhance the growth rate and number of leaves plant⁻¹, while Afe *et al.* (2015) reported that Boost extra is beneficial when combined with NPK and poultry manure.

Number of columns cob⁻¹ was highest (13.24) with *Moringa* leaf extract (1:36) sprayed once (T₅) which is at par with T₄, T₉, T₁₂ and T₁₃ and lowest (10.67) with Boost extra (3 lit ha⁻¹) foliar application (T₂). Treatment effects indicated that the highest number of grains cob⁻¹ (622.4) was obtained from *Moringa* leaf extract (1:36) sprayed once (T₅). However, this was not significantly different with T₁, T₄, T₆, T₈, T₉, T₁₂ and T₁₃. The lowest (404.03) was recorded with T₂ (Boost extra sprayed twice at 3 lit ha⁻¹). Mehboob (2011) reported similar results on the number of grains cob⁻¹ in maize.

Shelling percentage, harvest index, 1000 grain weight, grain weight and stover yield were affected by different treatments (Table 5). Shelling percentage was highest with T₁₁ (84.62%) while harvest index was highest (43%) with T₉ application. The shelling percentage obtained from control (T₁) was the lowest with 60.03% and harvest index from T₁₀ with 33%. Boost extra and *Moringa* leaf extract foliar spray had significant effect on 1000 grain weight in maize. Among the fertilizers, foliar application of *Moringa* leaf extract (1:32) at 2, 4 and 6 WAS (T₉) produced the highest 1000 grain weight (306.62 g) which was significantly higher than all other treatments while the lowest (255.16 g) was recorded with T₂. Sanjeev *et al.* (1997) reported that individual grain weight or 1000 grain weight are regarded as the basis for final economic yield. Yasmeen *et al.* (2011) and Anyeabu *et al.* (2013) also found increase in 100 grain weight in wheat due to application of *Moringa* leaf extract. This response could be attributed to the growth promoting hormones like zeatin a common form of cytokinin hormone which is a constituent of fresh *Moringa* leaf extract (Fugile, 2000). The high concentration of zeatin and several mineral elements in *Moringa* leaf extract has been reported by (Yasmeen *et al.*, 2014; Rady and Mohamed, 2015; Rady *et al.*, 2015). The result of this study reveals that the grain yield and stover yield were significantly (P=0.05) influenced by the application of *Moringa* leaf extract. The significant influence of Boost extra is revealed when applied in combination with *Moringa* leaf extract. The highest grain yield (4,879.9 kg ha⁻¹) was obtained from the application of *Moringa leaf extract* (1:32) sprayed at 2, 4 and 6 WAS (T₉) which was at par with T₁₂ and T₈ with 4,060.8 and 3,952.6 kg ha⁻¹, respectively. This indicates that T₉ and T₈ increased grain yield by 35.4 and 9.5%, respectively. These findings corroborate with the findings of Mvumi *et al.* (2013) who reported increased grain yield in maize by applying *Moringa* leaf extract. Similar response was observed with stover yield where T₉ had the highest stover yield (7,745 kg ha⁻¹) with the lowest (4,852 kg ha⁻¹) obtained from T₂. The weak response of grain and stover yields to Boost extra was also reported by Afe *et al.* (2015). Increase in stover yield from application of *Moringa* leaf extract was also reported by Chattha *et al.* (2015), Abbas *et al.* (2013).

CONCLUSION

The present study suggests that application of *Moringa* leaf extract as foliar fertilizer enhances growth and yield of maize. The benefit of Boost extra can only be obtained when combined with organic and inorganic fertilizers as it does not meet the requirement for the optimum growth and yield of maize when used alone. The combined application of *Moringa* leaf extract and Boost extra did not produce better yield than when applied separately. Therefore this study suggest that the application of *Moringa*

leaf extract diluted with distilled water at the ratio of 1:32 (v/v) sprayed at 2,4 and 6 weeks after sowing combined with NPK will enhance growth and yield of maize.

Table 1: Some physical and chemical properties of soil of the experimental site

Parameter	Value
Physical	
Sand (%)	53.8
Silt (%)	32.5
Clay (%)	13.7
Textural class	Sandy loam
Chemical	
Organic carbon g kg ⁻¹	3.70
Total N (g kg ⁻¹)	0.17
Available P (mg kg ⁻¹)	6.68
Potassium [Cmol (+)kg ⁻¹]	0.45
Calcium [Cmol (+)kg ⁻¹]	1.90
Magnesium [Cmol (+)kg ⁻¹]	0.41
Sodium [Cmol (+)kg ⁻¹]	0.35
CEC [Cmol (+)kg ⁻¹]	3.32

Table 2: Chemical composition of *Moringa oleifera* leaf extract

Element	<i>Moringa oleifera</i> leaf extract
P (mg/l)	8.10
K (mg/l)	52
Ca (mg/l)	34.7
Mg (mg/l)	35.0
Na (mg/l)	223
Fe (mg/l)	0.75
Cu (mg/l)	0.25
Zn (mg/l)	0.05
Ni (mg/l)	0.03
Pb (mg/l)	0.42
EC (μS/cm)	37.5
pH	7.0

Table 3: Composition of boost-extra foliar fertilizer

Element	Quantity (%)
Nitrogen	20
Phosphate	20
Potassium	20
Magnesium	1.5
Iron EDTA	0.15
Manganese EDTA	0.075
Copper EDTA	0.075
Zinc EDTA	0.075
Boron	0.0315
Cobalt EDTA	0.0012
Molybdenum	0.0012
pH (10% solution)	4.0-4.5
Density	1.51 SG

Source: Omex (2007)

Table 4: Effect of combined application of NPK, Moringa leaf extract and boost extra foliar fertilizers on plant height, number of leaves, leaf area, number of plants with 2 cobs, column cob⁻¹ and grain cob⁻¹ of maize.

Year	Plant height (cm)	Number of leaves	Leaf area (cm ²)	Plants with 2 cobs (%)	Column cob ⁻¹	Grain cob ⁻¹
2012	206.85	10.93	672.67	16.63	12.14	527.65
2013	205.28	10.99	689.59	16.69	12.17	533.61
SE(±)	8.61	0.195	24.51	2.80	0.37	40.35
LS	NS	NS	NS	NS	NS	NS
Treatment						
T ₁	214.17	11.07abc	730.20ab	19.3a	11.53de	548.13a-d
T ₂	196.94	11.02abc	663.22de	9.9c	10.67f	404.03f
T ₃	207.32	10.93bc	695.42a-d	14.6abc	11.02ef	511.50b-e
T ₄	212.81	11.44a	674.05de	11.5bc	12.78ab	603.07ab
T ₅	206.22	10.91bc	729.19abc	14.8abc	13.24a	622.40a
T ₆	202.42	10.94bc	746.06a	16.7ab	12.07bcd	538.33a-d
T ₇	203.26	11.09abc	653.15de	15.9abc	12.20bcd	499.33cde
T ₈	210.60	11.30ab	660.89de	20.6a	12.22bcd	565.27abc
T ₉	215.89	11.11abc	689.11a-d	21.2a	13.07a	568.73abc
T ₁₀	202.87	10.70c	650.03de	17.1ab	11.85cd	445.80ef
T ₁₁	208.38	10.68c	636.37e	19.1a	11.76cde	462.33def
T ₁₂	203.50	10.26d	640.70de	20.9a	13.17a	579.37abc
T ₁₃	199.92	10.99abc	687.24a-e	16.8ab	12.46abc	549.90a-d
SE(±)	8.61	0.195	24.51	2.8	0.37	40.35
LS	NS	**	**	**	***	***

Means in a column followed with the same letter (s) are not significantly different at 5% level of probability; LS=Level of significance *=Significant at 5% level of probability; **=Significant at 1% level of probability; ***=Significant at 0.1% level of probability; NS= Not significantly different at 5% level of probability, T₁= NPK (control); T₂=Boost extra (3 lit. ha⁻¹) sprayed twice; T₃=Boost extra (2 lit ha⁻¹) sprayed once; T₄= Moringa leaf extract (1:32) sprayed once; T₅= Moringa leaf extract (1:36) sprayed once; T₆= Moringa leaf extract (1:40) sprayed once; T₇= Moringa leaf extract (1:40) sprayed at 2, 4 and 6 WAS; T₈= Moringa leaf extract (1:36) sprayed at 2, 4 and 6 WAS; T₉= Moringa leaf extract (1:32) sprayed at 2, 4 and 6 WAS; T₁₀= Moringa leaf extract (1:32) + Boost extra (3 lit ha⁻¹) sprayed once; T₁₁= Moringa leaf extract (1:32) + Boost extra (2 lit ha⁻¹) sprayed once; T₁₂= Moringa leaf extract (1:36) + Boost extra (2 lit ha⁻¹) sprayed once; T₁₃= Moringa leaf extract (1:40) + Boost extra (2 lit ha⁻¹) sprayed once. NPK was added as basal to all treatments except T₂.

Table 5: Effect of combined application of NPK, *Moringa* leaf extract and boost extra foliar fertilizers on yield characters of maize.

Year	Shelling (%)	Harvest index (%)	1000 grain weight (g)	Grain yield (kg ha ⁻¹)	Stover yield (kg ha ⁻¹)
2012	71.05	37.16	255.52	3559.13	6361
2013	74.37	38.07	257.06	3619.11	6062
SE(±)	6.43	4.00	14.20	479.20	1144
LS	NS	NS	NS	NS	NS
Treatment					
T ₁	60.03c	35ab	260.25bc	3609.2bc	7430a
T ₂	65.73bc	39ab	225.18d	2593.6c	4852c
T ₃	75.12ab	35ab	238.69bcd	3514.4bc	6507abc
T ₄	76.47ab	39ab	254.80bcd	3277.1	4937c
T ₅	76.54ab	39ab	260.82bc	3705.0bc	6246abc
T ₆	70.52abc	39ab	265.20bc	3539.6bc	5513bc
T ₇	74.55abc	35ab	244.12bcd	3384.7bc	6269abc
T ₈	72.95abc	38ab	246.97bcd	3952.6ab	6597abc
T ₉	78.43ab	39ab	306.62a	4879.9a	7745ab
T ₁₀	74.10	33b	237.16cd	3222.8bc	6858abc
T ₁₁	84.62a	43a	264.93bc	3552.4bc	4679c
T ₁₂	72.60abc	42ab	271.42b	4060.8bc	5451bc
T ₁₃	63.57bc	35ab	255.63bcd	3367.7bc	6668abc
SE(±)	6.43	4.00	14.20	479.20	1144
LS	*	*	**	*	*

Means in a column followed with the same letter (s) are not significantly different at 5% level of probability; LS=Level of significance *=Significant at 5% level of probability; **=Significant at 1% level of probability; NS= Not significantly different at 5% level of probability, T₁= NPK (control); T₂=Boost extra (3 lit ha⁻¹) sprayed twice; T₃=Boost extra (2 lit ha⁻¹) sprayed once; T₄= *Moringa* leaf extract (1:32) sprayed once; T₅= *Moringa* leaf extract (1:36) sprayed once; T₆= *Moringa* leaf extract (1:40) sprayed once; T₇= *Moringa* leaf extract (1:40) sprayed at 2, 4 and 6 WAS; T₈= *Moringa* leaf extract (1:36) sprayed at 2, 4 and 6 WAS; T₉= *Moringa* leaf extract (1:32) sprayed at 2, 4 and 6 WAS; T₁₀= *Moringa* leaf extract (1:32) + Boost extra (3 lit ha⁻¹) sprayed once; T₁₁= *Moringa* leaf extract (1:32) + Boost extra (2 lit ha⁻¹) sprayed once; T₁₂= *Moringa* leaf extract (1:36) + Boost extra (2 lit ha⁻¹) sprayed once; T₁₃= *Moringa* leaf extract (1:40) + Boost extra (2 lit ha⁻¹) sprayed once. NPK was added as basal to all treatments except T₂.

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