Progressive Agriculture 27 (2): 136-143, 2016 ISSN: 1017 - 8139

Progressive Agriculture
Journal homepage:http://www.banglajol.info/index.php/PA

Effects of moringa leaf extract on growth and yield of maize

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Abstract

The present study was conducted in the Soil Science Field Laboratory at Bangladesh Agricultural University, Mymensingh during November 2014 to April 2015 to study the effect of moringa leaf extract on growth and yield of maize. The experiment comprised of five treatments viz., T_1 (control), T_2 (water sprayed at every 2 weeks, starting from 2 weeks after emergence), T_3 (moringa leaf extract sprayed at 2 weeks after emergence), T_4 (moringa leaf extract sprayed at 2 and 4 weeks after emergence) and T_5 (moringa leaf extract sprayed at 2 weeks after emergence and at every 2 weeks thereafter). The experiment was laid out in a Randomized Complete Block Design (RCBD) with 3 replications. Application of moringa leaf extract at 2 weeks after emergence and at every 2 weeks thereafter (T_5) significantly increased growth parameters like plant height, shoot length, fresh weight and dry weight of shoot, and yield components like number of grains cob^{-1}, 100-grain weight, grain weight plant^{-1}. The highest grain yield (9.2 t ha^{-1}), stover yield (10.1 t ha^{-1}) and harvest index (48%) were obtained from T_5 while the lowest grain yield (6.3 t ha^{-1}), stover yield (8.6 t ha^{-1}) and harvest index (42%) were found in the treatments where no moringa leaf extract was used (T_1 or T_2). From the results it can be concluded that moringa leaf extract should be applied for better growth and yield performance of maize in Old Brahmaputra Floodplain soil of Bangladesh.

Key words: Maize, moringa leaf extract, growth, yield.

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Introduction

Moringa (*Moringa oleifera*) is considered as one of the world's most useful trees, as almost every part of the tree has an impressive effect of food, medication and industrial purposes (Khalafalla *et al.,* 2010; Adebayo *et al.,* 2011; Moyo *et al.*, 2011). Moringa leaves are potential source of vitamin A and C, iron, calcium, riboflavin, b-carotene, phenolics (Nambiar *et al.,* 2005) and powerful natural antioxidants (Njoku and Adikwu, 1997). Now-a-days, moringa plant has attained enormous attention because of having cytokinin, antioxidants, macro and micro nutrients in its leaves (Abdalla and El-Khoshiban, 2012; Abdalla, 2013). Moringa has proved to be a potential source for research as scientists have moved their focus to this "Miracle tree". Today farmers are well aware about application of organic fertilizer to improve their crop production as well as farming land. Applying moringa leaf extract is a cheap and environment friendly organic technology which increases growth of most vegetable crops like rape, cabbage and tomato, and field crops including maize and common beans. Hence, moringa leaf extract can be used as an organic fertilizer for the farmers. The effect of moringa leaf extract is analogous to synthetic hormonal effect because the extract contains zeatin, a purine adenine derivative of plant hormone group cytokinin (Makkar *et al.*, 2007) and this zeatin enhances the antioxidant properties of many enzymes and protects the cells from aging effects of reactive oxygen species (Zhang and Ervin, 2004).

Bangladesh is a densely populated country. The food demand has been increasing day by day due to high population growth. At this juncture, only rice and

wheat cannot fulfill the total cereal food demand of the country. To meet this challenge, maize (*Zea mays* L.) can be chosen to supplement cereal food deficiency because of its higher yield potential as compared to rice and wheat (Mian *et al*. 2002). Moreover, malnutrition is a major problem in the country. The national food availability in terms of calories is much lower than the requirement. From the nutritional standpoint, maize grain has high nutritive value containing 66.2% starch, 11.1% protein, 7.12% oil and 1.5% minerals (Chowdhury and Islam, 1993). Maize is a high yield potential crop having highest photosynthetic rate among all the food crops and as a C_4 plant it can accumulate dry matter faster than rice, wheat or other cereals. Being an important cereal crop, maize is grown on about 3.64 lakh hectares of land with a total production of about 25.16 lakh metric tons (BAD, 2015). Moreover, the demand for maize is increasing progressively due to rapid development of the poultry industry. Although the current production of maize is low, there is a great prospect for increasing the area and production of maize in Bangladesh.

Although various parts of *Moringa oleifera* plant extracts are known to possess diverse medicinal and biological activity on human and animals, little is known scientifically about its potential effect as a growth enhancer in major crop plants because very few published literature are available that clearly explain the effects of moringa leaf extract in plants. In view of all the previous reports, it is hypothesized that leaf extract from moringa having a number of plant growth promoters, mineral nutrients and vitamins in a naturally balanced composition, may be beneficial for plant growth and development. The use of moringa leaf extract for agricultural purposes to enhance growth and yield of major crops in Bangladesh has not yet been thoroughly investigated. Keeping above facts in mind, the present study was undertaken to investigate the effect of moringa leaf extract on growth and development of maize and to determine the effect of moringa leaf extract on yield and yield components of maize.

Materials and Methods

The experiment was carried out at the Soil Science Field laboratory, Bangladesh Agricultural University (BAU), Mymensingh during the Rabi season from 24th November 2014 to 12th April 2015 to study the effect of moringa leaf extract on the growth and yield performance of maize crop. The experimental site belongs to the Sonatala soil series under the AEZ-9 (Old Brahmaputra Floodplain) having non-calcareous dark grey floodplain soil (UNDP and FAO, 1988). The soil was silt loam in texture having pH 6.4, organic matter content 1.13%, total N 0.106%, available P 11.92 ppm, exchangeable K 0.12 me% and available S 7.85 ppm. There were five treatments as follows:

T_1= Control-with no moringa extract added;

T_2= Water sprayed at every 2 weeks, starting from 2 weeks after emergence;

T_3= Moringa extract sprayed at 2 weeks after emergence;

T_4= Moringa extract sprayed at 2 and 4 weeks after emergence;

T_5= Moringa extract sprayed at 2 weeks after emergence and at every 2 weeks thereafter.

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The total number of unit plots was 15 and the size of unit plot was 3 m × 1.5 m. The distance maintained between two unit plots was 0.50 m and between blocks was 1 m. Treatments were randomly allocated in the experiment. The experimental land was prepared thoroughly by ploughing and cross ploughing with a power tiller. Each ploughing was followed by laddering to break the clods and to level the land. The land was cleaned by removing weeds, stubbles and crop residues and trimming ails. The final land preparation was done on the 20th November, 2014. In the experiment, full doses of fertilizers viz., triple super phosphate (50 kg P ha^{-1}), muriate of potash (90 kg K ha^{-1}), gypsum (30 kg S ha^{-1}), zinc sulphate (3 kg Zn ha^{-1}) and boric acid (2 kg B ha^{-1}) were applied at the time of final land preparation. In case of urea (190 kg N ha^{-1}), one third was applied during the final land preparation. The rest two thirds of urea were applied in two equal splits at 30 days after sowing (DAS) and at 65 DAS. Seeds of Titan hybrid maize were sown on the 24th November, 2014 in 75 cm distance between the rows by dibbling 3-4 cm deep furrow with country plough.

Two seeds were placed within the furrow for the purpose of establishing one plant per hill in 25 cm apart. After sowing, the seeds were covered with soil. Young moringa leaves of about 100 g were taken into a mortar with a pinch of water (10 ml/ 100 g fresh material) and ground with a pestle. The juice was extracted by hand pressure and was filtered through the cheese cloth. The solution was re-filtered using No.2 Whatman filter paper. Following the method developed by Fuglie (2000), the extract was diluted with distilled water at a ratio of 1:32 (v/v) and then sprayed directly onto maize plants. The extract was used within five hours from cutting and extracting. The extract prepared was stored at 0ºC and only taken out when needed for use. An amount of 25 mL (application rate) of the moringa leaf extract was applied per plant in the field. Hand sprayers were used to spray the extract. Plots for T_1 treatment remained unsprayed, plots for T_2 treatment were sprayed with water, and plots for T_3, T_4 and T_5 treatments were sprayed with moringa leaf extract. Special attention was given for complete coverage of the plant with spray materials. According to the treatments, spraying of moringa leaf extract to the maize plants started from two weeks after emergence of seedlings and ended until flowering. Ten plants were randomly selected and marked with polythene rope from each plot for collecting data on growth and yield parameters. The crop was harvested plot-wise at full maturity on the 12th April, 2015. For collecting necessary data, the sample plants were harvested separately. The harvested crop of each plot was bundled separately, tagged properly and taken to the threshing floor. The stover samples were dried in the sun before recording the weights. Grains were cleaned and dried to a moisture content of 14%. Final grain and straw yields plot^{-1} were recorded and converted to t ha^{-1}. To determine dry matter, the sample plants were air dried until constant weight was reached. At harvest, data were collected on plant height, number of leaves plant^{-1}, fresh and dry weight of shoot plant^{-1}, cob length, cob diameter, grains column^{-1}, grains cob^{-1}, 100-grain weight, grain weight plant^{-1}, grain yield, stover yield and harvest index. Collected data were compiled and tabulated in proper for statistical analysis. The recorded data were statistically analyzed to find out the significance of variation resulting from the experimental treatments. Collected data were analyzed using "Analysis of Variance Technique" with the help of a computer package programme MSTAT and the mean differences were adjudged by Duncan's Multiple Range Test (Gomez and Gomez, 1984).

Results and Discussion

Effect of moringa leaf extract on growth components of maize

Application of moringa leaf extract had significant effects on the growth parameters of maize viz. plant height, shoot length, fresh and dry weight of shoot plant^{-1} (Table 1). However, statistically insignificant but positive effects of moringa leaf extract were observed in number of leaves plant^{-1}, root length and fresh weight and dry weight of root plant^{-1} (Table 1). The highest values for plant height (222.7 cm), shoot length (187 cm), fresh weight of shoot plant^{-1} (386 g) and dry weight of shoot plant^{-1} (189 g) were recorded from treatment T_5 where moringa extract was sprayed at 2 weeks after emergence and at every 2 weeks thereafter. The lowest values for plant height (199.2 cm), shoot length (174.6 cm), fresh weight of shoot plant^{-1} (360 g) and dry weight of shoot plant^{-1} (161.3 g) were obtained from control treatments where no moringa leaf extract was applied (T_1 and/or T_2). All the growth parameters were increased with the increase of the frequency of moringa leaf extract application. Our finding is accorded with few previous reports (Ali *et al.,* 2011; Abbas *et al.,* 2013 and Chattha *et al.,* 2015), where suggested that application of moringa leaf extract can enhance the growth rate, number of leaves plant^{-1}, plant height, shoot and root length and fresh weight and dry weight of shoot and root of maize. Previously Foidle (2001) revealed that spraying of moringa leaf extract to many field crops can strengthen plants, promote the vegetative growth and increase the weight of root and shoot.

Effect of moringa leaf extract on yield components of maize

Yield components of maize including number of grains cob^{-1}, 100-grain weight and grain weight plant^{-1} were significantly affected by different treatments while the length and diameter of cob and number of

grains column^{-1} remained significantly unaffected (Table 2). Similar with the results for growth parameters, the yield components of maize improved with the frequency of applying moringa leaf extract. The performance of treatment T_5 (moringa extract sprayed at 2 weeks after emergence and after every two weeks thereafter) was the best as it produced the highest number of grains cob^{-1} (589), 100-grain weight (28.66 g) and grain weight plant^{-1} (171.23 g). For all the yield components, the performances of the control treatments (T_1 and T_2) were poor.

Table 1. Growth parameters of maize under different treatments

Treatments	Plant height (cm)	Number of leaves plant^{-1}	Root length (cm)	Shoot length (cm)	Fresh wt of root plant^{-1}(g)	Fresh wt of shoot plant^{-1}(g)	Dry wt of root plant^{-1}(g)	Dry wt of shoot plant^{-1}(g)
T_1	199.3b	10.60	37.6	175b	70.3	360c	25.40	161.4c
T_2	199.2b	10.53	37.3	174.6b	70.6	360.3c	25.77	161.3c
T_3	205.2b	10.93	39.6	178b	73.3	375 b	26.53	178ab
T_4	210.9ab	10.93	40	178.6b	75	383a	27.80	182.6ab
T_5	222.7a	11	40.3	187a	75.3	386a	28.07	189a
Level of significance	*	NS	NS	*	NS	**	NS	*
CV (%)	5.08	3.77	5.27	3.28	3.64	4.13	7.89	5.17

Figures in a column having common letter(s) do not differ significantly, CV = Co-efficient of variation, NS = Non significant, * = Significant at 5% level of probability, ** = Significant at 1% level of probability, T_1=Control-with no moringa leaf extract added, T_2=Water sprayed at every 2 weeks, starting from 2 weeks after emergence, T_3= Moringa leaf extract sprayed at 2 weeks after emergence, T_4= Moringa leaf extract sprayed at 2 weeks and 4 weeks after emergence, T_5= Moringa leaf extract sprayed at 2 weeks after emergence and after every two weeks thereafter.

Our results are also in agreement with Chatta *et al.* (2015) reported that the increase in grain weight plant^{-1} due to application of moringa leaf extract. Mehboob (2011) also reported similar results in case of number of grains column^{-1} and number of grains cob^{-1} in maize. Yasmeen *et al.* (2011) and Anyaegbu *et al.* (2013) also found increase in 100-grain weight and grain weight plant^{-1} in wheat and *Telfaria occidentalis* due to application of moringa leaf extract.

Table 2. Yield parameters of maize under different treatments

Treatments	Cob length (cm)	Cob Diameter (cm)	Number of grains column^{-1}	Number of grains cob^{-1}	100-grain weight (g)	Grain weight plant^{-1} (g)
T_1	20.20	17.00	33.53	493 d	23.60 b	116.83 c
T_2	20.33	17.06	33.83	494 d	24.17 b	121.07 c
T_3	21.20	17.13	35.07	546 c	27.17 a	148.23 b
T_4	21.33	17.20	35.70	562 b	27.80 a	157.53 b
T_5	21.83	17.57	37.30	589 a	28.66 a	171.23 a
Level of significance	NS	NS	NS	**	**	**
CV (%)	3.82	3.51	7.00	5.04	3.78	4.77

Figures in a column having common letter(s) do not differ significantly, CV = Co-efficient of variation, NS = Non significant, * = Significant at 5% level of probability, ** = Significant at 1% level of probability, T_1=Control-with no moringa extract added, T_2=Water sprayed at every 2 weeks, starting from 2 weeks after emergence, T_3= Moringa extract sprayed at 2 weeks after emergence, T_4= Moringa extract sprayed at 2 weeks and 4 weeks after emergence, T_5= Moringa extract sprayed at 2 weeks after emergence and after every two weeks thereafter.

Effect of moringa leaf extract on yield of maize

The result of this study reveals that the grain yield, stover yield and harvest index of maize were significantly influenced due to application of moringa leaf extract. The grain yield ranged from 6.3 to 9.2 t ha^{-1} whereas the stover yield ranged from 8.6 to 10.1 t ha^{-1}. For both grain and straw yields, the maximum values were observed in treatment T_5 (moringa extract sprayed at 2 weeks after emergence and after every two weeks thereafter) and the minimum values were found in control treatments (T_1 and/or T_2). The highest grain and straw yields as found in T_5 were statistically similar to the yields obtained in T_4 and T_3 treatments. For grain yield as well as straw yield, different treatments may be ranked in the order of $T_5>T_4>T_3>T_2>T_1$. Furthermore, the harvest index obtained from T_5 was the highest (48%) which was not statistically different from those found in T_4 (47%) and T_3 (45%). The harvest index obtained from T_1 (42%) was the lowest. These findings corroborate with the results of Mvumi *et al.* (2013) and Mehboob (2011) who reported increased grain and stover yield in maize by applying moringa leaf extract. Abbas *et al*. (2013) recorded minimum biological yield (10.17 t ha^{-1}) in control treatment and the highest (11.07 t ha^{-1}) in 20% moringa leaf extract application. Hussain (2010) noted that the mixture of moringa and canola extracts sprayed at 30 and 40 DAS increased grain yield of maize by 83%.

Correlation between grain yield and plant parameters

Yield is a complex character resulting from the interaction of various plant characters and for maize such parameters include plant height, weight of shoot, weight of root, number of grains cob^{-1}, grain weight $plant^{-1}$, 100-grain weight etc. The correlation matrix between grain yield and growth characters of maize are summarized in Table 4. Grain yield had significant positive correlation with plant height (r = 0.856**), number of leaves $plant^{-1}$ (r = 0.500*), root length (r = 0.632*), shoot length (r = 0.683*), fresh weight of root (r = 0.710**), fresh weight of shoot (r = 0.919**), dry weight of root (r = 0.606*) and dry weight of shoot (r = 0.932**). Again, Table 5 indicates the correlation matrix between grain yield and yield parameters of maize. Grain yield had non-significant positive relation with cob diameter (r = 0.289^{NS}) but significant positive relation with cob length (r = 0.756**), number of grains $column^{-1}$ (r = 0.531*), number of grains cob^{-1} (r = 0.950**), 100-grain weight (r = 0.979**) and grain weight $plant^{-1}$ (r = 0.999**).

Table 3. Effect of moringa leaf extract on the yield of maize

Treatments	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Harvest index (%)
T_1	6.3b	8.6b	42b
T_2	6.4b	8.6b	43b
T_3	7.9a	9.5ab	45ab
T_4	8.5a	9.7a	47a
T_5	9.2a	10.1a	48a
Level of significance	**	*	-
CV (%)	5.05	5.94	4.09

Figures in a column having common letter(s) do not differ significantly, CV = Co-efficient of variation, NS = Non significant, * = Significant at 5% level of probability, **=Significant at 1% level of probability, SE = Standard error of means, T_1= Control-with no moringa extract added, T_2= Water sprayed at every 2 weeks, starting from 2 weeks after emergence, T_3= Moringa extract sprayed at 2 weeks after emergence, T_4= Moringa extract sprayed at 2 weeks and 4 weeks after emergence, T_5= Moringa extract sprayed at 2 weeks after emergence and after every two weeks thereafter.

The present study suggests that the use of moringa leaf extract as a foliar spray will enhance the growth and yield of maize and that spraying is required during the whole vegetative stage of plant with 2 weeks interval. Increase in grain yield due to frequent application of moringa leaf extract was mainly due to the improvement of growth parameters like plant height, shoot length, fresh and dry weight of shoot and yield components like number of grains cob^{-1}, 100-grain weight and grain weight $plant^{-1}$. Importantly, it was zeatin, a cytokinin related hormone in the extract, which was responsible for the improved growth and yield as suggested by some researchers (Mvumi *et al*., 2013; Abdalla, 2013). This study recommends the application of moringa

leaf extract at 2 weeks after emergence and at every 2 weeks thereafter until flowering for better growth and yield of maize crop grown in soil under AEZ 9 (Old Brahmaputra Floodplain) of Bangladesh.

Table 4. Correlation matrix between grain yield and growth parameters of maize

Characters	Plant height (cm)	Number of leaves plant^{-1}	Root length (cm)	Shoot length (cm)	Fresh wt of root plant^{-1} (g)	Fresh wt of shoot plant^{-1} (g)	Dry wt of root plant^{-1} (g)	Dry wt of shoot plant^{-1} (g)	Grain yield (t ha^{-1})
Number of leaves plant^{-1}	0.608*								
Root length (cm)	0.388^{NS}	0.017^{NS}							
Shoot length (cm)	0.627*	0.006^{NS}	0.410^{NS}						
Fresh weight of root (g)	0.573*	0.390^{NS}	0.730**	0.417^{NS}					
Fresh weight of shoot (g)	0.728**	0.517*	0.573*	0.563*	0.652*				
Dry weight of root (g)	0.530*	0.371^{NS}	0.658*	0.251^{NS}	0.578*	0.456^{NS}			
Dry weight of shoot (g)	0.741**	0.352^{NS}	0.570*	0.791**	0.578*	0.919**	0.372^{NS}		
Grain yield (t ha^{-1})	0.856**	0.500*	0.632*	0.683*	0.710**	0.919**	0.606*	0.932**	

* Indicates significant at 5% level of probability, ** Indicates significant at 1% level of probability, NS indicates non-significant

Table 5. Correlation matrix between grain yield and yield parameters of maize

Characters	Cob length (cm)	Cob diameter (cm)	Number of grains column^{-1}	Number of grains cob^{-1}	100-grain weight (g)	Grain weight plant^{-1} (g)	Grain yield (t ha^{-1})
Cob diameter (cm)	0.350^{NS}						
Number of grains column^{-1}	0.618*	0.504*					
Number of grains cob^{-1}	0.673*	0.293^{NS}	0.407^{NS}				
100-grain weight (g)	0.735**	0.206^{NS}	0.528*	0.889**			
Grain weight plant^{-1}	0.760**	0.287^{NS}	0.533*	0.953**	0.978**		
Grain yield (t ha^{-1})	0.756**	0.289^{NS}	0.531*	0.950**	0.979**	0.999**	

* Indicates significant at 5% level of probability, **Indicates significant at 1% level of probability, NS indicates non-significant

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