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Research Article

Effect of Moringa Extract on Growth and Yield of Maize and Common Beans

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ABSTRACT

An evaluation on the potential benefit of using *Moringa oleifera* leaf extract as a growth hormone on common beans (*Phaseolus vulgaris*) and maize (*Zea mays*) was done. Trials were carried out in the greenhouse and field. In the greenhouse, five treatments were used: control (M0, only water applied), second control (ME, only ethanol applied), moringa extract (in 80% ethanol) applied (on leaves) once at 2 weeks from emergence (M1), moringa extract applied at 2 and 4 weeks from emergence (M2), and moringa extract applied every 2 weeks to maturity from two weeks from germination (M3). The same treatments were adopted in the field except ME, which was considered unnecessary after observing the results of the greenhouse experiment. Results showed that moringa extract increased growth and yield of beans in both greenhouse and field, and of maize in the field. However, the extract showed no significant effect on DM yield, root DM or plant height of maize in the greenhouse. The highest DM and root weight, height and crop yields in greenhouse and field experiments for beans, and for maize in the field only, were obtained at M3. The study recommends the application of extract at M3.

INTRODUCTION

Maize and beans are important crops for the supply of human nutritional requirements. These two types of basic food nutritionally complement each other. When each component provides about 50 percent of the protein in the diet a high quality is obtained, higher than the individual qualities of the components alone, but according to reports by Stock (2004), half of the countries of Africa South of the Sahara were designated by FAO as having short supply of these grain/seed. This has caused notable food shortages. In Sub-Saharan Africa, one of the constraints to sustained production of these crops is lack of hormonal application. This leads to poor plant growth which results in decline in agricultural food production.

Plant hormones can be used to increase yield because they influence every phase of plant growth and development. Traditionally, there are five groups of growth which are listed: auxins, gibberellins, abscisic acid, ethylene and cytokinins (Prosecus, 2006). For the most part, each group contains both naturally occurring hormones and synthetic substances. Cytokinins regulate cell division and stimulate leaf expansion (Prosecus, 2006). Cytokinins enhance food production as they are involved in cell growth and differentiation, and their exogenous supply delays senescence of crop plants. Zeatin is one form of the most common forms of naturally occurring cytokinin in plants. Fresh *Moringa oleifera* leaves have been shown to have zeatin, a cytokinin related hormone Fuglie (2000). Moringa leaves sampled from various parts of the world were found to have high zeatin concentrations of between 5 µg and 200 µg/g of leaves (El Awady, 2003).

Moringa leaf extract was sprayed onto leaves of onions, bell pepper, soyabeans, sorghum, coffee, tea, chilli, melon and maize and was shown to increase yields of these crops (Fuglie, 2000). If moringa extract can increase yields, then the potential benefit to the smallholder farmers in Africa would be great because moringa can be locally available. *Moringa oleifera* leaf extract is low-cost and environmentally friendly (**Noaman et al., 2010). However,** the effect of moringa extract on other crops is unknown.

The objective of the study was to test effect of moringa extract on growth and development of maize and the common bean.

The hypothesis of this research was application of moringa extract to common beans (*Phaseolus vulgaris* L) and maize (*Zea mays* L) can increase the growth and yield of these crops.

MATERIALS AND METHODS

The effect of applying *Moringa oleifera* leaf extract on two crops was evaluated in the greenhouse and in the field at Africa University (AU) from November 2006 to March 2007.

Greenhouse Experiment

Three crops were planted in black polythene bags containing 10 kg of soil. The soil used was loamy orthoferralitic soils, 7E (Nyamapfene, 1991). This was red loamy type of soil. The chemical characteristics of the soil are presented in Table 1.

Table 1: Chemical characteristics of the soil used for the greenhouse and field experiments at Africa University (AU) from November 2006-March 2007.

------Nutrient level in the soil----------pH	Ca	Mg	K	TEB	P	Total N
($CaCl_2$ scale)----------me %----------					(ppm)	(%)
5.1	8.57	5.15	0.70	14.42	18.5	0.12

Total N was also considered. It is the sum of nitrate-nitrogen (NO_3^- N), nitrite-nitrogen (NO_2^- N), ammonia-nitrogen (NH_3^- N) and organically bonded nitrogen.

The two crops used were common beans and maize. Each crop was tested as an independent experiment. The following treatments were imposed on each crop:

1. Control-with no moringa extract added (M0).
2. Control- 80 % ethanol sprayed (onto the leaves) at every 2 weeks, starting from 2 weeks after emergence (ME).
3. Moringa extract sprayed at 2 weeks after emergence (seedling stage) (M1).
4. Moringa extract sprayed at 2 weeks and 4 weeks after emergence (M2).
5. Moringa extract sprayed 2 weeks after emergence and after every two weeks thereafter (M3).

The alcohol control was added to establish if its use in the extract had any effect on the growth of the plants.

The design was a Randomized Complete Block Design (RCBD) with three replicates.

Below were the fertilizer rates used per crop.

Maize: The fertilizer rates used were 35 kg N/ha (0.46 g AN/10kg soil), 50 kg P_2O_5/ha (0.23 g SSP/10 kg soil) and 25 kg K_2O/ha (0.23 g sulphate of potash/10 kg soil). Maize received one top-dressing of 86 kg N/ha (1.14 g AN/10kg soil), at 4 weeks only.

Beans: Fertilizer rates of beans were 28 kg N /ha (0.37 g AN/10 kg soil), 64 kg P_2O_5/ha (1.53 g SSP/10 kg soil) and 20 kg K_2O/ha (0.18 g sulphate of potash/10 kg soil). Four seeds were directly sown into the bags at a depth of 2.5 cm. The plants were thinned to two plants per bag two weeks after emergence. Water was applied uniformly to each bag of each crop after every 3 days when the soil looked dry. All bags were kept weed free. Pests were controlled using Carbaryl 85 % WP applied at 20 g per 10 litres to control leaf eating pests and copper oxychloride at 50 g per 10 litres of water to prevent any fungal diseases which may attack common beans. The two chemicals were applied after every 7 days.

Preparation of moringa extract

Moringa plants were raised through direct seeding in the field at Africa University farm to get plants with correct leaf ages to use for deriving the extract. As the plants were growing, new shoots were harvested at 35 days after emergence. An amount of 20 g of young moringa leaves was mixed with 675 ml of 80 % ethanol as suggested by (Makker and Becker, 1996). The suspension was ground and stirred using a homogenizer to help maximize the amount of the extract. The solution was then filtered by wringing the solution using a mutton cloth. The solution was re-filtered using No. 2 Whatman filter paper. Using 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 plants. The extract was used within five hours from cutting and extracting (if not ready to be used, the extract or the solution prepared was stored at 0 ^{0}C and only taken out when needed for use).

An amount of 25 ml (application rate) of the solution was applied per plant in the greenhouse.

Variables measured

Plant height, root dry matter weight and above ground dry matter were measured.

Data analysis

Analysis of variance (ANOVA) was done using Genstat, version 4.2.

Field experiment

Three crops were planted in plots which were 1.8 m long by 1.8 m wide, giving an area of 3.24 m^2. The two crops evaluated were common beans and maize.

The following treatments were applied:
1. Control-no moringa extract added (M0).
2. Moringa extract sprayed at 2 weeks after transplanting (M1).
3. Moringa extract sprayed at 2 weeks and 4 weeks after transplanting (M2).
4. Moringa sprayed after every 2 weeks up to physiological maturity, starting from two weeks after transplanting (M3).

The control in which ethanol 80 % (ME) was applied alone was not included. It was proved not significantly different from water during the greenhouse experiment in which both the ethanol 80 % (ME) and water (M0) were used as controls during the test for each crop.
The design was a RCBD with three replicates.

Fertilizer rates used

The fertilizer rates used at planting were equivalent to those used in the greenhouse experiment except the following additions or changes.

Maize: The top-dressing was a split application: at 4 weeks (knee height) and at 8 weeks (at flowering).

Beans: Refer to rates used in the greenhouse experiment.
All the other agronomic operations were similar to those described in the greenhouse study.

Moringa extract

Moringa extract for the field experiment was prepared and applied as described for the greenhouse experiment.
Variables measured

Maize: The measurements taken for maize were plant height at maturity in the same manner the greenhouse maize

plants were measured, grain yield (in kilograms) and shelling percentage. The maize yield was measured at a moisture content of 12 %.

Common beans: Grain yield as dry beans was the measurement taken in kilograms, at a moisture content of 15 %.

Data analysis

Analysis of variance (ANOVA) was done using Genstat, version 4.2.

RESULTS

Greenhouse Experiment

Effect of moringa extract on growth and yield

Parameters

Beans

Considering the LSD, M0, ME, M1 and M2 had no significant effect on total DM yield, root dry weight and height of beans. However, application of moringa every two weeks up to harvest (M3) significantly ($p<0.05$) increased the dry matter weight of beans by 90 % and the root weight by 85 %. Spraying moringa extract at 2 and 4 weeks after germination (M2) and at every two weeks up to harvest significantly increased plant height by 37 %.

Maize

Analysis of variance for DM, root weight and crop height of greenhouse maize plants revealed that the moringa extract had no significant effect ($p>0.05$) on all the parameters measured and the moringa extract treatments were not significantly different (Table 3).
Root weight results were varied, but none was statistically different.

Field Experiment

Beans

From the analysis shown, using the LSD, results of common beans (Table 4) showed that there was no significant difference between the control where no extract was added (M0), and the treatment where moringa extract was applied once at 2 weeks after emergence (M1). All the moringa extract treatments significantly increased bean seed yield. However, there was no significant difference between applying the extract once at 2 weeks after germination (M1) and applying at 2 and 4 weeks (M2). M1 and M3 significantly ($p<0.05$) increased bean seed yield by 41 % and 145 % respectively.
Comparatively, spraying moringa extract every two weeks showed the highest yield.

Maize

All the moringa extract treatments significantly ($p<0.05$) increased the grain yield of maize plants (Table 5). Spraying moringa extract once at 2 weeks after germination (M1) increased the grain yield by 59 %; spraying at 2 and 4 weeks by 52 % while spraying every 2 two weeks up to physiological maturity increased the maize grain yield by 128 %. The control, where no extract was applied (M0) had lowest shelling percentage (81.0 %). Shelling percentage was not significantly ($p>0.05$) increased when one moringa extract spray was done (M1), unlike when the extract was applied at 2 and 4 weeks (M2) and every two weeks up to physiological maturity. The highest shelling percentage (88.6 %) was obtained by spraying moringa extract every two weeks up to physiological maturity.

Table 2: Mean above ground dry matter, root dry matter yield and plant height at 49 days after planting for common bean plants treated with moringa extract in the greenhouse.

Treatment	Total DM yield (g/bag)	Root dry weight (g/bag)	Height (cm)
M0	17.1	7.7	31.0
ME	13.1	10.7	31.0
M1	24.8	10.6	37.0
M2	24.6	13.0	42.7
M3	32.5	21.1	42.7
Mean	22.4	12.6	0.4
SE±	4.4	4.0	0.07
P	**	*	*
$LSD_{(0.05)}$	8.4	7.6	17.7
CV (%)	19.8	32.1	12.9

*, ** Significant at P=0.05, P=0.01 respectively. M0=control-with no moringa added, ME=control-80 % ethanol sprayed every 2 weeks starting from 2 weeks after mergence, M=moringa extract sprayed 2 weeks after emergence, M2=moringa extract sprayed at 2 weeks and 4 weeks after emergence, M3=moringa extract sprayed 2 weeks after emergence and after every two weeks thereafter.

Table 3: Mean above ground dry matter, root dry matter yield and mean plant height at 49 days after planting for maize plants treated with moringa extract in the greenhouse.

Treatment	DM yield (g/bag)	Root dry weight (g/bag)	Height (cm)
M0	76.6	56.1	147
ME	77.2	34.4	148
M1	88.1	57.8	155
M2	83.7	58.1	156
M3	92.7	61.7	154
Mean	83.7	53.6	152
SE±	6.9	22	13
P	(NS)	(NS)	(NS)
$LSD_{(0.05)}$	13.1	42.2	9.2
CV (%)	8.3	41.1	26

NS=Not significant at P=0.05. M0=control-with no moringa added, ME= control-80 % ethanol sprayed every 2 weeks starting from 2 weeks after mergence, M=moringa extract sprayed 2 weeks after emergence, M2=moringa extract sprayed at 2 weeks and 4 weeks after emergence, M3=moringa extract sprayed 2 weeks after emergence and after every two weeks thereafter.

Table 4: Mean bean seed yield (t/ha) for plants treated with moringa extract in the field.

Treatment	Bean seed yield (t/ha)
M0	0.3
M1	0.4
M2	0.6
M3	0.8
Mean	0.5
SE±	0.1
P	**
LSD $_{(0.05)}$	0.2
CV (%)	14.8

** Significant at P=0.01. M0=control-no moringa extract added, M1=moringa extract sprayed at 2 weeks after emergence, M2=Moringa extract sprayed at 2 weeks and 4 weeks after emergence, M3=Moringa extract sprayed every 2 weeks up to physiological maturity, starting from two weeks after emergence.

Table 5: Mean grain yield (t/ha), shelling percentage and plant height of maize treated with moringa.

Treatment	Grain yields t/ha	Shelling %	Plant height (m)
M0	5.6	81.0	2.6
M1	8.9	83.2	2.9
M2	9.9	84.9	3.2
M3	12.8	88.6	3.6
Mean	9.3	84.4	3.0
SE±	1.0	1.4	0.2
P	***	**	***
$LSD_{(0.05)}$	1.6	2.8	0.3
CV (%)	8.5	1.6	5.0

, * Significant at P=0.01, P=0.001 respectively. M0=control-no moringa extract added, M1=moringa extract sprayed at 2 weeks after emergence, M2=Moringa extract sprayed at 2 weeks and 4 weeks after emergence, M3=Moringa extract sprayed every 2 weeks up to physiological maturity, starting from two weeks after emergence.

DISCUSSION

There was no response to moringa extract by maize in the greenhouse. This study is contrary to findings by Fuglie (2000) who reported that application of moringa

extract increased maize growth. There are some known physiological effects caused by the application of hormones like cytokinin which depend on the type of cytokinin and crop species (Salisbury and Ross, 1992**; Davies, 1995).** Similarly, exogenous application of moringa extract causes responses which can vary depending on the plant species.

Responses also depend on the cultural practices and the environmental conditions under which the crop is growing. Fuglie (2000) showed that to get the optimum results from the foliar spray of moringa leaf extract to crops, it should be used in addition to (and not in lieu of) fertilizers, watering and sound agricultural practices. The soil nutrient status is complementary to the effectiveness of moringa extract sprays**.**

In this study, the potted maize plants could have depleted the nutrients which were in the pots, due to the small pot size, which led to nutrient stress. They were tall and spindly. So, in this crop study, the non significant effect of moringa extract on root weight, plant height and dry matter weight of maize is associated with adverse environmental factors in which the maize plants were growing.

There were differences between greenhouse and field results for maize. In the greenhouse, all the variables measured were non significant, contrary to field where all the variables were significant with M3 showing the highest significance.

The bean yield obtained in this trial involving common beans was generally low (0.317 t/ha) as compared with those quoted in literature. Yields in the Sub-Saharan Africa range between 2 and 8 t/ha, and 14 t/ha in commercial sectors depending on the environmental conditions (Bose et al., 1993). As proved in the maize greenhouse experiment, the low yield of beans could be associated to poor soil fertility and other environmental conditions. However, **application of moringa extract increased the yield by nearly 100% in the greenhouse experiment and more than 100% in the field**. El Awady (2003) pointed out that in moringa, there is zeatin hormone in very high concentrations of between 5 mcg and 200 mcg/g of material. Fuglie (2000) confirmed that this cytokinin (CK) related hormone increases crop yields when sprayed as an extract from fresh moringa leaves.

CONCLUSION AND RECOMMENDATIONS

This study showed that use of moringa leaf extract as a growth hormone will increase crop growth and yields. The extract also showed potential of increasing root growth and plant height of common beans and maize. It was zeatin, a cytokinin related hormone in the extract, which was responsible for the improved growth and yields.

The lack of response of maize in these growth parameters was thought to be due to depletion of soil fertility in the pots, due to the small pot size, which led to nutrient stress.

Under field conditions, moringa extract increased yields of the two crops tested. The applications of M1 to M3 gave yield increases, which ranged from 20-150%. The higher the frequency of moringa application, the greater the increase in plant height, dry matter and yield of the crops. The highest frequency of moringa application (M3) gave the highest yield. Of the two crops, maize showed greater response to moringa extract in terms of yield. The percentage increases in yields for maize in the field through moringa extract application at M3, was 128% while the percentage increase for common beans was more than 100%.

From the results of both the greenhouse and field experiments, it is concluded that increase in crop yields in response to moringa extract treatment depends on the frequency of spraying and the type of crop species. The higher the frequency of application, the higher the yield. The results show that moringa extract is a technology that has great potential. Additional research is needed to determine the rate of moringa application that will give optimum yield.

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