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Full Length Research Paper

Effect of *Moringa oleifera* leaf aqueous extract on growth and yield of rape and cabbage

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The potential effect of *Moringa oleifera* leaf extract on growth and yield of cabbage (*Brassica oleracia* L. var. *capitata*) and rape (*Brassica napus* L. var. Giant rape) was evaluated. In the greenhouse, five treatments were used: the control, where only water was added (M0), second control where ethanol 80% was added (ME), *Moringa* leaf extract applied once at two weeks from emergence (M1), *Moringa* leaf extract applied at two and four weeks from emergence (M2), and *Moringa* extract applied every two weeks to maturity, starting from two weeks from germination (M3). The same treatments were adopted in the field except the ME which was considered unnecessary after observing the results of the greenhouse experiment. Results show that *Moringa* leaf extract significantly increased above ground dry matter yield (DM), root dry matter weight and plant height for the two crops. Yields obtained at MI, M2 and M3 were increasing in ascending order from M1. Highest DM, root weight, height and crop yields in the greenhouse and field experiments were obtained at M3. The study recommends the application of extract at M3.

Key words: *Moringa oleifera*, dry matter, cabbage, rape, greenhouse.

INTRODUCTION

Vegetables are important crops for additional supply of human nutritional requirements. Temu and Temu (2005) described vegetables, which include rape and cabbage as high-value crops which have high nutritive value. In particular, they are high in vitamins, minerals and fibre but according to reports by Stock (2004), half of the Sub-Saharan countries were designated by Food and Agricultural Organisation (FAO) as having short supply of these crops. One of the constraints to sustained production of rape and cabbage in this region 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 per unit area because they influence every phase of plant growth and development. Traditionally, there are five groups of growth regulators which are listed: auxins, gibberellins, abscisic acid, ethylene and cytokinins (Prosecus, 2006); cytokinins enhance food production. Zeatin is one form of the most common forms of naturally occurring cytokinin in plants. Fresh *Moringa oleifera* leaves have been shown to have high zeatin content. *Moringa* leaves gathered from various parts of the world were found to have high zeatin concentrations of between 5 mcg and 200 mcg/g of leaves (El-Awady, 2003).

Moringa leaf extract was sprayed onto leaves of onions, bell pepper, soyabeans, sorghum, coffee, tea, chilli, melon, 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. The effect of *Moringa* extract on other crops is unknown.

The aim and objective of this study was to test the effect of *Moringa* extract on growth and development of cabbage and rape. The hypothesis of this research, the application of *Moringa* extract to rape (*Brassica napus* L. var. Giant rape) and cabbage (*Brassica oleracea* L. var.

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Abbreviations: AN, Ammonium nitrate; **DM,** dry matter; **FAO,** Food and Agricultural Organization; **SSP,** single super phosphate; **TEB,** total exchangeable bases; **WP,** wettable powder.

Table 1. Chemical characteristics of the soil used at Africa University (AU) during the 2006 to 2007 cropping season.

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

capitata L.), can increase the growth and yield of these crops.

MATERIALS AND METHODS

The effect of applying *Moringa* extract on three crops was evaluated in the greenhouse and in the field at Africa University (AU) during the 2006 to 2007 rainy season. The soil used was loamy orthoferralitic soils, 7E (Nyamapfene, 1991).

Greenhouse experiment

Three crops were planted in black polythene bags containing 10 kg of soil. The soil type was red loamy. The chemical characteristics of the soil are presented in Table 1. The two crops used were: rape (*B. napus* L.) and cabbage (*B. oleracea* L.) var. capitata. 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 at every two weeks, starting from two weeks after emergence (ME), 3) *Moringa* extract sprayed at two weeks after emergence (M1), 4) *Moringa* extract sprayed at two weeks and four weeks after emergence (M2), 5) *Moringa* extract sprayed two 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.

Fertilizer rates used

Rape

Fertilizer rates were 70 kg N/ha (0.92 g ammonium nitrate (AN)/10 kg soil), 160 kg P_2O_5/ha (3.83 g single super phosphate (SSP)/10 kg soil) and 100 kg K_2O/ha (0.45 g sulphate of potash/10kg soil).

Cabbage

The amounts used were 70 kg N/ha (0.92 g AN/10kg soil), 160 kg P_2O_5/ha (3.83 g SSP/10 kg soil) and 100 kg K_2O/ha (0.45 g sulphate of potash/10 kg soil). AN = 34.5% N, SSP = 18% P_2O_5, sulphate of potash = 50% K_2O_5.

The seed was directly sown into the pots at a depth of 1.5 cm for the two vegetable crops. Four seeds were planted per pot. The plants were thinned to two plants per pot, two weeks after emergence. Water was applied according to the requirements of each crop. All pots were kept weed free. Pests were controlled using carbaryl 85% WP applied every 7 days at 20 g per 10 litres to control leaf eating pests.

Preparation of *Moringa* extract

Moringa plants were planted through direct seeding in the field at Africa University farm to raise plants with appropriate 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 Makkar and Becker (1996). The suspension was 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 a method developed by Fuglie (2000), the extract was diluted with distilled water at a ratio 1:32 (v/v) and then sprayed directly onto plants. The extract was used within 5 h from cutting and extracting (if not ready to be used, the extract or the solution prepared was stored at 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.

Field experiment

Three crops were planted in plots which were 1.8 m long and 1.8 m wide, giving an area of 3.24 m^2. The chemical characteristics of the soil used were the same as those presented in Table 1. The two crops evaluated were: rape (cultivar Giant rape) and cabbage (cultivar Sugarloaf).

The treatments applied were the same with those applied in the greenhouse, except that 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.

Rape

Top-dressing fertilizer was AN, applied to rape at a rate of 34.5 kg N/ha (32.4 g AN/plot), two times at three week interval from two weeks after transplanting.

Cabbage

An amount of 34.5 kg N/ha (32.4 g AN/plot) was applied as topdressing fertilizer, two times at three week interval starting from two weeks after transplanting. All the other agronomic operations were similar to those described in the greenhouse study. The two vegetable crops were planted in the nursery and then transplanted after four weeks. The following spacing were used: 45 cm inter-row × 25 cm in-row for rape and 50 cm inter-row × 45 cm in-row for cabbage.

Table 2. Mean above ground dry matter yield (DM), root dry matter and plant height at 49 days after planting (DAP) for rape plants treated with *Moringa* extract in the greenhouse.

Treatment	Total DM yield (g/pot)	Root dry weight (g/pot)	Height (cm)
M0	29.6	8.1	20.3
ME	31.4	8.5	20.0
M1	37.2	12.0	24.3
M2	39.3	16.3	31.6
M3	45.9	22.7	45.3
Mean	37.7	13.5	28.3
SE±	4.2	4.26	3.8
P	*	*	***
$LSD_{(0.05)}$	11.3	8.03	7.2
CV (%)	7.8	31.5	13.4

*, ***Significant at P = 0.05, 0.001, respectively. M0, Control, with no *Moringa* added; ME, control, 80% ethanol sprayed every two weeks starting from two weeks after emergence; M, *Moringa* extract sprayed two weeks after emergence; M2, *Moringa* extract sprayed at two and four weeks after emergence; M3, *Moringa* extract sprayed two weeks after emergence and after every two weeks thereafter.

Moringa extract

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

Soil and statistical data analysis

Soil used was first analyzed (Nyamapfene, 1991). Data for growth and yields of the two crops were taken, recorded and then subjected to analysis of variance (ANOVA) using Genstat, version 4.2.

RESULTS

Greenhouse experiment

There was no significant difference between the control, where no extract was applied (M0), and the treatment where only alcohol was applied (ME) (Table 2). All *Moringa* extract treatments significantly (P<0.05) increased dry matter yield of the rape plants. Applying *Moringa* spray at two weeks after germination (M1), at two and four weeks after germination (M2), every two weeks up to harvest (M3) increased rape dry matter yields by 26, 32 and 55%, respectively, compared to applying no *Moringa* extract. The root weight increase of M3 was 180% compared to that of the control. *Moringa* extract applied at two and four weeks after emergence (M2) and every two weeks up to harvest (M3) significantly increased plant height by 55 and 122%, respectively, compared to where no *Moringa* extract was applied (M0).

The control where no extract was applied (M0), and the treatment where only alcohol was applied (ME), were not significantly different. All the three *Moringa* extract treatments (M1, M2 and M3) used, significantly increased dry matter yield of the cabbage plants. Applying the extract once, at two weeks after germination (M1) resulted in 33% increase in plant biomass, application at 2 and 4 weeks after germination gave 31% and every two weeks 52% increase in biomass compared with the control. The differences in dry matter yield between the three *Moringa* treatments were however not significantly different. There was no significant difference in root weight between the control and one spray at two weeks after germination (M1) and spraying at two and four weeks after germination (M2). Spraying the extract every two weeks up to harvest had a significant ($p < 0.05$) effect on root weight. When compared with the control, the increase was 224% (Figure 1).

Field experiment

Applying *Moringa* extract once at two weeks after germination (M1) significantly ($p < 0.05$) increased rape fresh yield and dry matter yield by 39 and 47%, respectively (Table 3).

However, there was no significant difference between applying once at two weeks (M1) and applying at two weeks and four weeks (M2). Applying the extract every two weeks up to physiological maturity significantly increased fresh leaf yield and dry matter yield by 70 and 90%, respectively. Table 4 shows that the effect of *Moringa* extract on cabbage head yield showed no significant difference ($P > 0.05$) between the control, and the treatment with only one application of the extract at two weeks after transplanting. Higher application frequency (of every two weeks) up to physiological maturity resulted in highly significant yield. Plants sprayed with *Moringa* extract every two weeks were the most vigorous in growth. There was no significant difference between applying the extract at two and four weeks (M2) and applying every two weeks up to and four weeks after germination increased head yield by

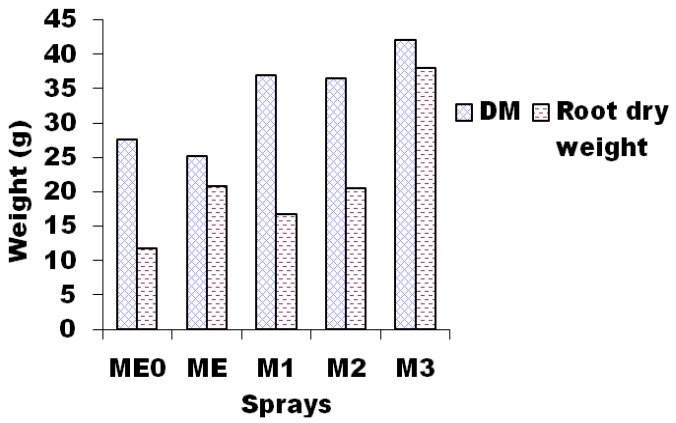

Figure 1. Cabbage above ground DM yield and root dry weight response to *Moringa* extract foliar spray in the greenhouse.

Table 3. Mean leaf fresh weight (t/ha) mean dry matter (DM) for rape plants treated with *Moringa* extract in the field.

Treatment	Fresh weight (t/ha)	DM (t/ha)
M0	50.4	3.2
M1	67.7	4.7
M2	74.4	5.4
M3	87.5	6.1
Mean	70.0	4.8
SE±	6.1	0.4
P	**	***
$LSD_{(0.05)}$	11.3	8.0
CV (%)	8.6	7.6

**, ***Significant at P=0.01, 0.001, respectively.

Table 4. Cabbage heads mean weight (t/ha) at 120 days after planting (DAP) for cabbage plants treated with *Moringa* extract in the field.

Treatment	Head yield (t/ha)
M0	23.9
M1	33.2
M2	48.2
M3	57.9
Mean	40.8
SE±	5.5
P	***
$LSD_{(0.05)}$	10.9
CV (%)	13.3

***Significant at P = 0.01.

physiological maturity (M3). Applying the extract at two52% and applying every two weeks up to physiological maturity increased the yield by 73%.

DISCUSSION

There were similarities in the greenhouse between rape and cabbage results. All *Moringa* extract treatments (M1, M2 and M3) showed significant effect on dry matter (DM) yield of both rape and cabbage in the greenhouse experiment.

Also, M3 had the highest yield increase of DM yield and root weight to both crops in the greenhouse. Application of *Moringa* extract significantly increased dry matter yield, root dry weight and plant height of rape and cabbage. Comparably, root weight percentage increase for rape (180%) was lower than for cabbage (224%).

However, the DM yield percentage increase of rape was higher than that of cabbage. This outcome can be due to 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.

In the greenhouse, cabbage plants sprayed with *Moringa* showed rich green colour and vigour (Figure 2). Similar results were observed by Saupe (2009), who reported that *Moringa* leaf extract promotes chlorophyll synthesis.

In field, cabbage showed that there were no significant differences in yield between the treatments from M0 to M3, although M2 and M3 significantly increased head yield. The non significant difference in yield between M2 and M3 was due to a comparably slower response in growth and head formation of the cabbage plants to *Moringa* extract (M3). Application of *Moringa* extract increased DM yield by nearly 100% in the field for rape, while cabbage head yield percent increase was 73% in 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

The extract showed the potential of increasing root growth, plant height and leaf/head yield of rape and cabbage. Zeatin, a hormone in *Moringa* extract, is thought to be responsible.

From the results of both the greenhouse and field experiments, it may be concluded that the higher the frequency of *Moringa* application, the greater the increase in plant height, dry matter and yield of the crops. The study recommends the application of extract at M3.

(a) (b)

Figure 2. In the greenhouse, (a) cabbage treated with *Moringa* extract showing an increased height and greener colour; (b) cabbage not treated with *Moringa* (but alcohol or water only) lacks vigour and the rich green colour.

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