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Effects of Kraal Manure ApplicationRates on Growth and Yield of Wild Okra (*Corchorus olitorius* L) in a Sub-tropical Environment

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Abstract: Wild okra (*Corchorus olitorius* L) is an important indigenous vegetable in Swaziland. Although the crop is a popular vegetable among rural communities, not much has been done to produce organic fertilizer application recommendations for its production. The purpose of this research was to investigate the effects of kraal manure application rates on growth and yield of wild okra. Kraal manure was applied at varying rates of 20, 40 and 60 tons/ha in a Randomized Complete Block Design (RCBD) where 2.3.2 (22) an inorganic fertilizer was used as a control, and was applied at the rate of 150 kg/ha. For every increase in the application level of kraal manure there were significant ($p<0.05$) increases in all the growth parameters that were measured. There were also significant ($p<0.05$) differences of fresh mass and dry mass yield of wild okra. There was an increase in fresh and dry mass yield with every increase in application level of kraal manure while the least fresh and dry mass was recorded in plants provided with 2.3.2 (22). Kraal manure applied at 60 ton/ha gave the highest yield of wild okra under the conditions of this experiment.

Key words: Kraal Manure, Leaf Area Index (LAI), organic farming, wild okra (*Corchorus olitorius* L), yield

INTRODUCTION

Indigenous vegetables are important in human diets. They supply the body with minerals, vitamins and certain hormone precursors in addition to protein and energy (Antia *et al*., 2006; Kader *et al*., 2006; Ekesa *et al*., 2009). Some indigenous vegetables are more nutritious than most popular exotic vegetables. Indigenous vegetables are relatively cheaper than exotic vegetables. Many indigenous vegetables are collected from the wild. The research and development strategies on wild species are fruitful topics in South Africa, encouraging food preservation from the enriched genetic resources (Modi *et al*., 2006; Vorster *et al*., 2008; van Vuuren, 2006).

Corchorus olitorius L., commonly known as wild okra, belongs to the family Tiliaceae. It is widely consumed as a vegetable among rural communities in most parts of Africa (Modi *et al*., 2006; Velempini *et al*., 2003; Masarirambi *et al*., 2010). In West Africa it is commonly cultivated and very popular among people of all classes especially in Nigeria (Oyedele *et al*., 2006; Ekesa *et al*., *2009*). The plant is also eaten in some parts of Asia (Furumuto *et al*., 2002). According to Zakaria *et al*. (2006), wild okra is used in folklore medicine in the treatment of gonorrhoea, chronic cystitis, pain, fever and tumors. *Corchorus olitorius* L is known to contain high levels of iron and folate which are useful for the prevention of anaemia (Oyedele *et al*., 2006). This vegetable is just as nutritious as other common exotic vegetables such as cabbage (*Brassica oleracea*) and spinach (*Spinacea oleracea*) (Ndlovu and Afolayan, 2008). Ecologically, the crop grows more easily in rural subsistence farming systems when compared to exotic species like cabbage and spinach (Schippers, 2000; Modi *et al*., 2006). This makes this vegetable very important to local resource poor communities of Southern Africa in combating hunger and malnutrition (Jansen Van Rensburg *et al*., 2004).

In Swaziland *C. olitorius* L grows in the wild in the Middleveld and some parts of the Lowveld agro-ecological zones. It is mostly eaten by people of lower class. Although the vegetable has the potential to be developed as a valuable crop, very little is known about its role in the overall food acquisition system in different parts of Swaziland especially in relation to its contribution to the intake of important micronutrients.

The cultivation of *C. olitorius* L is not common in Swaziland if there is any taking place; it normally grows as a weed in cultivated land. Women pick it up to make a relish in their homesteads in summer when it is dominant. It usually grows under rain fed conditions and is in competition for light, water and nutrients with the main crop in most cases maize. *C. olitorius* L has a potential to become one of the major vegetables in Swazi households. It can be grown either on its own or intercropped with other common food crops such as maize and sorghum.

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Traditional vegetables could help in finding a long term solution in the fight against modern age diseases such as cancer (Furumuto *et al*., 2002; Zakaria *et al*., 2006; Anon., 2008) HIV and AIDS.

Reducing the synthetic chemical content in foods is a priority of some agricultural researchers as more researches are now being carried out on organic farming. This can be achieved by reducing the use of chemically synthesized inputs. The introduction of organic farming and the increase in demands for organically produced crops can play an important role in reducing chemical residues in food crops. Organic farming is an agricultural practice whereby the use of synthetic fertilizers and pesticides, plant growth regulators and livestock feed additives is excluded in organic farming (Lampkin, 2002; Anonymous, 2008). The role of organic farming in agriculture is to sustain and enhance the health of ecosystems and organisms from the smallest in the soil to human beings (Anonymous, 2008)

In Swaziland the most common organic manure used is kraal manure from cattle because cattle are the most common livestock in the country. It is closely followed by chicken manure then other types such as goat and sheep manure which may be available in smaller quantities. Kraal manure contains most of the nutrients that are required by plants for growth including nitrogen (N), phosphorus (P) and potassium (K). Besides its ability to add nutrients to the soil, kraal manure also significantly improves the soil structure. Addition of kraal manure to the soil improves the ratio of large pore spaces to small pore spaces so that there is gaseous exchange between the soil and the atmosphere and this also helps improve the water holding capacity of the soil (van Averbeke, 1997).

Chemical fertilizers are expensive for many households in Swaziland yet crops do not grow well without fertilizer therefore yields become disappointingly low. After spending hours and days in the garden or field one may rejoice in attaining good yields of their crop but that can only happen when crops are grown on fertile soil. However there is an alternative to the use of chemical fertilizers of which one of them is the use of kraal manure. The objective of the study was to determine the rate of cattle kraal/manure application that produces the highest yield compared to the spinach recommended application rate of 2:3:2(22) at 150 kg/ha fertilizer as basal dressing on the yield and nutritive value of wild okra (*Corchorus olitorius* L.)

Inorganic fertilizers are expensive for home growers of vegetables, especially those that have a low economic value like *C. olitorius* L (*ligusha*) and *Amaranthus hybridus* (*imbuya*). The study aimed at finding the best affordable alternative method of soil fertilization so that home growers can be able to grow these crops at relatively lower cost. Kraal manure is the alternative fertilizer that was studied in this experiment. The use of kraal manure was inspired by the fact that in Swaziland cattle rearing is a tradition. Many Swazis in the rural communities practice this culture of keeping cattle. This means kraal manure is highly accessible in the rural communities and is cheaper than inorganic fertilizer like 2.3.2 (22).

MATERIALS AND METHODS

Experimental site: The research was carried out at the Horticulture Department Farm panel 17, between January and April 2010, Faculty of Agriculture, Luyengo Campus of the University of Swaziland. The farm is located at Luyengo, Manzini Region, on the Middleveld agro-ecological zone. Luyengo is located at 26º34′ S and 31º

BLOCKS	TREATMENTS			
1	Control 2.3.2 (22)	20 tons/ha	40 tons/ha	60 tons/ha
2	40 tons/ha	Control 2.3.2 (22)	60 tons/ha	20 tons/ha
3	60 tons/ha	40 tons/ha	20 tons/ha	Control 2.3.2 (22)
4	20 tons/ha	60 tons/ha	Control 2.3.2 (22)	40 tons/ha

Fig. 1: Field lay-out of the treatments in a randomized complete block design (RCBD)

12′ E.The average altitude of this area is 750 m above sea level. The mean annual precipitation is 980 mm with most of the rain falling between October and April. Drought hazard is about 40%. The average summer temperature is 27ºC and winter temperature is about 15ºC. The soils of Luyengo are classified under Marlkerns series. They are Ferrasolic or merely a Ferralitic soil intergrade to Fersialitic soils or typic Ultisols. The soils in the experimental area are sandy loams (Murdoch, 1970).

Experimental design: The experiment was done using different application rates of kraal manure. Kraal manure treatments were applied at 20, 40 and 60 t/ha while the control used for the experiment was inorganic fertilizer 2.3.2 (22) applied at 150 kg/ha as done for spinach. The treatments were laid down in a completely randomized block design (CRBD). Kraal manure was applied into the soil two weeks before sowing. This was to give it time to naturally breakdown and release nutrients as much as possible so that they would be available to the plants at the time of planting. Broadcasting was used when applying kraal manure to plots. In total there were four treatments including the control distributed across four blocks. Figure 1 is an illustration of the field lay-out of the experiment.

Planting: *C. olitorius* seeds require seed dormancy breaking treatment before they are planted. Seeds can be dormant for several months (Palada and Chang, 2003). There are several methods of breaking seed dormancy in *C. olitorius* seeds. In this experiment seeds were immersed in just-boiled water for ten seconds. Seeds were then allowed to dry overnight. Treated seeds were sown quickly since they cannot be stored (Palada and Chang, 2003). At planting time, seeds were mixed with sand to encourage uniform distribution of seeds in the soil because *C.olitorius* seeds are relatively very small. Spacing between rows was 45 cm. Two weeks after planting seedlings were thinned to allow a spacing of 15 cm between plants in a row. Direct seeding was used to avoid transplanting shock. After planting the plots were irrigated to encourage uniform germination.

Maintenance of experimental site: Irrigation was carried out when there was a need especially after long periods without rain. Sprinklers were used for irrigation. Control of weeds was through cultivation and hand removal. Cultivation also helped to break the soil cap so that water could infiltrate easily into the root zone. It also helped to open up pore spaces so that there was ample gaseous exchange between the soil and the atmosphere.

Data collection: The growth and yield parameters that were collected and used to assess the response of *C.olitorius* L to the kraal manure treatments were, plant height, number of leaves per plant, shoot fresh weight per plant, shoot dry matter weight per plant, and yield per hectare. For the measurements of these parameters, five plants from each plot were sampled at random to obtain an average. Sampling of plants for growth analysis began two Weeks After Sowing (WAS) and continued weekly. The meter rule was used for the measurement of the *C.olitorius* L plant height from base to the tip of the main shoots starting from three weeks after sowing up to five weeks. The number of leaves of the sampled plants were counted and recorded for five weeks starting from three WAS. The fresh weight and dry weight of the harvested plants shoots were determined in the laboratory using weighing a balance. MSTATC (Nissen, 1989) statistical software was used in the analysis of the data. Data collected were subjected to analysis of variance (ANOVA) in a RCBD. Means were compared using Least Significant Difference (LSD) at the 5% level of probability (Gomez and Gomez, 1984).

Table 1: Chemical composition of the soil used in this experiment

Parameters	Value
pH	5.5
Exchangeable acidy (meq/100 g)	0.2
P (mg/kg)	23
K (mg/kg)	245
Mg (mg/kg)	4.5
Ca (mg/kg)	5.8

Analysis was done at Malkerns Research Station

Table 2: Chemical composition of kraal manure used in this experiment

Parameters	Value
P (%)	0.017
K (%)	0.864
Mg (%)	0.300
Zn (%)	1.254
Mn (%)	3.663
Fe (%)	1.537
Cu (%)	0.390
pH	7.700

Analysis was done at Malkerns Research Station

RESULTS

Soil analysis: The results of the soil analysis taken before the application of the kraal manure on the onset of the experiment are presented in Table 1. The soil was loam with moderate organic matter content and good moisture retaining properties. Most of the nutrients in this soil are below the critical level (Edje and Ossom, 2009). Hence there was a need for the application of soil amendments inform of organic manure.

Kraal manure analysis: The results of the kraal manure analysis that were taken before the application are illustrated in Table 2. The pH was neutral that was an advantage than if the soil had been highly acidic. No lime was required after application of kraal manure. There was a low Percentage of Phosphorus (P), though manganese

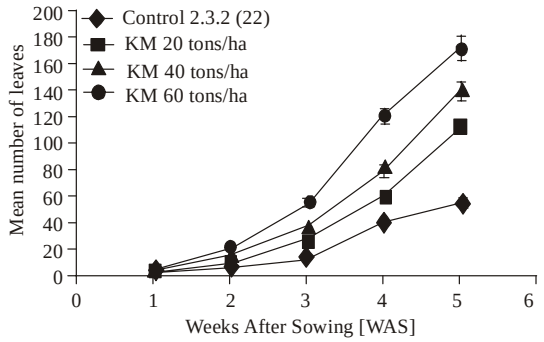

Fig. 2: Effects of levels of kraal manure on number of leaves of *C. olitorius* L

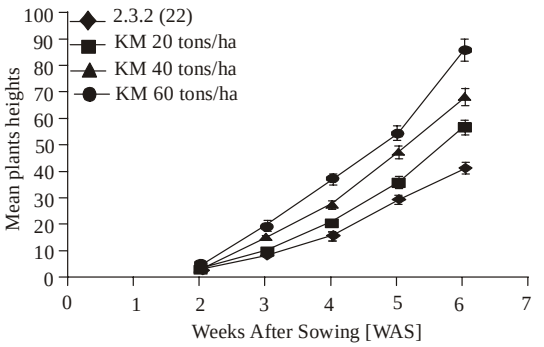

Fig. 3: Effects of kraal manure on plant height of *C. olitorius* L

(Mn), iron (Fe) and zinc (Zn) were available in higher percentages. Other elements available were magnesium (Mg) and copper (Cu).

Number of leaves: There were significant ($p<0.05$) differences in the number of leaves across all four treatments. Number of leaves increased with increased application of kraal manure. Fig. 2 shows the average number of leaves obtained from each treatment spread across the duration of data collection. Number of leaves decreased as the rate of application of kraal manure was reduced. The number of leaves affected by the levels of kraal manure over the duration of the experiment is shown in Fig. 2.

Plant height: There were significant ($p<0.05$) differences in plant height across all the levels of kraal manure applied. An increase in kraal manure application rate increased plant height. Kraal manure application at 60 t/ha resulted in the highest vigour in terms of plant height as shown in Fig. 3 while lower levels of kraal manure resulted in less vigour. Lower levels of kraal manure were less responsive than when compared at the highest level (60 t/ha). The average plant height increased rapidly at 5 WAS at the application rate of 60 t/ha in plots (Fig. 3).

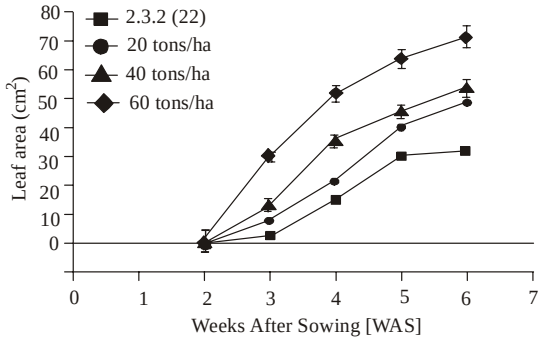

Fig. 4: Response of leaf area of *C. olitorius* L to levels of kraal manure

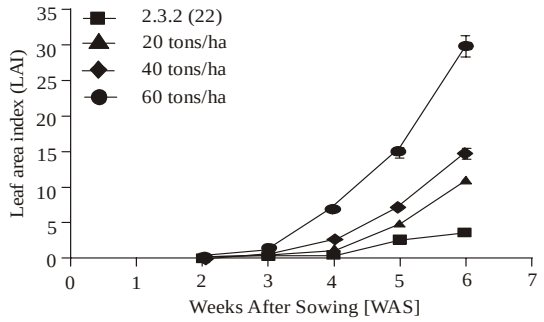

Fig. 5: Leaf area index of *C. olitorius* L recorded between 2 WAS and 6 WAS

Leaf area: There was a significant ($p<0.05$) difference in leaf area across all the treatments as affected by the different levels of kraal manure applied. Plants grown on 60 t/ha kraal manure application rate had the largest leaf area, followed by 40 t/ha and lastly 20 t/ha. Leaf area in all the treatments began to be constant at 5 WAS (Fig. 4).

Leaf area index: There were significant ($p<0.05$) differences in leaf area indices across all the levels of kraal manure. Leaf area index continued to increase with time during the duration of the experiment. At 3 WAS the leaf area index of plants grown in plots where kraal manure was applied at 60 tons/ha was the only one that showed a significant ($p<0.05$) difference from the others. There was very little difference in the leaf area index of the control and at application of kraal manure at the rate of 40 t/ha at 4 WAS. Considerable difference in leaf area index was noticed at 5 and 6 WAS (Fig. 5). Leaf area index increased with increased application of kraal manure.

Yield parameters: There was a significant ($p<0.05$) differences in the yield of *C.olitorius* L shoots as affected by the rates of kraal manure application (Fig. 6). The average yield of fresh mass increased as the level of application increased. There was a huge difference between the highest fresh mass yield and the lowest fresh

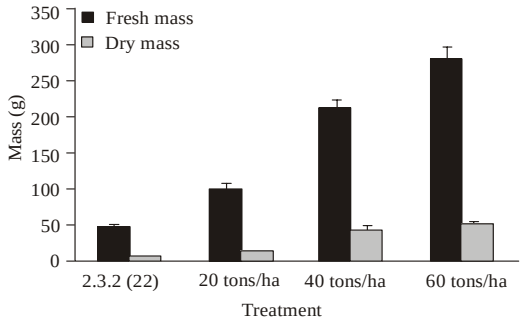

Fig. 6: Relative fresh mass and dry mass of *C. olitorius* L at harvesting

mass yield. Also noticed is the significant ($p<0.05$) difference in dry mass across all levels of kraal manure. It shows that there is a huge difference between dry mass and fresh mass as effected by the various treatments.

The dry mass of plants applied with kraal manure were higher than that of the control. An increase in kraal manure application also increased the dry mass of the plant (Fig. 6). More dry matter was weighed for plants grown on plots with kraal manure applied at 60 t/ha than at the other levels of application. The highest dry mass (about 50 g) was measured for plants harvested from plots previously fertilized with 60 t/ha and followed in decreasing order by those plants from plots fertilized by 40 t/ha (about 45 g), 20 t/ha (about 12 g) and lastly 2.3.2(22) inorganic fertilizer which had the least dry mass of about 5 g (Fig. 6)

DISCUSSION

The results presented here may be the first showing the response of *C. olitorius* L to varying levels of kraal manure in Swaziland. It is interesting that these results show a great opportunity of increasing the yield of this valuable traditional vegetable grown organically. Organic farming is now viewed as an alternative healthy way of farming into the future (Lampkin, 2002; Reynolds, 2004; Rosin and Campbell, 2009).

C. olitorius L responds very well to added fertilizer especially N however organic fertilizer will improve the yield and improve the soil structure as well. The ability of kraal manure to retain moisture and also improve the total pore spaces in the soil makes it more advantageous than inorganic fertilizer. *C. olitorius* L grown at higher levels of kraal manure application rate showed considerable vigour in the growth parameters that were measured (number of leaves, plant height, leaf area and leaf area index). The vigour decreased with reduced application level of kraal manure. Dry mass yield and fresh mass yield also increased with increased application level of kraal manure.

There were significant ($p<0.05$) differences in all the growth parameters that were measured as affected by the different levels of kraal manure. Plants that grew on plots that had higher levels of kraal manure produced higher yields than those grown on the control and the other lower levels of kraal manure. These results agree with the findings of Palada and Chang (2003) who reported an increase in yields of *C.olitorius* L grown using organic fertilizer. In okra (*Abelmoshus esculentus* L. Moench) kraal manure increased pod yield in a semi-arid sub-tropical environment (Ogunlela *et al*., 2005). This increase in yield as affected by the higher application rate of kraal manure could be a result of the relatively high mineral contents found in kraal manure. The kraal manure used in our experiment showed relatively ample amounts of nutrients from the chemical composition analysis. In their study of the nutritive composition of kraal manure, Christian *et al.* (2001) found that animal manure had all 13 essential plant nutrients. This may have influenced the response of the growth and yield of *C.olitorius* L because animal manure adds organic matter to the soil and also reduces the pH of the soil.

Plants grown on plots where kraal manure was applied grew more vegetatively than those where synthetic fertilizer was used. This was observed on the leaf area and leaf area index where both parameters showed higher values than in their synthetic fertilizer applied counterparts. This could be attributed to the high N concentration in kraal manure. It was also observed that the vegetative growth of *C. olitorius* L increased with increased levels of application of kraal manure. As kraal manure application level increased the level of available nutrients also increased in the soil. It is important to establish the kraal manure upper threshold rate for okra growth in order to find the maximum application rate that gives the highest yield of the vegetable. A possible limitation to the use of kraal manure is its competition for use in production of the main staple *Zea mays* and the fact that not all families are endowed with cattle. Intercropping wild okra with *Zea mays* will bring a harmonious out come. Animal manures may negatively carry weed seeds, diseases and other unwanted materials hence the need for complete composting prior to use.

Bringing wild vegetables into conventional production has far reaching effects of attaining food security and reduction of malnutrition (Van Vuuren, 2006; Modi *et al*., 2006; Ndlovu and Afolayan, 2008). Genetic improvement of *C. olitorius* L (Chweya, 1997) and its formal subsequent cultivation will bring relief to local communities.

CONCLUSION

This study has shown the potential of increasing the yield of *C. olitorius* L using kraal manure. This will be of benefit to home growers of *C. olitorius* L because relatively lower costs will be incurred when using kraal manure as compared to inorganic fertilizer. Besides being

relatively affordable, kraal manure has shown good results compared to synthetic fertilizer in growth and yield of *C. olitorius* L. Adding to its plant nutritive qualities, kraal manure can also improve the structure of the soil. Based on the results and conclusion drawn from the research, the following may be suggested:

- *C. olitorius* L can be grown with kraal manure rather than synthetic fertilizer because kraal manure resulted in higher yields more so at 60 t/ha.
- A similar research be carried out but this time around irrigation should be monitored, in a move to gear towards commercial production of *C. olitorius* L in Swaziland.

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