THE EFFECT OF FARMYARD MANURE AND CALCIUM AMMONIUM NITRATE FERTILISERS ON MICRONUTRIENT DENSITY (IRON, ZINC, MANGANESE, CALCIUM AND POTASSIUM) AND SEED YIELDS OF *SOLANUM VILLOSUM* (BLACK NIGHTSHADE) AND *CLEOME GYNANDRA* (CAT WHISKERS) ON EUTRIC NITISOL

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Abstract
The overall objective of the study was to investigate the effect of farmyard manure (FYM) and calcium ammonium nitrate (CAN) and cooking on micronutrient content (iron, zinc, potassium, calcium, manganese) and seed yield in two African leafy vegetables (ALVs), *Solanum villosum* and *Cleome gynandra* in Keiyo District of the Rift Valley Province. The micronutrients were determined using the energy dispersive X-ray fluorescence (EDXRF) analysis method. Results from the study indicated that addition of various levels of fertilisers either had no effect, depressed or slightly increased the amounts of various micronutrients in the two ALVs. Edible portions of *Solanum villosum* were found to be richer than their *Cleome gynandra* counterparts in iron, manganese and potassium content. *Cleome gynandra* on the other hand contained more zinc and calcium than *Solanum villosum*. Incorporation of either FYM or CAN decreased the iron accumulation in leafy tissues of the two ALVs. Application of FYM or CAN had no significant or clear effect on the levels of zinc and potassium in both ALVs, while moderately high levels of FYM increased the levels of manganese in *Cleome gynandra* but showed no clear trend in *Solanum villosum* edible tissues. The farmer's crop was comparable in the measured attributes to the produce grown on soil amended with low levels of either FYM or CAN. Boiling significantly decreased the amount of micronutrients retained in edible portions of both vegetables, except for manganese where it had no effect. The FYM and CAN fertilisers significantly increased seed yields of both ALVs. In conclusion, *Solanum villosum* and *Cleome gynandra* are rich sources of iron, zinc, calcium, potassium and manganese and incorporation of various levels of FYM and CAN improved seed yields in the two ALVs, although showing no major influence on the micronutrient densities. Traditional methods of prolonged boiling to reduce the bitter anti-nutrients and make them palatable seriously eroded the levels of micronutrients in some instances by up to 65%.

Key words: African leafy vegetables, *Cleome gynandra,* farmyard manure, nitrogen, fertilisers, *Solanum villosum*

1.0 Introduction

African leafy vegetables (ALVs) are reputed to play a key role in providing necessary micronutrients for balanced diets (Moomaw, 1979). In Kenya and other African countries where increasing food insecurity continues to ravage most people living in rural areas or slum areas in urban centres, there is urgent need to address issues relating to hidden hunger. The low income levels of these marginalised groups disqualify them from accessing benefits from exotic vegetables that require high levels of inputs (Chweya, 1984; Onyango, 1993). The ALVs, though neglected over the years by scientists, farmers and policy makers, offer a possibly cheaper and more readily available source of micronutrients. Some of the important micronutrients that can be obtained from ALVs include iron, calcium, zinc, potassium, iodine and magnesium.

Iron is essential for the formation of haemoglobin and myoglobin and its deficiency leads to anaemia, a condition of low haemoglobin. This condition inflicts 2.1 billion people, 42% of whom are women (Fairbanks, 1978), resulting in low work productivity. Growing children, pregnant and breastfeeding mothers and heavy duty workers require large amounts of calcium which is crucial for the formation of strong bones and strong teeth. Problems associated with calcium deficiency in diets such as osteoporosis (bone mineral loss), leading to rickets in children and osteomalacin in adults, are increasingly being recognised in Africa as an important contributing factor to fractures in old age among women (FAO, 1997). Zinc is another mineral that has been recognised as necessary for normal growth, resistance to infectious diseases and reduction of incidences of still-births and possibly impaired cognitive development.

The main sources of micronutrients such as iron and calcium are meats, milk and supplements. Among the third world countries however, and especially among marginalised communities, these rich sources are expensive and beyond the reach of many. Edible green leafy vegetables, some of which grow in the wild or are semi-cultivated, such as ALVs, could therefore provide a potentially cheaper and readily available alternative source among the resource-poor and marginalized groups, especially women, children and the elderly.
Available literature on nutrient composition of ALVs vary greatly with agro-ecological zones as well as mineral availability from the soil (Mengel, 1979; Gomez, 1982; Maundu *et al.,* 1999; Onyango *et al.,* 2000). The expansion of production and promotion of the consumption of ALVs in Kenya is hampered by declining soil fertility levels, necessitating supplemental fertilisation (Okoko *et al.,* 1997). To our knowledge, there has been no study on the relationship between fertiliser application and nutrient density levels in any part of Kenya's Rift Valley.

The main objective of the current study was therefore to evaluate the effects of FYM and CAN fertilisation on macro (calcium, potassium) and micro (iron, zinc, manganese) nutrient content and seed yields of *Solanum villosum* and *Cleome gynandra* in Keiyo District. We also studied the effect traditional cooking methods used by the Keiyos on the levels of the same nutrients in the two ALVs.

2.0 Materials and Methods

2.1 Site

The experiment was carried out between April and December 2002 in Metkei Location, Keiyo District, Rift Valley Province, on a farmer's field. The study site lies at an altitude of 2700 m above sea level and is within latitude 0° 20'N and longitude 35° 40'E. The site receives an average rainfall of 1700 mm per year, with long rains starting from April/May and ending in June/July, while short rains fall between September and December. The mean monthly maximum and minimum temperature are 23.8°C and 12.4°C respectively. The site is under eutric nitisol units according to FAO/UNESCO classification (FAO/UNESCO, 1974). These soils are deep, well drained and have a dark reddish-brown colour. This area was chosen based on the popularity and levels of utilisation of *Solanum villosum* and *Cleome gynandra,* by the community residing there, as well as the ready availability of FYM.

2.2 Soil Sampling and Analysis

Soil samples from the site were taken from a depth of 0-20 and 20-40 cm.The samples were air-dried and ground to pass through a 2 mm sieve and analysed for total N by Kjedhal method; organic carbon by Walkey-Black method; available P by Mehlich method; pH using a ratio of 1:2.5 soil water, and K, Na, Ca, Mg and cation exchange capacity (CEC) by leaching methods as outlined by Page *et al*. (1982). The results of the soil analysis are outlined in the table 1.

Table 1: The macro and micro nutrient concentration in ppm in eutric nitisol soils in Keiyo District using energy dispersive x-ray fluorescence method over 2 seasons

Source	**Macronutrients**		**Micronutrients**					**Beneficial elements**	
	K	**Ca**	**Mn**	**Fe**	**Co**	**Cu**	**Zn**	**Sr**	**Br**
SEASON 1									
Farmyard manure	47566.7	21366.7	410.3	13500	Trace	23.8	109.7	106.7	71.7
0-20 cm soil	7013.3	1865	1677.7	78676.7	1683.3	6.8	123.0	31.1	27.1
20-40 cm soil	60900	30200	12600	513000	9910	42.2	1390	283	139
SEASON 2									
Farmyard manure	49608	19320	378.3	13333.3	Trace	20.8	113	107.7	74.6
0-20 cm soil	9209.3	4176.7	1723.3	74870.3	1981.7	8.0	133	32.7	30.6
20-40 cm soil	10733.3	5293.3	2053.3	81500	1177.8	17.2	224.7	68.2	17.8
Solanum (Average)	46298.4	9640.1	451.6	1280.7	Trace	Trace	43.2	67.6	236.8
Cleome (Average)	40366.6	25414.9	111.1	936.4	Trace	Trace	84.9	64.3	21.5
% uptake Solanum	40.1	1818	3.1	0.2	Trace	Trace	2.7	16.1	99.6

% uptake Cleome	35	47.6	0.8	0.2	Trace	Trace	5.2	15.3	9

2.3 Land Preparation and Plant Establishment

The seeds of locally grown *Cleome* variant with pink stem and leaf petiole pigmentation were obtained from a farmer, Mrs. Elizabeth Chepsiolei since commercial seed did not germinate. The farmer's seeds were obtained from previous season's crop and had been stored in a dry, cool conditions in a granary on the farm. The seeds were directly sown in drills made 30 cm apart and covered at about 1 cm deep. Thinning was done four weeks later to give a spacing of 30 cm within row and between the plants.

2.4 Experimental Design and Treatments

The experimental design was randomised complete block design with 4 replicates. Each plot measured 2 x 2 m. The treatments were four levels of FYM (decomposed cattle manure: 0, 5, 10, 15 and 20 t/ha), four rates of CAN (26, 52, 78 and 104 kgN/ha with a non-fertilised control. The FYM was applied one week before planting, while CAN was applied during thinning. The farmer was also given a portion of land and supplied with the inputs to plant and apply her own husbandry practices the way she normally did. The plots were kept weed free manually throughout the experimental period.

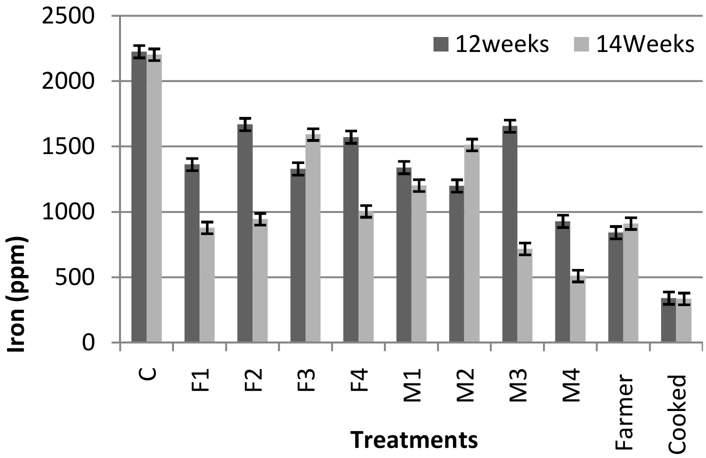
2.5 Sampling Plant and Data Analysis

Ten plants per plot were randomly selected and tagged for data collection. Samples for micronutrient content analyses were taken at 12 and 14 weeks after planting for *Solanum villosum* and at 6 and 8 weeks for *Cleome gynandra*. The *Solanum villosum* seeds were extracted from the berries by squeezing out the seeds and pulp 20 weeks after planting. Drying was done in the shade for a day. The *Cleome gynandra* seeds were extracted by plucking dry brown pods, threshing and drying the seeds obtained. The seeds from each plot were weighed and expressed as tons/hectare. The micronutrient content analysis in edible tissues of each vegetable sample was carried out using the energy dispersive X-ray fluorescence (EDXRF) analysis method (IAEA, 1997) at the Department of Nuclear Science, University of Nairobi. For the experiment to determine the effect of cooking on micronutrient density the leafy portions of the vegetable were boiled in water for 5 minutes and the boiling water discharged. The EDXRF data were subjected to analysis of variance (ANOVA) tests using Genstat Statistical Software (Lane and Payne, 1996). Means were compared using the least significant difference (LSD) test at 5% level of significance.

3.0 Results

Results of the present study indicate that nutrient (iron, zinc, calcium, potassium, manganese) content in *Solanum villosum* and *Cleome gynandra* leaf tissues were influenced by the type and rate of fertiliser applied, plant age and farmer's agronomic practices. The *Solanum villosum* leaves were found to be richer in iron when compared with those of *Cleome gynandra.*

(a)



(b)

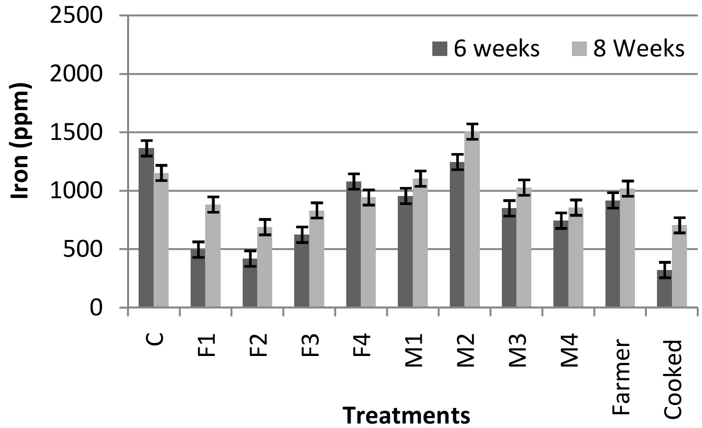


Figure 1: Effects of farmyard manure and calcium ammonium nitrate fertilisers on iron content of (a) Solanum villosum and (b) Cleome gynandra in Eutric Nitisol
LSD bars represent 5% level of error

Incorporation of either FYM or CAN fertiliser decreased the accumulation of iron in both young and old tissues of both vegetables. Although the trend was not clear, the younger tissues of *Solanum villosum* contained more iron than the older tissues, while the opposite was true for *Cleome gynandra*. Boiling and discharging water from the leafy portions decreased the iron content in both young and older tissues by about 59% and 63% in *Solanum villosum* and by 65% and 31% in *Cleome gynandra*. The younger leafy tissues of farmer's produce accumulated less iron in comparison to the controls, but as the leaves matured, the iron content became similar to those of control plants. Using the EDXRF method, Fe concentration in soils was 3 times more than FYM, yet the uptake (%) was similar in both crops.

Edible leafy portions of *Cleome gynandra* were richer in zinc than those of *Solanum villosum* (figure 2(a) and (b))Neither the incorporation of various levels of FYM or CAN nor the farmer's agronomic practices had any effect on the zinc content of either the young or older leafy tissues of *Solanum villosum,* while prolonged boiling slightly depleted the zinc content in these tissues.

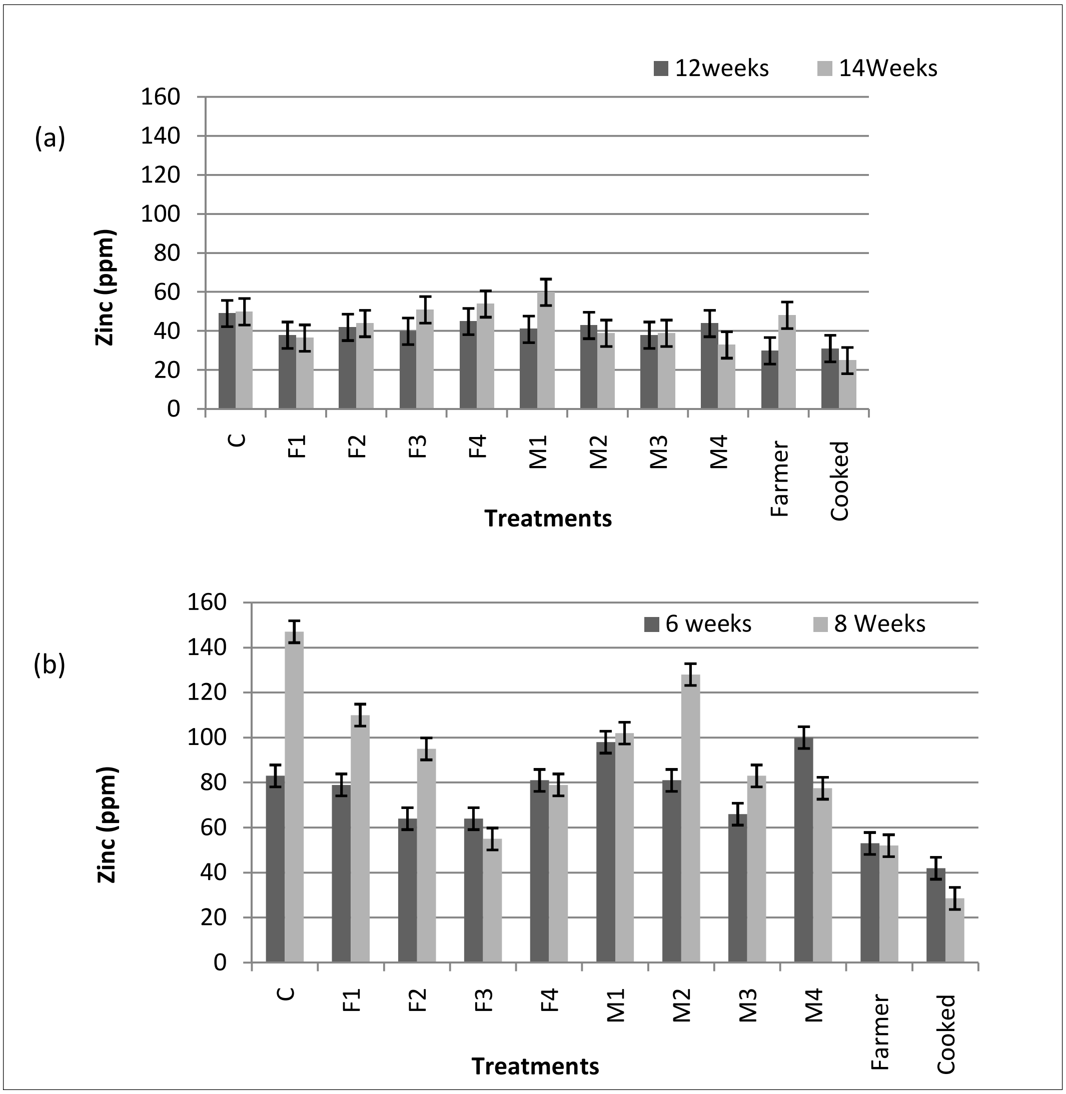


Figure 2: Effects of farmyard manure and calcium ammonium nitrate fertilisers on zinc content of (a) Solanum villosum and (b) Cleome gynandra in Eutric Nitisol

Key: *LSD bars represent 5% level of error*

C = Control	*M1= 5tons/ha FYM*
F1=100kg/ha CAN	*M2=10tons/ha FYM*
F2=200kg/ha CAN	*M3=15tons/ha FYM*
F3=300kg/ha CAN	*M4=20tons/ha FYM*
F4=400kg/ha CAN	*Cooked=cooked farmers sample*

Twelve-week-old *Cleome gynandra* leaves contained about 80 ppm of zinc. As the leaves matured, there was a marked increase in the zinc content to about 150 ppm. Incorporation of various levels of CAN resulted in a slight decrease in zinc content of both younger and older tissues of *Cleome gynandra*. Incorporation of FYM on the other hand had no significant influence on zinc content of younger tissues but caused a slight decline in older tissues. The farmer's crop accumulated lower levels of zinc compared to control plants. Boiling leafy portions of *Cleome gynandra* decreased the zinc content from 80 to about 40 ppm in young and from about 150 to about 30 ppm in older tissues.

Leafy portions of 12-14 week old *Solanum villosum* contained slightly more potassium than those of 6-8 week old *Cleome gynandra* (Figure 3a and b)

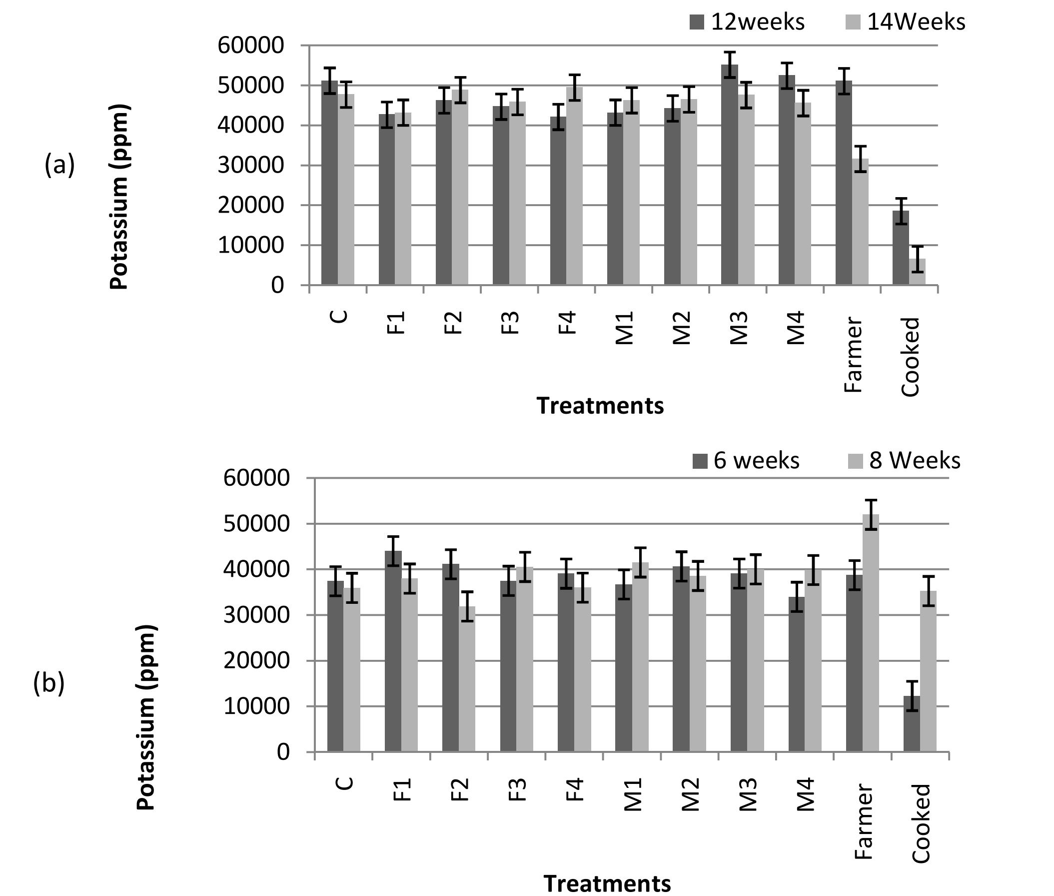


Figure 3: Effects of farmyard manure and calcium ammonium nitrate fertilisers on potassium content of (a) Solanum villosum and (b) Cleome gynandra in eutric nitisol

Key: *LSD bars represent 5% level of error*
C = Control M1 = 5tons/ha FYM
F1 = 100kg/ha CAN M2 = 10tons/ha FYM
F2 = 200kg/ha CAN M3 = 15tons/ha FYM
F3 = 300kg/ha CAN M4 = 20tons/ha FYM
F4 = 400kg/ha CAN Cooked =cooked farmers sample

Application of various levels of FYM and CAN had no or slight effect on the levels of potassium in tissues of these two ALVs. The young tissues from the farmer's *Solanum villosum* crop contained comparable amounts as those of control plants while the older tissues contained less potassium. As for the *Cleome gynandra* leafy portions, application of either FYM or CAN had no effect on potassium accumulation, and there was no difference between the younger and older tissues. Boiling of the leafy portions of both *Solanum villosum* and *Cleome gynandra* caused a depreciation in potassium content by about 68% and 32%, respectively, except in the older tissues of *Cleome gynandra* where there was no effect.

The edible leafy portions of *Cleome gynandra* were found to be richer in calcium than those of *Solanum villosum* (Figure 4a and b).

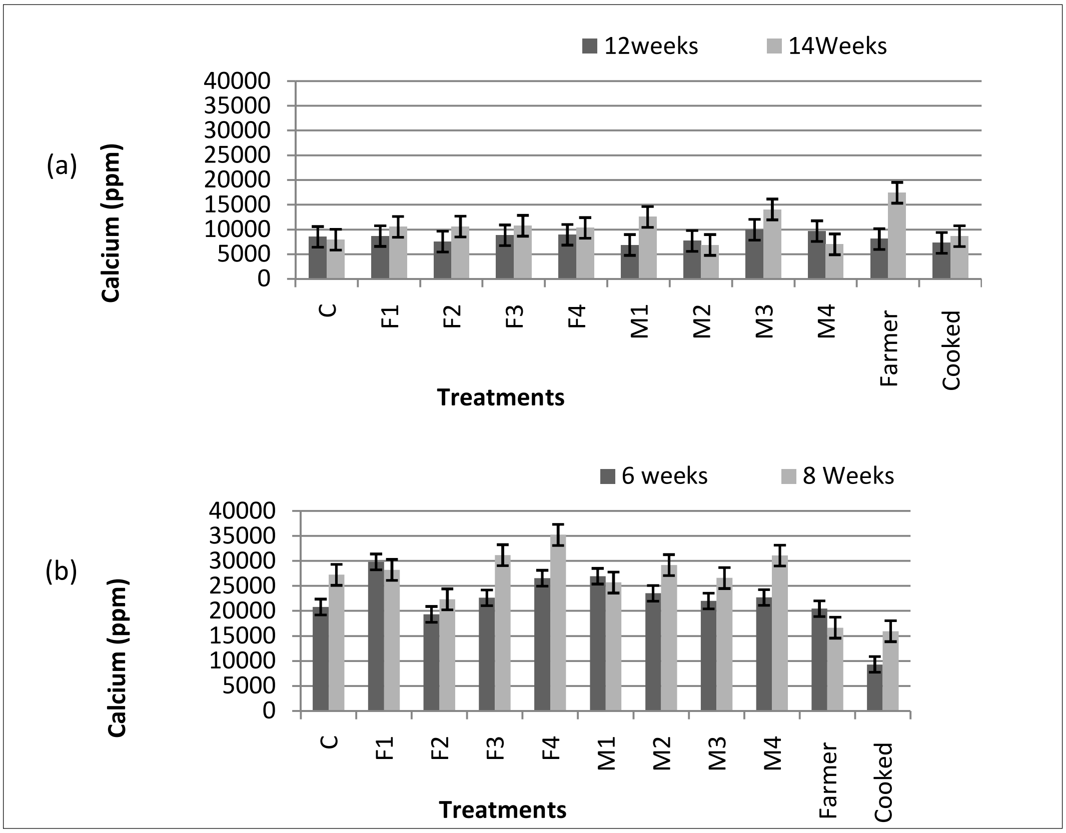


Figure 4: Effects of farmyard manure and calcium am(a) Solanum villosum and (b) Cleome gynandra in Eutric Nitisol monium nitrate fertilisers on Calcium content of LSD bars represent 5% level of error

Key: *C = Control M1 = 5tons/ha FYM*
F1 = 100kg/ha CAN M2 = 10tons/ha FYM
F2 = 200kg/ha CAN M3 = 15tons/ha FYM
F3 = 300kg/ha CAN M4 = 20tons/ha FYM
F4 = 400kg/ha CAN Cooked =cooked farmers sample

There was generally a greater accumulation of calcium in older than in younger tissues. The incorporation of either FYM or CAN fertiliser had no significant effect on calcium content in young leafy tissues of *Solanum villosum*. However, there was a slight increase in levels of calcium in older tissues of plants grown in soils incorporated with FYM. While the farmer's produce contained similar amounts of calcium with control plants 12 weeks after planting, there was an unexpected increase in Ca content in older tissues from the farmer's crop. Similar trends were observed in the effect of various levels of FYM and CAN, as well as the farmer's agronomic practices on the accumulation of calcium in young and older tissues of *Cleome gynandra* with some concentrations slightly increasing and some slightly depressing the accumulation of calcium. While there was no significant decrease in the accumulation of calcium between the farmer's produce and those of control plants 6 weeks after planting, there was a slight overall decrease 2 weeks later. Prolonged boiling of *Cleome gynandra* leafy portions reduced the calcium content in young tissues by over 50 %, and had no effect on the older tissues.

Leafy portions of *Solanum villosum* grown in Keiyo District were found to be much richer in manganese than *Cleome gynandra* Figure 5(a) and (b).

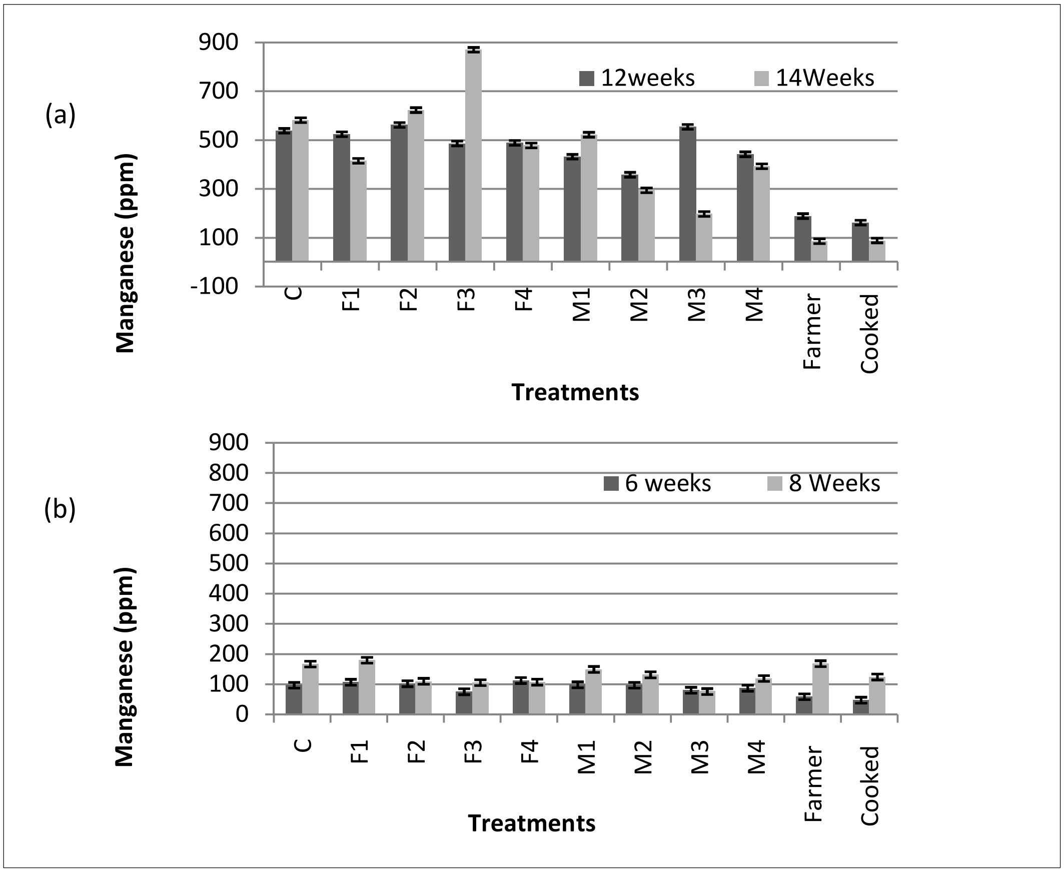


Figure 5: Effects of farmyard manure and calcium ammonium nitrate fertilisers on manganese content of(a) Solanum villosum and (b) Cleome gynandra in Eutric Nitisol LSD bars represent 5% level of error

Key:
C = Control

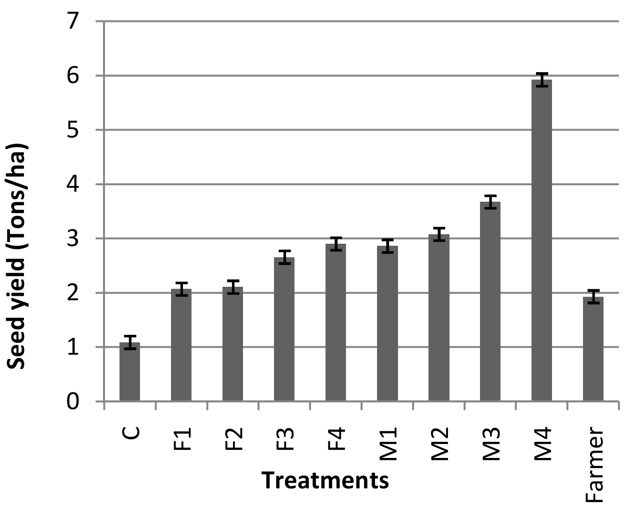
F1 = 100 kg/ha CAN M1 = 5 tons/ha FYM
F2 = 200 kg/ha CAN M2 = 10 tons/ha FYM
F3 = 300 kg/ha CAN M3 = 15 tons/ha FYM
F4 = 400 kg/ha CAN M4 = 20 tons/ha FYM

Plants grown without addition of either FYM or CAN fertiliser contained about 550 and 100 ppm respectively. The type and rate of fertiliser incorporated into the soil influenced the amount of manganese that accumulated in the leafy portions of the 2 ALVs in the current study. Application of CAN had no effect on the accumulation of manganese in 12-week-old tissues and as plants aged, plants raised on low and high levels contained less and moderate levels, contained more manganese than the controls. Only moderate levels of FYM increased manganese levels in young tissues and depressed the content in older tissues. In *Cleome gynandra,* application of CAN had no effect on younger tissues, but depressed the manganese content in older tissues. All levels of FYM I had no effect on manganese levels in younger tissues but depressed the content as plants grew older. Boiling had no effect on manganese content in *Solanum villosum* leafy tissues, but slightly depressed the levels in *Cleome gynandra*.

The seed yields of *Solanum villosum* and *Cleome gynandra* grown in Keiyo District were influenced by the incorporation of FYM and CAN top-dressing fertiliser as well as the farmer's agronomic practices (Figures 6 and 7).

Incorporation of various rates of FYM and CAN fertiliser increased the seed yields of *Solanum villosum* from 1 ton/ha in control plants to between 3 and 6 tons/ha (Figure 6a and b) and of *Cleome gynandra* from 0.4 tons/ha in controls to between 2 and 3 tons/ha (Figure 7a and b) in both seasons.

(a)



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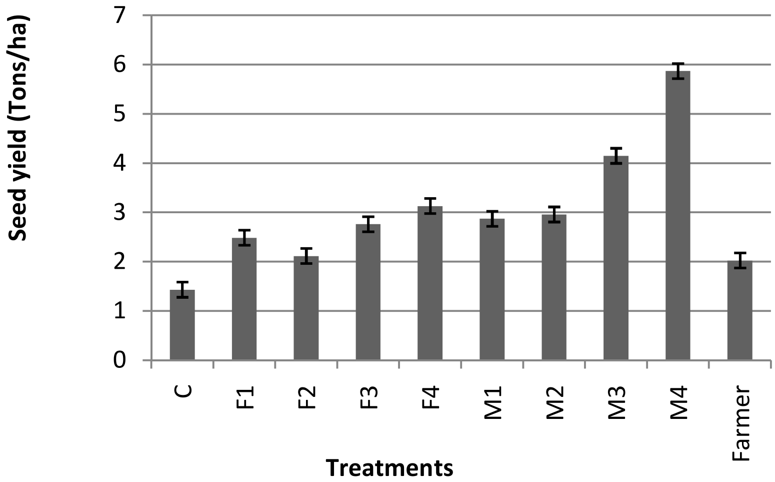
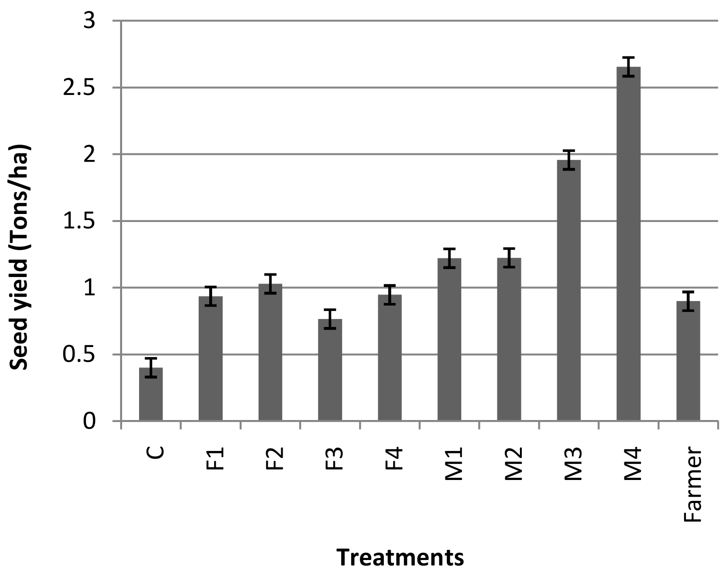


Figure 6: Effects of Farmyard Manure and Calcium ammonium nitrate fertilisers on seed yield of Solanum villosum eutric nitisol during 2002 long rains (a) and 2002 short rains (b)

Key: *LSD bars represent 5% level of error*
C = Control
F1 = 100 kg/ha CAN M1 = 5 tons/ha FYM
F2 = 200 kg/ha CAN M2 =10 tons/ha FYM
F3 = 300 kg/ha CAN M3 = 15 tons/ha FYM
F4 = 400 kg/ha CAN M4 = 20 tons/ha FYM

(a)



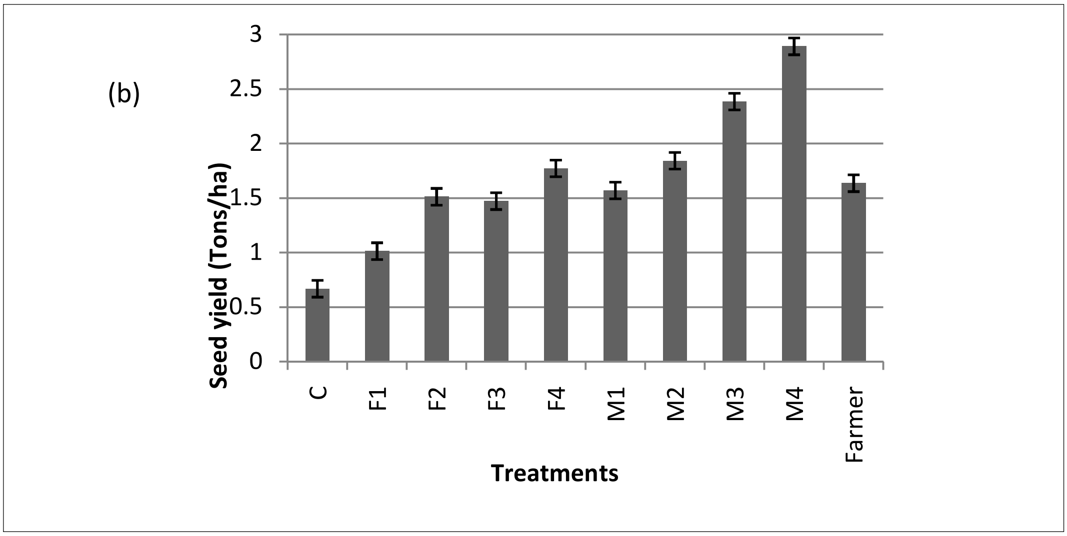


Figure 7: Effects of farmyard manure and calcium ammonium nitrate fertilisers on seed yield of Cleome gynandra eutric nitisol during 2002 long rains (a) and 2002 short rains (b)

Key: *LSD bars represent 5% level of error*
C = Control
F1 = 100 kg/ha CAN M1 = 5 tons/ha FYM
F2 = 200 kg/ha CAN M2 = 10 tons/ha FYM
F3 = 300 kg/ha CAN M3 =15 tons/ha FYM
F4 = 400 kg/ha CAN M4 = 20 tons/ha FYM

Increasing the amount of FYM or CAN incorporated into the soil resulted in a corresponding increase in seed yield in both crops, with FYM application of 20 tons/ha giving the greatest seed yields in both crops. Irrespective of treatment, there was no significant difference between seed yields obtained during the long and short rainy seasons. In both seasons, plants grown with FYM supplementation produced more seeds than those with CAN fertiliser. In both seasons, the seed yields from the farmer's field were higher than the controls but equivalent to those of low levels of either FYM or CAN fertiliser in the two ALVs.

4.0 Discussion and Conclusions

The iron content of edible portions of *Solanum villosum* and *Cleome gynandra* decreased with application of N fertilisers. Application of N has also been reported to depress the iron content of other vegetables such as *Amaranthus caudatus*, *Cucurbita pepo*, *Telfairia occidentalis*, *Solanum aethiopicum* and *Solanum macrocarpon* (Taylor *et al.,* 1983). The results of the present study indicate that addition of FYM and CAN fertiliser had no significant effect on zinc content of edible leafy portions of *Solanum villosum*. Application of N has been reported to have no effect on the zinc content in other crops like the *Solanum nigrum* complex (Murage, 1990), *Amaranthus caudatus*, *Cucurbita pepo*, *Telfairia occidentalis*, *Solanum aethiopicum* and *Solanum macrocarpon* (Taylor *et al.,* 1983).

The addition of FYM and CAN fertiliser decreased the zinc content on the edible leafy portions of *Cleome gynandra*. This contradicts what Taylor *et al*. (1983) found in other vegetables. The balance between zinc available due to complexion with fulvic acid and decrease associated with alteration to soil solution chemistry by the organic matter might have been the reason for the lack of response by the plants upon application of more organic manure (Tagwira *et al.,* 1992). Also, the lack of response could be associated with the decrease with the decrease in solubility due to high pH of FYM (Verma and Minhas, 1987).

The results of the present study indicate that addition of FYM and CAN fertiliser had no significant effect on potassium content of edible leafy portions of *Solanum villosum* and *Cleome gynandra*. Application of N has been reported to have no effect on potassium content in other crops such as *Solanum nigrum* complex (Murage, 1990), *Amaranthus caudatus*, *Curcubita pepo*, *Telfairia occidentalis*, *Solanum aethipicum* and *Solanum macrocarpon* (Taylor *et al.,* 1983). This shows that the levels of minerals in leafy vegetables are dependent on mineral availability from the soil, hence soil organic matter amendment could influence availability of micronutrient to plants (Mengel, 1979; Murage, 1990).

Application of CAN at 26 and 52 kg N/ha had no significant influence on manganese content in *Solanum villosum* and *Cleome gynandra.* Calcium ammonium nitrate at 78 kg N/ha increased manganese accumulation only in *Solanum villosum* but had no influence in *Cleome gynnandra.* Manganese content of *Solanum villosum* leaves however decreased with application of FYM. Application of N has been reported to have no effect on manganese content in other crops such as *Solanum nigrum* complex (Murage, 1990). Similar results of depressed manganese content on application of FYM have been reported in other crops, e.g., *Amaranthus caudatus*, *Curcubita pepo*, *Telfairia occidentalis*, *Solanum aethipicum* and *Solanum macrocarpon* (Taylor *et al.,* 1983). This could be due to the high pH of FYM which could have led to reduced solubility of manganese (Verma and Minhas, 1987). The application of N had no effect on manganese content of edible leafy portions of *Cleome gynandra*. These results contradict the findings in *Amaranthus caudatus*, *Curcubita pepo*, *Telfairia occidentalis*, *Solanum aethipicum* and *Solanum macrocarpon* (Taylor *et al.,* 1983) despite similar increases with age in all crops.

Incorporation of CAN fertiliser had no significant effect on calcium content in young leafy tissues of *Solanum villosum*. Calcium is almost immobile in the phloem and as result the calcium accumulation is less in most young tissues (Salisbury and Ross, 1992). Application of N has been reported to have no effect on accumulation of calcium in other crops like *Amaranthus caudatus, Curcubita pepo, Telfairia occidentalis, Solanum aethipicum* and *Solanum macrocarpon* (Taylor *et al.,* 1983). The results of the present study indicate that levels of some minerals in the leafy vegetables are dependent on mineral availability from the soil. Therefore, accumulation of some minerals could be enhanced by application of an appropriate fertiliser (Mengel, 1979; Murage, 1990). This could be the reason for the increase of calcium upon application of 5-10 tons/ha of FYM. Also the incorporation of CAN fertiliser increased calcium content in edible portions of *Cleome gynandra*. On the other hand, application of N had no effect on the accumulation of calcium in *Amaranthus* *caudatus, Curcubita pepo, Telfairia occidentalis, Solanum aethipicum* and *Solanum macrocarpon* (Taylor *et al.,* 1983). The pH strongly influences the solubility of certain elements in the soil and rate of which they are absorbed by plants. The pH of the FYM was around 9.1, while that of the soils was between 4 and 5 (Table 2).

Table 2: The pH, EC, CEC, %N, %C and available P in eutric Nitisol soils in Keiyo District using wet chemistry over 2 seasons

Source	*pH (H_2O*	*pH (0.01 M $CaCl_2$*	*EC-dS m^{-1}*	*CEC (cmol kg^{-1})*	*%N*	*%C*	*Available P (ppm) EDXRF*
SEASON 1							
Farmyard manure	9.3	8.9	2.0	32.6	2.0	21.4	2350
0-20 cm soil	4.0	4.1	3.3	26.9	0.6	6.4	26.9
20-40 cm soil	4.2	4.0	2.0	22.2	0.5	5.4	19.4
SEASON 2							
Farmyard manure	10.4	7.9	2.0	35.3	2.1	19.3	1081
0-20 cm soil	5.7	4.6	2.5	33.6	0.6	5.7	48.8
20-40 cm soil	5.4	4.5	2.0	17.5	0.5	5.2	41.3

Iron, zinc and manganese are less soluble in alkaline than acidic soils because they precipitate as hydroxide at high pH (Salisbury and Ross, 1992). The FYM at a pH of 9.1 may have had an effect on physical and chemical properties of the soil; hence it could have affected the solubility of these minerals. The results of this study suggest that fertiliser application may not be the only factor determining vegetable nutrient composition.

The micronutrient contents in the leafy portions of *Solanum villosum* and *Cleome gynandra* leafy portions were much higher than those previously reported by Ephenhuijsen (1974), Murage (1990) and Chweya (1993). *Solanum* species has been reported to have a range of 10-808 ppm of iron, 2900-3577 ppm of calcium and 7060-48500 ppm of potassium. In the present study, using a different method of determination, *Solanum villosum* contained between 515-2227 ppm iron, 6873-17433 ppm calcium, 31633-55200 ppm potassium, 30-60 ppm zinc and 197-870 ppm manganese. *Cleome gynandra* has been reported to contain 60 ppm of iron and 2880 ppm of calcium. In the present study, *Cleome gynandra* contained between 498-1507 ppm iron, 16666-35233 ppm calcium, 31933-55567 ppm potassium, 52-147 ppm zinc and 59-179 ppm manganese. The values of micronutrient density reported in the present study are higher than those reported from other studies an indication of possible varietal and ecological variations in addition to possibly better methods of extraction and/ or detection using the EDXRF method employed in the current study when compared to the wet chemistry method employed in other studies.

Results of the present study indicate that the traditional methods of cooking ALVs as practised in the community where the study was conducted is detrimental to retention and availability of micronutrients for nutrition. There were significant reductions in the levels of all micronutrients during boiling. The ALVs contain bitter anti-nutrients such as oxalates, phenols, nitrates, glucosinolates and gluco-alkaloids which necessitate excessive cooking to make them palatable (Gomez, 1982). Similar observations have been reported by Imungi and Potter (1985), Pearson (1973) and Lees (1975). The possible reason for this is that some of these micronutrients are soluble in water and during boiling, become leached to the cooking water and is subsequently lost with the discarded water, while others may undergo oxidation during cooking (Mziray, 1999).

Incorporation of FYM and CAN fertiliser increased the seed yields of *Solanum villosum* and *Cleome gynandra* grown in Keiyo District. Similar trends have been observed in other crops where increasing levels of various nutrients especially nitrogen increased the seed yields such as Pigeon pea (Lenka and Satpathy, 1976; Mukindia, 1993), common bean (Wistinghausen and Ritcher, 1983), Cat's whiskers and Collard (Omuolo, 2002). Farmyard manure at the tested levels contained high levels of nitrogen, phosphorus and potassium (Kipkosgei, 2004). The significant improvement of seed yield beyond that from CAN fertilisation could be attributed to observed significant improvement of the rooting system (Kipkosgei, 2004), which in turn improved nutrient and water uptake resulting in overall improvement in plant growth and development. It is also possible that less N was leached in soils incorporated with FYM as it possibly had improved structure, texture, water holding capacity as well as higher cation exchange capacity (Brady, 1984). Seed yields from the farmer's field indicate below optimum levels of fertilisation.

In summary, results from the present study indicate that *Solanum villosum* and *Cleome gynandra* are rich sources of iron, calcium, zinc, potassium and manganese micronutrients. The micronutrient levels reported in this study are higher than those previously reported by other researchers, an indication of possible varietal and locational differences in addition to using a possibly more efficient method (EDXRF) for analysis compared to wet chemistry method commonly used by other scientists. The use of fertilisers did not have a consistent effect on accumulation of micronutrients and further research is recommended to find out why fertilisers improve yields (including seed yields) which do not directly lead to increased accumulation of micronutrient densities in the leafy portions of *Solanum villosum* and *Cleome gynandra.* It should be noted that the amount of micronutrients that can be detected is a product of biosynthesis, translocation and storage. The results further confirm the fear that the traditional methods of boiling ALVs to rid them of bitter anti-nutrients, erodes most micronutrients and nothing basically remains, not even roughage, thus making the reality of achieving food security continue being evasive. The use of fertilisers, especially FYM which improves the structure of soils, can be of use in increasing biological yields (Kipkosgei, 2004) and seed yields. Results from the present study indicate possibilities to use FYM for seed multiplication, especially in view of ALVs continued neglect by farmers, scientists and policy makers.

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