# THE EFFECT OF FARMYARD MANURE AND CALCIUM AMMONIUM NITRATE ON VEGETATIVE GROWTH, LEAF YIELD AND NUTRITIVE QUALITY OF *CLEOME GYNANDRA* (CAT WHISKERS) IN KEIYO DISTRICT, RIFT VALLEY PROVINCE

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## ABSTRACT

African leafy vegetables (ALVs), which have been neglected by policy makers, researchers, extension workers and farmers, are receiving renewed interest as a possible intervention to food insecurity and malnutrition among resource-poor farmers. A study was carried out with the objective of determining the effects of various levels of farmyard manure and calcium ammonium nitrate (CAN) on vegetative growth, yield and quality (vitamins A and C and nitrates) of *Cleome gynandra* in Keiyo District, during long and short rains of the year 2002. The experimental layout was a RCBD with four replicates. The treatments were four levels of farmyard manure (FYM; 5, 10, 15, 20 t/ha) and four rates of CAN (100, 200, 300, 400 kg/ha). The addition of various rates of FYM and CAN that were tested significantly improved vegetative growth and increased leaf yields of *Cleome gynandra*. The yields obtained from plants grown with FYM were generally higher than from those with CAN. The incorporation of either FYM or CAN increased vitamin A content in both seasons. During Season 1, FYM increased vitamin C content in both young and older tissues, while CAN had no effect on the same. The application of 300 kg/ha of CAN increased the accumulation of nitrates in young and old tissues, while FYM had no effect on the same. In conclusion, fertilizer type and rate of application, season, plant age and management had a significant influence on vegetative growth, leaf yield and quality of *Cleome gynandra.*

***Keywords:*** *African leafy vegetables, farmyard manure, nitrogen fertilizers, Cleome gynandra.*

## 1.0 INTRODUCTION

African leafy vegetables (ALVs) are receiving renewed interest as a possible intervention to food insecurity and malnutrition among resource-poor farmers, despite historical neglect by policy makers, researchers, extension workers and farmers (Chweya, 1993; Onyango, 1993). Most of these ALVs grow under marginal and/or semi-cultivated conditions (Opiyo, 2000). Due to their marginalisation, they are usually grown in small plots and receive little or no fertilizer or manure (FAO, 1997). Available data however indicate that ALVs are comparable and sometimes superior to exotic vegetables in terms of nutrient content - vitamins, minerals, fibre, carbohydrates and proteins (Gomez, 1982). The Keiyos of the Rift Valley in Kenya, for example, rely on milk products for their nutritional needs, but feed ALVs to pregnant and lactating mothers and circumcision initiates for improved milk production and quick healing, respectively.

The promotion of ALVs is prudent as these vegetables are adapted to local environmental conditions. Available literature on yields and nutrient composition of ALVs vary greatly (Maundu *et al.*, 1999). Comparisons of yield potentials of various ALV's including *Gynandropsis gynandra* in Kisii, Nyanza Province of Kenya, pinpoint lack of fertilizer use as one of the key constraints to improved production (Onyango *et al.*, 2000). In order to increase productivity and utilization of these ALVs, there is need to develop suitable agronomic practices for farmers in specific agro-ecological zones. Most of the ALVs contain some anti-nutrients such as phenolics, glucosinolates, glyco-alkaloids and nitrates (Chweya, 1997; Onyango *et al.* 2000).

The main objective of this study was to evaluate the effect of farmyard manure and calcium ammonium nitrate on vegetative growth, leaf yield, vitamins A and C and nitrate (anti-nutrient) content of *Cleome gynandra* in Keiyo District, Rift Valley Province.

## 2.0 MATERIALS AND METHODS

The experiment was carried out between April and December, 2002 in Metkei Location, Keiyo District of the Rift Valley Province on a farmer's field. The study site lies at an altitude of 2,100 m above sea level and is within latitude 0° 20'N and longitude 35° 40'E. The site receives an average rainfall of 1,700 mm per year, with long rains starting from

April/May and ending in June/July, while the short rains occur between September and December. The mean monthly maximum and minimum temperatures are 23.8°C and 12.4°C, respectively. The soils at the site are Eutric nitisol units according to FAO/UNESCO classification (FAO/UNESCO, 1974). These soils are deep, well drained and have a dark reddish brown color. This area was chosen based on the level of utilisation of *Cleome gynandra* by the residents.

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 Mehlic method; pH using ratio 1: 2.5 and K, Na, Ca, Mg and cation exchange capacity (CEC) by leaching methods, as outlined by Page *et al.* (1982). The seeds of a locally grown *Cleome* variant with pink stem and leaf petiole pigmentation were obtained from a farmer. The seeds were directly sown in drills 30 cm apart and covered to a depth of 1cm. Thinning was done 4 weeks after planting to give a spacing of 30 cm within row and between plants.

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: 5, 10, 15 and 20 t/ha), four rates of CAN (100, 200, 300 and 400kg CAN/ha) and a 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 seeds from the same lot. The farmer periodically applied kitchen refuse on the plots as normally done. The plots were kept weed free manually throughout the experimental period. Ten plants per plot were randomly selected and tagged for data collection at week 6, 8, 10, and 12 after planting. Growth attributes were determined on five of the tagged plants, while the other five were used to measure edible leaf yield. Vitamins A (ß carotene) and C and nitrates were analysed at weeks 6 and 8 using methods by AOAC (1984), Barakat *et al.* (1955) and Cataldo *et al.* (1975), for vitamins and nitrates, respectively. Data obtained was analysed using the procedure of analysis of variance (ANOVA) using the statistical analysis package, Genstat (Lane and Payne, 1996).

## 3.0 RESULTS

The incorporation of various levels of FYM and CAN significantly improved the vegetative attributes (plant height, canopy width, stem girth and branch and leaf number) of *Cleome gynandra* (Table 1). The attributes improved with increasing levels of FYM and CAN incorporated into the soils, with FYM being generally more effective than CAN. The farmer's plants were slightly better than the controls, but had similar attributes to those raised on low levels of fertilizers. Plants grown during the first season had better vegetative growth than those of the second season.

The yields of edible leafy portions from *Cleome gynandra* grown in Keiyo District over the two seasons were generally influenced by incorporation of FYM and CAN fertilizer as well as farmer's agronomic practices (Figure 1). Incorporation of various rates of FYM or CAN significantly increased leaf yield with higher yields generally obtained during Season 1 compared to Season 2. In both seasons, higher leaf yields were obtained from plants grown on soils amended with organic rather than CAN. Increasing the amount of FYM or CAN caused a corresponding increase in leaf yield with 15 tons/ha FYM giving the highest yields of 2.25 tons/ha at the $8^{th}$ week of Season 1 and 1.58 tons/ha of edible shoots in Season 2 compared to 0.29 and 0.51 tons/ha from the controls, with 0.94 and 0.79 tons/ha from farmer-managed plots, in Seasons 1 and 2, respectively. Irrespective of the season, the second harvest (week 8), always gave the greatest leaf yield with a decline in subsequent harvests. In both seasons, the yields from the farmer's field were higher than those of control, but equivalent to those of low levels of fertilizers. The plants grown in the first season generally had higher yields than those of Season 2, which experienced water stress, as the rains were erratic. The number and length of primary and secondary roots formed by the *Cleome* plants also improved with the increasing rates of FYM compared to CAN (Figure 2).

The type and rate of fertilizer applied as well as the season of growth and age of the plant significantly influenced the ß-carotene (vitamin A precursor) content of *Cleome gynandra* (Figure 3). There was generally a greater accumulation of vitamin A during Season 1 (7-15 mg/100gm FWT) of growth compared to Season 2 (6-13 mg/100gm FWT). The incorporation of either FYM or CAN fertilizer increased vitamin A content in young and older tissues of *Cleome gynandra* during both seasons. The younger tissues of the farmer's produce were high in vitamin A in both seasons. However a variation occurred for older tissues, the levels went down in comparison to the control in Season 1, but in Season 2 it was comparable with controls.

The vitamin C content of *Cleome gynandra* edible leafy portions was influenced, significantly, by the type and rate of fertilizer applied, the season of growth, plant age and the farmer's agronomic practices (Figure 4). Irrespective of treatments, *Cleome gynandra* accumulated more vitamin C in older than younger tissues in Season 2, but younger tissues were high in the same vitamin when compared to the older tissues in Season 1. During Season 1, incorporation of FYM increased vitamin C content in both young and older tissues while in Season 2, FYM had no effect in young and old *Cleome gynandra* tissues. However, there were variations in CAN treatments. During the first season, CAN had no significant effect on vitamin C content of young tissues. In older tissues (8 weeks old) CAN at 300-400 kg/ha decreased the accumulation of vitamin C, while CAN at levels 100-200kg/ha had no effect on the same. In Season 2, CAN at 100 kg/ha had no effect, but 200-400kg/ha of CAN significantly lowered vitamin C content in young tissues. The analysis done two weeks later indicated that all CAN levels had no effect on vitamin C content in old tissues of *Cleome gynandra.* There was a significant decrease in accumulation of vitamin C in farmer's-managed produce in both young and older tissues in both seasons.

The accumulation of nitrates (anti-nutrients) in *Cleome gynandra* plants grown in Keiyo District varied with season, type and rate of fertilizer applied, age of plants and farmer's agronomic practices (Figure 5). Irrespective of treatments, *Cleome gynandra* accumulated more nitrates in older than younger tissues in both seasons. During the first season, application of CAN fertilizers at 100-200kg/ha had no effect on the accumulation of nitrates in young tissues while 300-400 kg/ha increased the nitrate accumulation. As tissues matured, all levels of the two fertilizers had no significant effect on nitrate accumulation. During the second season, incorporation of FYM and CAN had no significant effect on nitrate accumulation in both young and older tissues of *Cleome gynandra.* Nitrate accumulated in the farmer's-managed produce was comparable to the controls for both younger and older tissues in the first season. In Season 2, the younger tissues of farmer's produce contained higher levels of nitrates, while older tissues contained slightly lower levels of nitrates in relation to the controls.

## 4.0 DISCUSSION AND CONCLUSION

The vegetative growth and leaf yields of *Cleome gynandra* improved with increasing levels of FYM and CAN incorporated into the soils, with FYM being generally more effective than CAN fertilizer. The FYM and CAN fertilizer significantly improved yields of *Cleome gynandra* edible portions from about 0.29 tons/ha in the control to about 2.25 and 1.5 tons/ha, respectively. These yields were also greater than those of the farmer-managed fields (around 0.9 tons/ha). The significant yield improvement by FYM even beyond the CAN could be attributed to observed significant improvement of the rooting system, canopy width, stem girth and height, as well as number of bearing branches and leaves of the plants. Farmyard manure could have therefore facilitated vigorous growth of the plants which could have translated into the yield of the vegetable. It is also possible that there could have been lower leaching of N due to possible improved texture, structure, water holding capacity and CEC of soils amended with FYM. Salisbury and Ross (1991) and Janick (1986) reported that the promotion of vegetative growth by increasing N resulted in more succulent and bushy plants. Nitrogen promotes vegetative growth through induced leaf production and increased surface area (Hewith and Smith, 1975). A similar trend of improved vegetative growth and fresh weight with increasing N levels has been reported in other crops like kale (Chweya, 1984), *Cleome gynandra* (Mwaumba, 1993), cabbage (Sorensen, 1984), *Solanum nigrum* (Murage, 1990) and broccoli (Temblay, 1989). The lower yields during the short rainy season (Season 2), relative to Season 1, are indicative of possible inadequate moisture, high temperature and pest and disease prevalence that prevented optimum growth and development of *Cleome gynandra* plants. According to Edmond *et al.* (1975), under conditions of water deficit, plant growth is slow and the yields are low. The first harvest (pinching) done after 6 weeks stimulated branching, leading to increased yields in the second harvest (week 8). Later, the steady decline in yield after the second harvest could be due to a decline in photosynthetic leaf area caused by continued defoliation during harvesting. Similar observations were made by Onyango (1993) who reported that leaf yield of *Solanum* *nigrum* increased with each subsequent harvest until the seventh week, after which yield declined. The low yields from farmer's field could be an indication of possible below optimum application of fertilizers. Most small-scale farmers cannot afford fertilizers, hence they apply little or no fertilizers/ manure, while some use kitchen refuse to supplement (Chweya, 1993).

The ß-carotene content in edible portions of *Cleome gynandra* increased with increasing levels of FYM and CAN fertilizers. Nitrogen, which is present in appreciable amounts in both organic and inorganic fertilizers, could have facilitated formation of chloroplasts which are rich in ß-carotene (Salisbury and Ross, 1991). Application of N has been reported to improve ß-carotene content in other crops such as *Solanum nigrum* in the Central Province of Kenya (Murage, 1990), carrot (Habben, 1973) and spinach (Fritz and Habben, 1973). The unclear trends of ß-carotene content in relation to plant age suggest a possible dynamic relationship between vitamin A and its precursor, ß-carotene. Oke (1968) reported a decrease in ß-carotene content with plant age in *Cleome gynandra*. The high accumulation of ß-carotene in the second harvest during Season 2 could be attributed to unusually heavy rains received after the first harvest, which made the plants more succulent and dark green in colour (Mengel, 1979).

During Season 1, while incorporation of CAN had no influence on vitamin C content for the first harvest, FYM application caused a slight increase. Subsequent harvests generally had significantly lower levels of vitamin C content, irrespective of treatment, with FYM still recording higher levels than CAN. This effect probably resulted from competition for photosynthates between carbohydrates and synthesis of amino acids (Salisbury and Ross, 1991). The synthesis of vitamin C is closely associated with carbohydrate metabolism and when nitrogen supply is high, more photosynthates are used for the synthesis of amino acids and thus less photosynthates are available for synthesis of hexose, disaccharides and polysaccharides (Murage, 1990; Salisbury and Ross 1991). Application of N has been reported to decrease vitamin C content in other crops, such as cabbage and leek (Nilsson, 1979), *Solanum nigrum* (Murage, 1990) and several horticultural crops (Arthey, 1975). The FYM contains some appreciable amount of potassium. It could be possible that the greater amounts of K present in FYM favoured the efficient conversion of radiation energy into chemical energy, hence greater synthesis of ascorbic acid (Mengel, 1979; Salisbury and Ross, 1991). The ascorbic acid content of *Cleome* significantly increased with plant age during Season 2, results that compare with those reported for *Corchorus olitorous* (Oke, 1968) and *Cleome* (Mwaumba, 1993). As the plants grow, materials for carbohydrate biosynthesis become more available, leading to increased ascorbic acid synthesis (Oke, 1968).

The results of the present study show a greater accumulation of nitrates (anti-nutrients) in older than in younger tissues during Season 1 compared with Season 2. Accumulation of nitrates in vegetable tissues is not static and depends on the amount absorbed. The FYM is a slow release fertilizer and the slow release of N could have resulted in low nitrates accumulating in the *Cleome* plants. On the other hand, increasing inorganic N rates has similarly been reported to increase nitrate accumulation in other crops like *Amaranthus spp.* (Carlsson, 1983), *Brassica oleracea* var. acephala (Chweya, 1986), kales and collards (Kanampiu, 1987) and *Solanum nigrum* (Carlsson, 1983; Murage, 1990). Low moisture levels observed during Season 2 (dry spell) could have restricted crop uptake of plant nutrients like N (Webster and Wilson, 1980) with corresponding low nitrate levels in the edible portions of *Cleome* plants.

In summary, FYM was more effective than CAN in increasing the vegetative growth and yield, vitamin A and C, while slightly reducing the accumulation of nitrates in *Cleome gynandra* plants grown in Keiyo District of the Rift Valley. The small-scale farmers, who may not afford inorganic fertilizers such as CAN, could use FYM in the production of good quality *Cleome gynandra*. These results of the present study indicate that yield and quality of *Cleome gynandra* can be optimised by FYM fertilization as a strategy for mitigating food insecurity among resource-poor farmers.

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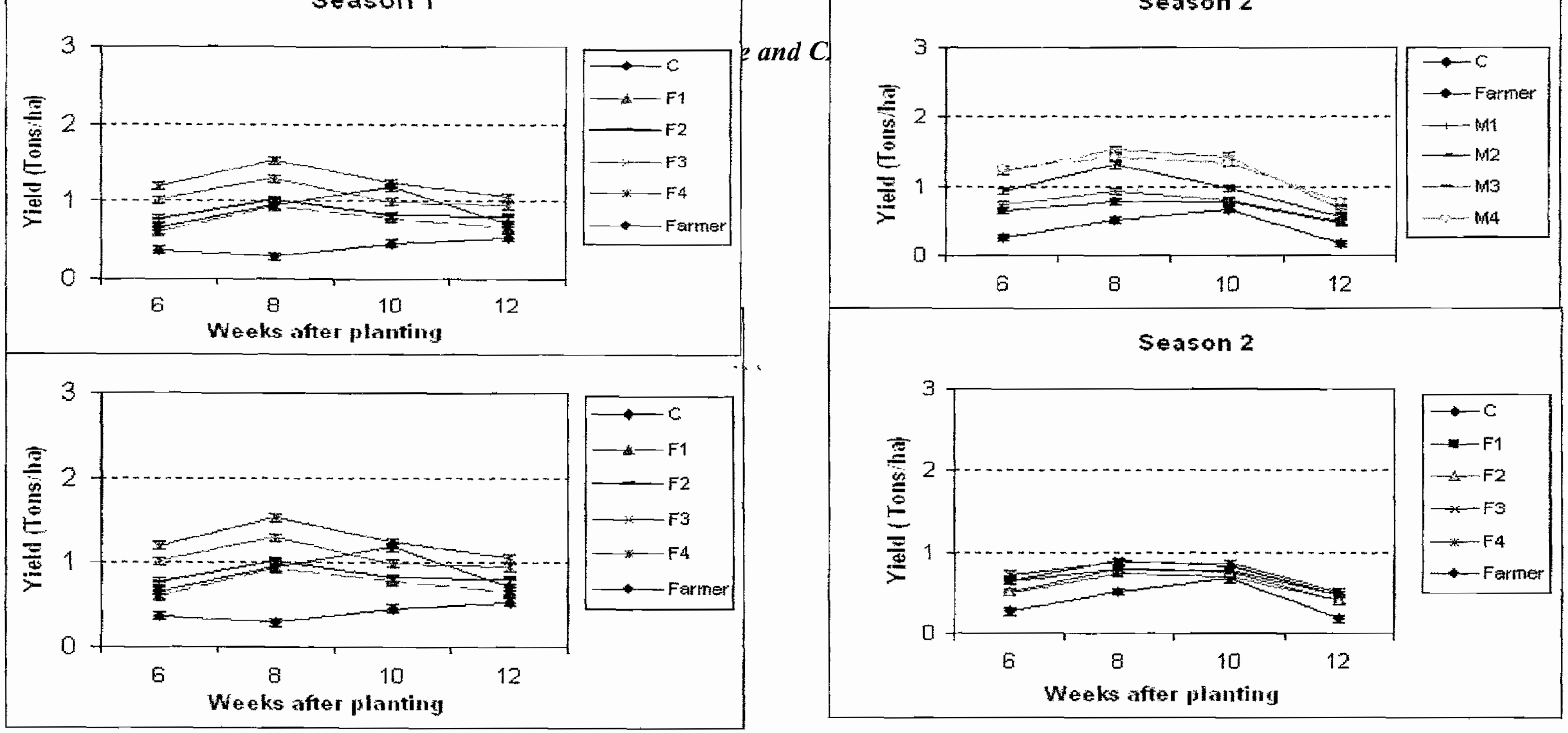
*Table 1: Effect of farmyard manure and CAN on vegetative growth of Cleome gynandra in Keiyo District 12 weeks after planting*

| Growth attribute | Season | Control | Farmyard Manure Levels (tons/ha) | | | | Calcium ammonium Nitrate (kg/ha) | | | | Farmers | SE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 5 | 10 | 15 | 20 | 100 | 200 | 300 | 400 | | |
| | 1 | 78 | 86 | 98 | 113 | 105 | 86 | 98 | 113 | 105 | 59 | 1.3865 |
| Plant height (cm) | 2 | 68 | 94 | 94 | 110 | 118 | 80 | 79 | 98 | 96 | 80 | 1.3865 |
| | 1 | 29 | 29 | 39 | 45 | 48 | 29 | 29 | 29 | 29 | 29 | 1.1675 |
| Stem girth (cm) | 2 | 35 | 39 | 44 | 49 | 45 | 34 | 34 | 38 | 39 | 34 | 0.985 |
| | 1 | 4 | 6 | 6 | 8 | 9 | 5 | 5 | 6 | 6 | 4 | 0.2833 |
| No. of branches | 2 | 7 | 10 | 10 | 13 | 13 | 8 | 9 | 10 | 10 | 9 | 0.191 |
| | 1 | 23 | 29 | 36 | 45 | 49 | 25 | 23 | 28 | 29 | 16 | 1.263 |
| Number of leaves | 2 | 14 | 20 | 21 | 26 | 25 | 16 | 17 | 19 | 19 | 18 | 0.513 |

and C



Season 1
Yield (Tons/ha)
Weeks after planting
C
F1
F2
F3
F4
Farmer
Season 2
Yield (Tons/ha)
C
Farmer
M1
M2
M3
M4
Yield (Tons/ha)
Weeks after planting
C
F1
F2
F3
F4
Farmer
Season 2
Yield ( Tons/ha)
Weeks after planting
C
F1
F2
F3
F4
Farmer

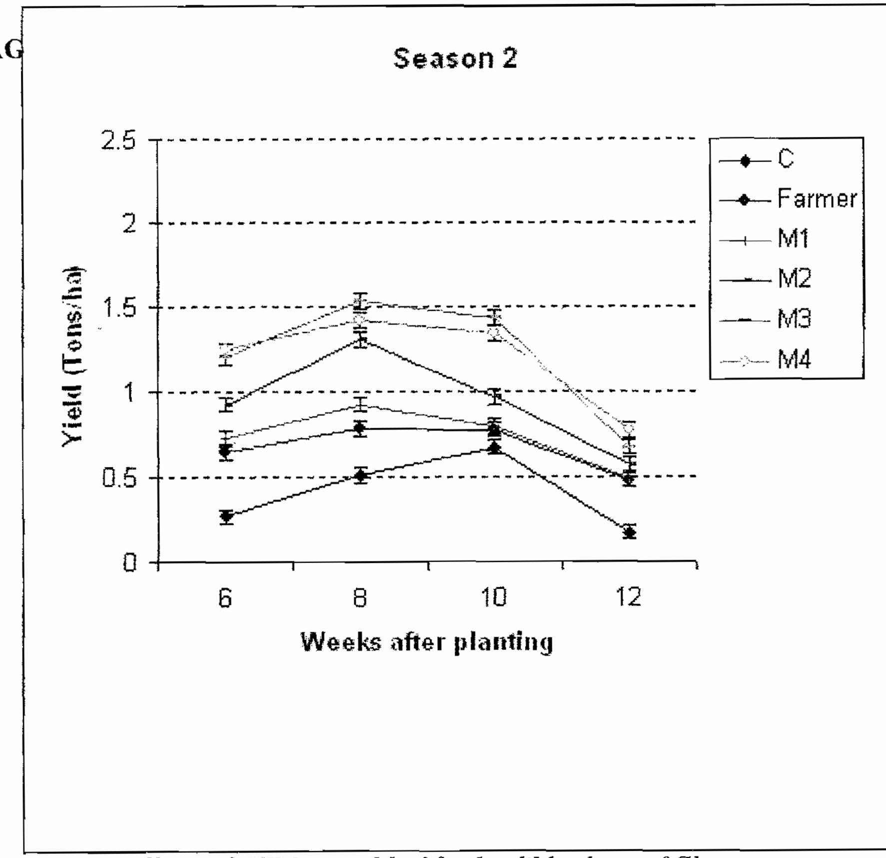



*Figure 2(a): Effects of FYM on yield of fresh edible shoot of Cleome gynandra in Keiyo District*



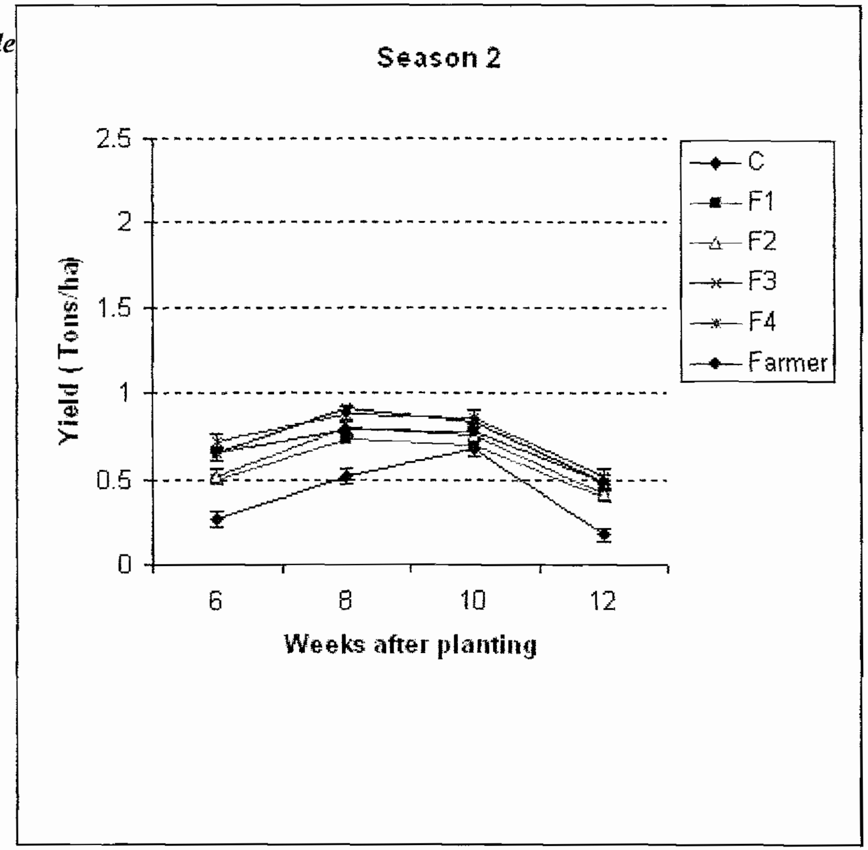
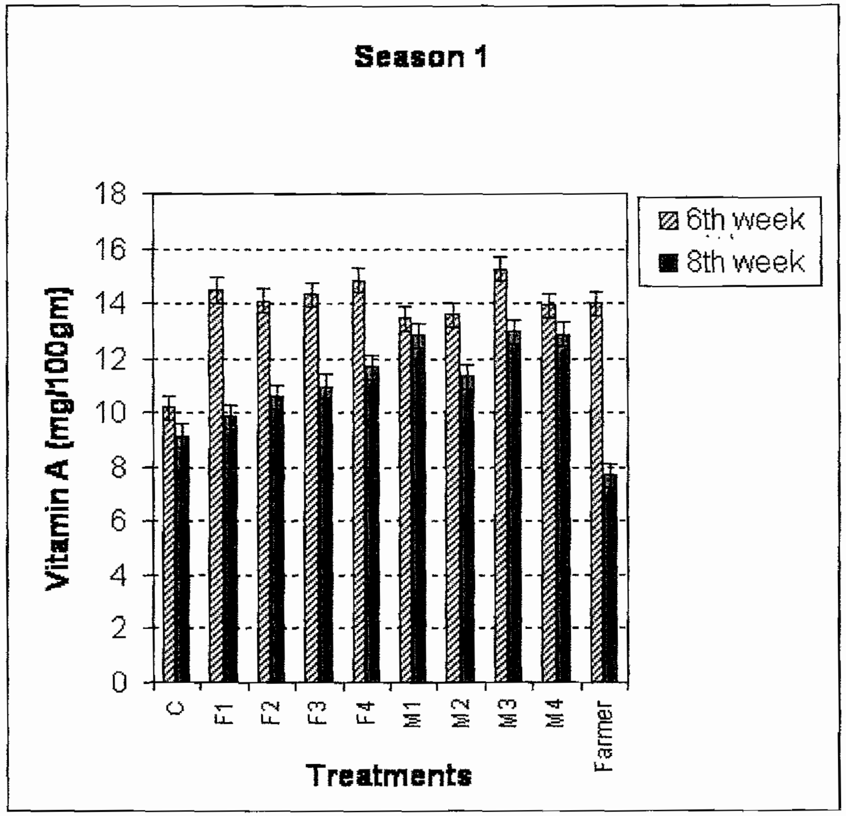



*Figure 2(b): Effects of inorganic fertilizers (CAN) on yield of fresh edible shoc of Cleome gynandra in Keiyo District*

Key:
C – Control
F1 – 100 kg/ha CAN
F2 – 200 kg/ha CAN
F3 – 300 kg/ha CAN
F4 – 400 kg/ha CAN

M1 – 5 tons/ha FYM
M2 – 10 tons/ha FYM
M3 – 15 tons/ha FYM
M4 – 20 tons/ha FYM
Cooked - cooked farmers sample



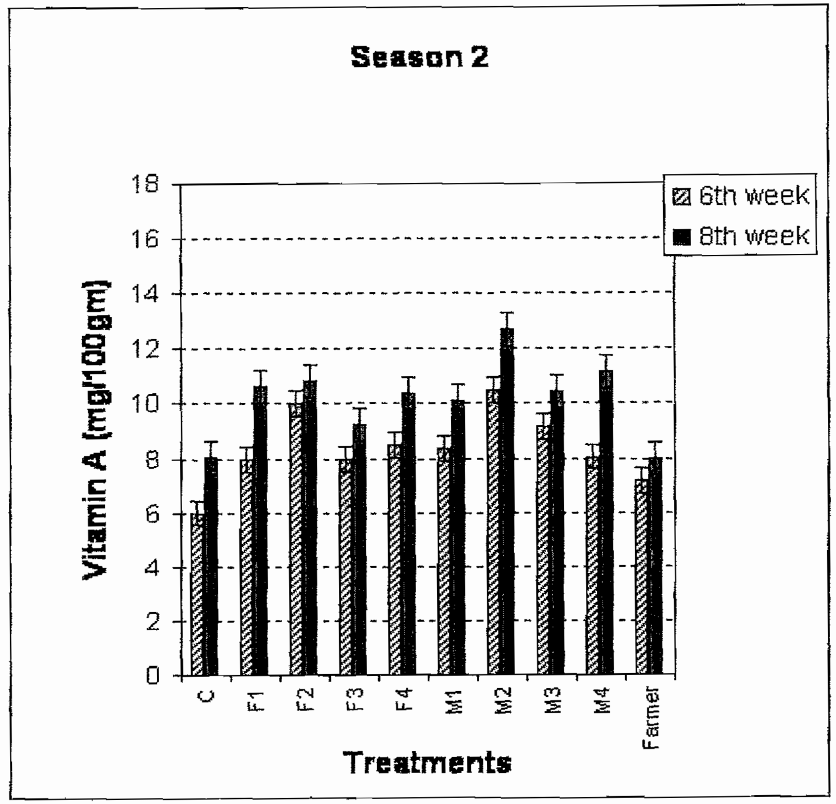
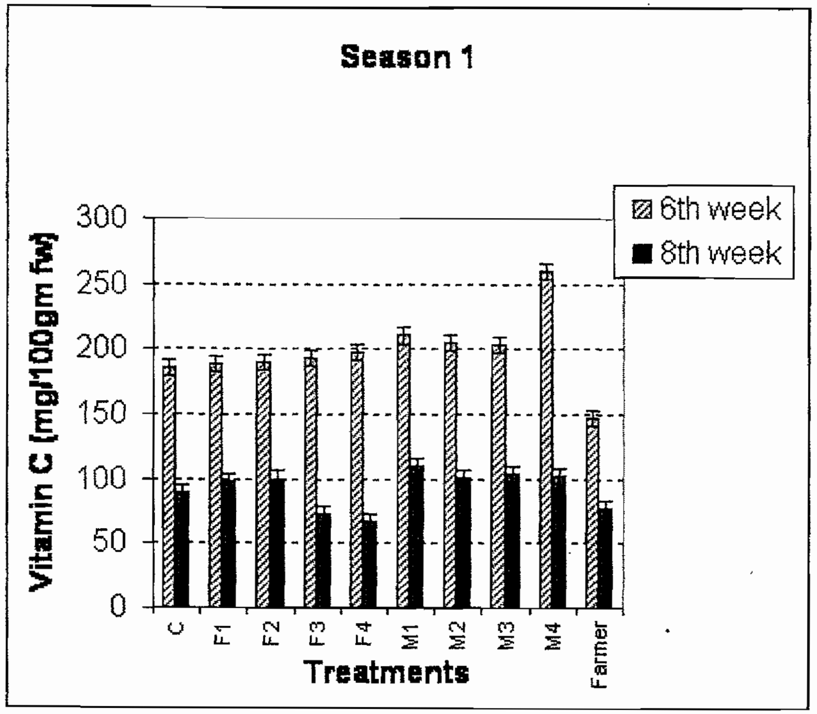




*Figure 3: Effects of farmyard manure (FYM) and calcium ammonium nitrate (CAN) fertilizers on vitamin A content of Cleome gynandra in Keyo District*
Bars represent standard errors of means

Key:
C- Control

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



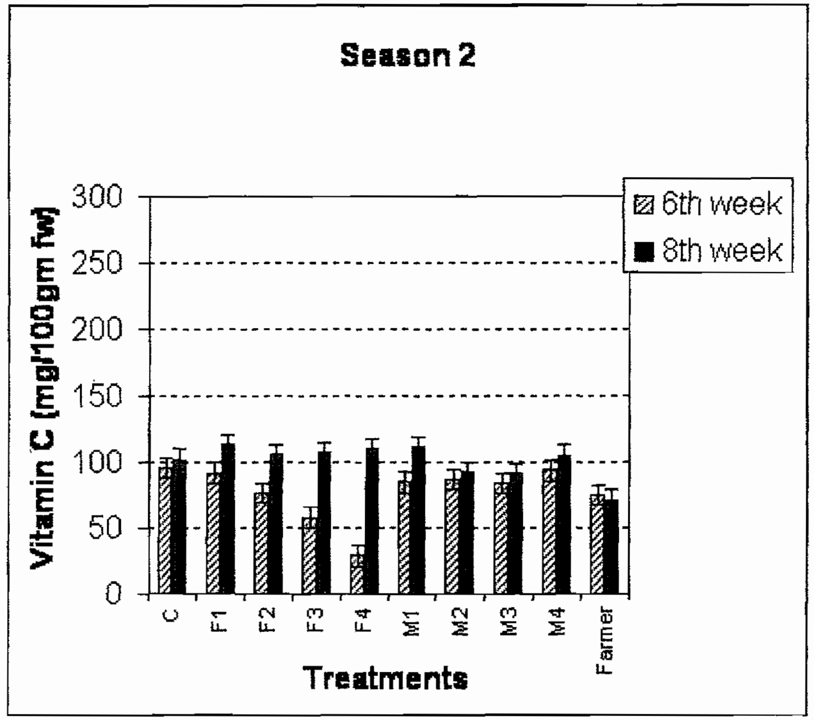




*Figure 4: Effects of farmyard manure (FYM) and calcium ammonium nitrate (CAN) fertilizers on vitamin C content of Cleome gynandra in Keiyo District*

Bars represent standard errors of means

Key:

C - Control
F1- 100kg/ha CAN
F2- 200kg/ha CAN
F3- 300kg/ha CAN
F4- 400kg/ha CAN

M1- 5tons/ha FYM
M2 - 10tons/ha FYM
M3 - 15tons/ha FYM
M4 - 20tons/ha FYM

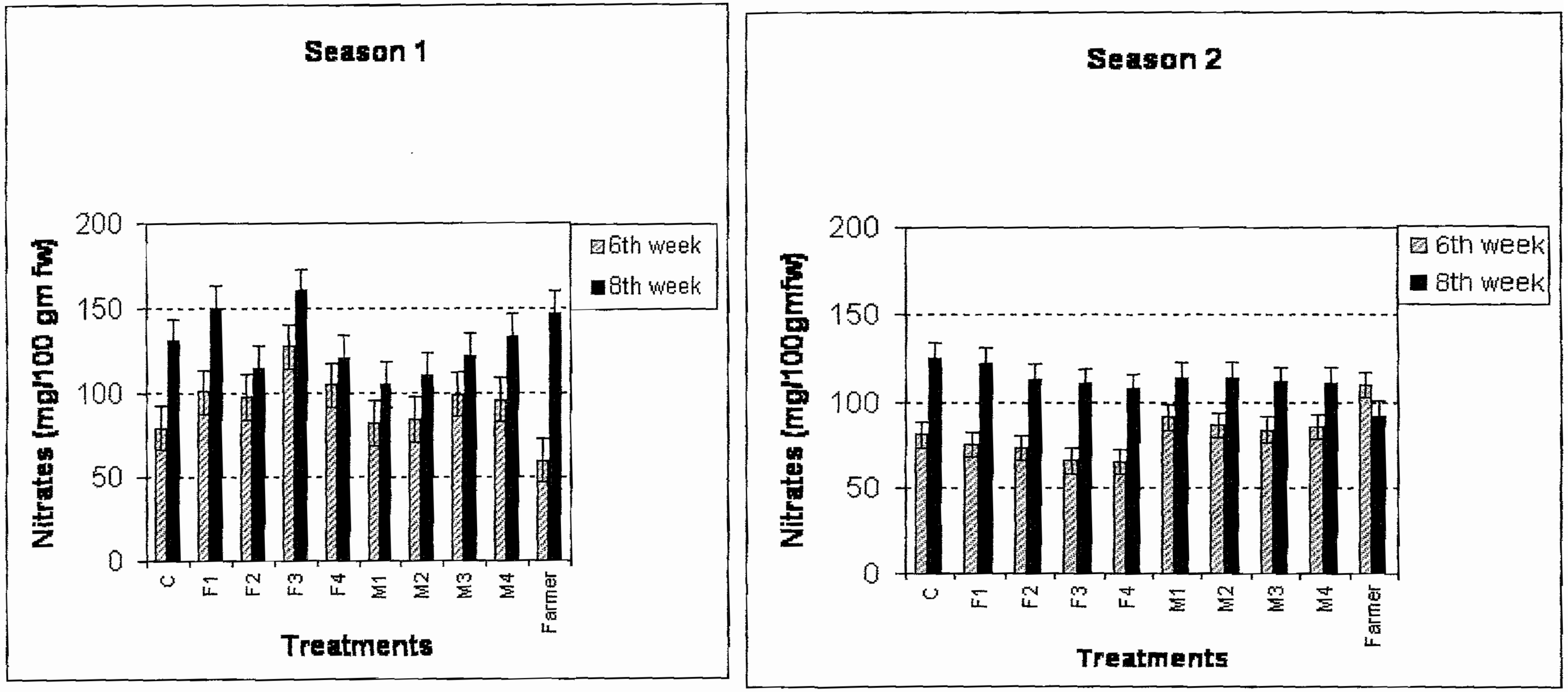



*Figure 5: Effects of farmyard manure (FYM) and calcium ammonium nitrate (CAN) fertilizers on nitrate content of Cleome gynandra in Keiyo District*

Bars represent standard errors of means

Key:

C – Control

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