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The effect of farmyard manure and nitrogen fertilizer on vegetative growth, leaf yield and quality attributes of *Solanum villosum (*Black nightshade) in Keiyo district, rift valley

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Abstract. The African Leafy Vegetables (ALVs) are particularly important as adjunct accompaniment to the staple cereal foods such as the East African corn meal (*ugali*). In order to increase productivity and utilization of these ALVs, there is needed to develop suitable agronomic practices suited for farmers in specific agro-ecological zones. A study was carried with an objective of determining the effects of various levels of Farmyard manure and Calcium Ammonium nitrate (CAN) on vegetative growth, yield and quality (Vitamins A & C, Nitrates) of *Solanum villosum* in Keiyo district, between long rains and short rains of Year 2002. Effect of prolonged cooking by the Keiyos on vitamin A and C as well as anti-nutrient (nitrate) content of this vegetable was also determined. The experimental layout was a RCBD with four replicates. The treatments were four levels of organic manure (5, 10, 15, 20 t/ha) and four rates of nitrogen fertilizers (100, 200, 300, 400 kg/ha). The addition of various rates of organic and inorganic fertilizers that were tested significantly improved vegetative growth and increased leaf yields of *Solanum villosum* ($p<0.05$). The yields obtained from plants grown with organic manure were generally higher than from those with inorganic fertilizers. The incorporation of either organic or inorganic fertilizer increased Vitamin A content especially in older (14 week) tissues during both seasons. The organic manures at high levels (20t/ha) increased, while application of C.A.N at 200-400 kg/ha decreased Vitamin C content in both young and older tissues. During the first season, application of both organic and inorganic fertilizers decreased the accumulation of nitrates in young tissues. Traditional methods of boiling the ALV's for long significantly reduced vitamin A and C and nitrates content. In all experiments, the farmer's crop, though better than the controls, were comparable to low fertilizer levels, in all attributes determined. In conclusion the quality attributes of *Solanum villosum* was influenced, significantly, by the kind and rate of fertilizer applied, the season of growth, plant age, farmer's agronomic practices as well as cooking.

Key words: African Leafy Vegetables, Farmyard manure, Nitrogen fertilizers, *Solanum villosum.*

Introduction

The role of vegetables in a balanced diet is indisputable. African leafy vegetables (ALV's) which have been neglected in the past by policy makers, researchers extension workers and even farmers is receiving renewed interest as possible substitutes to exotics vegetables in improving food security especially among the small-scale resource-poor farmers (Chweya, 1985; Onyango, 1993). As a result of prolonged neglected, most of the popular ALV's such as *Solanum* complex, *Amaranthus, Cleome gynandra* grow either in wild, semi-cultivated or as small-scale productions. Agronomic data or information that would be necessary for improving production and productivity is either lacking or too scanty to be useful. Available literature on yield, nutrient composition and preparation of ALV's vary greatly with the agro-ecological region and community.

Comparison of yield potential of some ALV's e.g. *Solanum* complex and *Cleome gynandra* among the Kisii or Nyanza, North western Kenya indicated that lack of fertilizer use was one of the key constrain to improve production (Maundu *et al.,* 1999, Onyango *et al.,* 2000).

Most of the rural communities in Kenya posses indigenous knowledge and practices that may be useful in developing packages that are acceptable and easily adopted by the various communities. The Keiyo's of Rift Valley feed pregnant and lactating mothers as well as circumcision initiates with the belief of improved production of breast milk and quick recovery, respectively. However among the Keiyo's these ALV's, which are bitter to taste, because of presence of anti-nutrients such as phenolics, glucosinolates, gluco-alkaloids and nitrates (Chweya, 1997), are boiled for long with 1 or 2 changes of water. The effect of this prolonged boiling on some nutrients especially Vitamin A, which is heat labile (Imungi and potter; 1983), is of concern to scientists and nutritionists. The main objective of the study was to evaluate the effect of F.Y.M and Inorganic nitrogen fertilizer (C.A.N) on the vegetative growth, leaf yield, vitamin A and C as well as nitrates (anti-nutrients) content of *Solanum villosum* in Keiyo district.

Materials and Methods

The experiment was carried out between April and December 2002 in Metkei Location, Keiyo district of the Rift Valley on a farmer's field. The study site lies on an altitude of 2700m above seas level and is within latitude 0º 20'N and longitude 35° 40'E. The site receives an average rainfall of 1700mm per year, with long rains starting in April/May and ending in June/July while short rains season occur 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 color.

Soil samples from the site were taken from a depth of 0-20 and 20-40cm.The samples were air-dried and ground to pass through a 2mm sieve and analyzed 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 *Solanum villosum* variant with non-serrated leaves were obtained from a farmer Mrs. E. Chepsiolei as commercial seed did not germinate. The seeds were first placed in a seedbed for 6 weeks before transplanting. Seedlings were planted at a spacing of 30x30cm on slightly raised beds.

The experimental layout was a randomized complete block design with 4 replicates. The treatments were four levels of FYM (decomposed cattle manure: 5,10,15and 20tons/ha) and four rates of C.A.N (100,200,300 and 400kg/ha). The FYM was applied one week before planting, while C.A.N was applied four weeks after transplanting when the 1st trifoliate leaf had formed.

The fields were manually maintained weed-free. Harvesting of edible portions was at various times after planting (12, 14, 16 and 18 weeks) while samples for analysis of quality attributes were taken after 12 and 14 weeks after planting. Vitamins A (ß carotene), Vitamin C and nitrates were determined using methods outlined in AOAC (1984) and Cataldo *et al.* (1975) for vitamins and nitrates, respectively. Data was analyzed using the procedure of analysis of variance (ANOVA) using Genstat computer package analysis (Lane and Payne, 1996).

Results

Vegetative growth. Incorporation of various concentrations of FYM and inorganic N fertilizer, C.A.N, significantly improved the vegetative attributes of plant height, plant width (girth), number of branches and number of leaves per plant (Table 1). The above attributes improved with increasing levels of FYM and inorganic N incorporated into the soils, with FYM being generally being more effective than inorganic N. 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 were generally better than those of season 2 in terms of the same attributes.

Yields. The yields of edible portions of *Solanum villosum* grown in Keiyo district over two seasons were influenced by incorporation of FYM and inorganic N fertilizer as well as farmer's agronomic practices. Incorporation of various rates of FYM or C.A.N significantly increased yields with higher yields generally obtained during Season 1 (long-rainy season) compared to Season 2 (short-rainy season), irrespective of treatment (Figures 1-2). In both seasons, higher yields were obtained from plants grown on soils supplemented with organic than inorganic fertilizers. Increasing the amount of F.Y.M or C.A.N caused a corresponding increase in yield with 20tons/ha F.Y.M giving the highest yields irrespective of season. In all experiments the first harvest always gave the greatest yield with a decline in subsequent harvests. In both seasons the yields from the farmers field were higher than those of control but equivalent to those of low levels of fertilizer application. Of significance was the improvement of rooting by FYM application (Figure 3). Increasing the rate of FYM improved the number and length of roots formed on *Solanum villosum* plants.

Vitamin A. The content of ß-carotene, the precursor of Vitamin A, was significantly influenced by the kind and rate of fertilizer applied as well as the season of growth and age of *Solanum villosum* tissues (Figure 4a – b). There was generally a greater accumulation of Vitamin A (8-14 mg/100gm FWT) during Season 1 (long-rainy season) of growth compared to Season

2 (short rainy season; 5-10mg/100gm FWT). The incorporation of either organic or inorganic fertilizer increased Vitamin A content especially in older (14 week) tissues during both seasons. For younger tissues, there was no significant effect during Season 1 but a varied increase during Season 2 with only 100 and 300 kg/ha C.A.N and high levels of FYM (>15tons/ha) increasing Vitamin A content in the edible portions of *Solanum villosum.* The farmer's produce was comparable with controls in both seasons. Prolonged boiling accompanied by one discharge of water depleted Vitamin A content in these tissues, although in Season 2 there was no major effect on older tissues.

Vitamin C. The Vitamin C content of *Solanum villosum* edible leafy portions was influenced, significantly, by the kind and rate of fertilizer applied, the season of growth, plant age, farmer's agronomic practices as well as prolonged boiling (Figure 5a-b). Irrespective of treatments, *Solanum villosum* accumulated more Vitamin C in older than younger tissues during both seasons of growth. During Season 1, incorporation of C.A.N decreased Vitamin C content in both young and older tissues, while all levels of organic manure had no effect on Vitamin C content of young tissues. The FYM at level 20 tons/ha increased while 5tons/ha decreased the Vitamin C content but moderate levels (10-15 tons/ha) had no effect in older tissues. However, during the second season, there was a variation in the response among different ages of tissue. In 12 week old tissues, only FYM at 15-20 tons/ha increased the Vitamin C content while 10 tons/ha of FYM decreased, but all levels of C.A.N had no significant effect. In older tissues (14 week old) CAN at 300-400 kg/ha and all levels of FYM (5-20 tons/ha) had no significant effect on the accumulation of Vitamin C. While there was no significant difference between the farmer's produce and the controls at the 12th week, there was an increase in accumulation of Vitamin C of the same in samples harvested at the 14th week during both seasons of growth. Prolonged boiling severely depleted Vitamin C content in *Solanum villosum* tissues harvested in both seasons of growth.

Nitrates. The accumulation of nitrates (anti-nutrients) in edible leafy portions of *Solanum villosum* varied with season, type and rate of fertilizer applied, age of plants, farmer's agronomic and cooking techniques among the Keiyos of Rift Valley (Figure 6a-b). During the first season, application of both organic and inorganic fertilizers decreased the accumulation of nitrates in young tissues. As tissues matured, the organic manure caused a slight increase while inorganic fertilizers showed no clear trend. During Season 2, there was a marked difference between the young and older tissues of *Solanum villosum* in the amount of nitrates accumulated. The younger tissues, generally, contained significantly much more nitrates than older tissues. Inorganic fertilizers showed no clear trend with 200 and 400 kg/ha increasing and 100 and 300 kg/ha showing no significant effect on the amount of nitrates accumulated in younger tissues. Only C.A.N at 200 kg/ha decreased while the rest (100, 300, 400 kg/ha) had no effect on the nitrate content in older tissues. On the other hand, FYM at 5 tons/ha lowered nitrate content in young tissues while increasing in older tissues. Higher rates of FYM (10-20 tons/ha) however had no significant influence on the amount of nitrate accumulation in both old and young tissues during this second season. During the first season, the farmer's produce was comparable with the controls for older tissues but contained slightly lower levels of nitrates in younger tissues. In Season 2, the younger tissues of farmer's produce contained higher levels of nitrates while older tissues were comparable with the controls. Cooking by prolonged boiling, during both seasons, severely decreased the amount of nitrates in the tissues of *Solanum villosum.*

Discussions and conclusion

The vegetative growth and leaf yields of *Solanum villosum* grown in Keiyo District improved with increasing levels of FYM and inorganic N incorporated into the soils, with FYM being generally more effective than inorganic N. Incorporation of FYM and nitrogenous fertilizer, improved yields of edible portions from about 2 tons/ha in controls to about 10 and 16 tons/ha. These yields were also greater than those of the farmers (about 4 tons/ha). Similar trends of improved vegetative growth with increasing N levels has been reported in other crops like kale (Chweya, 1984), *Gynandropsis gynandra* (Mwaumba 1993), cabbage (Sorensen, 1984) *Solanum nigrum* (Murage, 1990) and Brocolli, (Temblay 1989). FYM at the tested levels contained higher levels of N, P and K (data not shown). The significant improvement of FYM even beyond the inorganic N could be attributed to observed significant improvement of the rooting system, girth and height of plants, number of bearing branches of the plants and the higher levels of N, P and K of FYM at tested levels when compared to C.A.N. It is also possible that there could have been lower leaching of N due to possible improved soil texture, structure, water holding capacity and CEC of soils amended with FYM. Yields from farmer's field indicate below optimum levels of fertilizer (N.P.K) application. The steady decline in yield after 1st harvest could be due a decline in photosynthetic leaf area caused by defoliation. In addition, the short rainy season is indicative of possible inadequate moisture and temperature levels for optimum growth and development of *Solanum villosum* plants. Improved vegetative growth and yield usually has bearing on quality attributes of plants. The quality of *Solanum villosum* improved with incorporation of organic and inorganic fertilizers and with age of plants.

The content of ß-carotene in edible portions increased with increasing levels of fertilizers. Some of the unclear trends of ß-carotene content in the present study suggest a possible dynamic relationship between Vitamin A and its precursor, ß-carotene, being determined. Application of N has been reported to improve ß-carotene content in other crops such as *Solanum nigrum* in Kabete, Central Kenya (Murage, 1990), carrot (Habben, 1973), spinach (Fritz and Habben, 1973) and cabbage (Nillson 1979). Nitrogen facilitates formation of chloroplasts, which are rich in ß-carotene (Salisbury and Ross, 1991).

The results of the present study indicated that addition of F.Y.M and C.A.N had a varied effect on Vitamin C content of edible leafy portions of *Solanum villosum.* FYM increased, while inorganic nitrogen tended to decrease vitamin C content. Application of N has been reported to decreases vitamin C content in other crops such as cabbage and leak (Nilsson, 1979), *Solanum nigrum* complex (Murage, 1990) and several horticultural crops (Arthey, 1975). Ascorbic acid content has also been reported to significantly increase with plant age in *Corchorus olitorous* (Oke, 1968) and *Gynandropsis* (Mwaumba, 1993). It is possible that the greater amounts of K, present in FYM and higher levels of carbohydrates in older tissues, favored greater synthesis of ascorbic acid (Salisbury and Ross, 1991).

The accumulation of nitrates in vegetable tissues is not static but quite dynamic and its amount is dependent on balance of absorbed, synthesized and assimilated amounts. Results of the present study indicate a greater nitrate accumulation in older than in younger tissues. FYM and C.A.N generally either decreased or had no significant effect on levels of nitrates accumulating in tissues. Younger tissues contained higher levels of nitrates during the drier short rainy season. The lack of significant response is because nitrates are not directly involved in metabolic pathways for growth and reproduction, rather they are secondary metabolites and by products of plant metabolism. Increasing N rates has been reported to increase accumulation of nitrates in *Amaranthus spp*., *Solanum nigrum*, *Brassica oleracea* var *Acephala* (Chweya, 1986), kales and collards (Kanampiu, 1987) and *Solanum nigrum* (Murage, 1990). The significantly lower levels of nitrates in 14-week old tissues during the second season could be due to increased leaching as a result of unusually heavy rains experienced in December 2002.

The traditional method of cooking *Solanum villosum* by the Keiyos, while reducing the levels of the bitter anti-nutrient compounds such as nitrates, also depleted Vitamin A and C content in cooked tissues. The results from the present study are comparable to those reported by Imungi and Porter (1983) and Barakat *et al*. (1955). Vitamin A is soluble in water and during boiling becomes available and is subsequently lost with discharged water. Vitamin C easily undergoes heat degradation and oxidation during cooking. Being water soluble also, most of the ascorbic acid lost during cooking of vegetables can be traced to cooking water (Imungi and Potter, 1983; Mziray, 1999).

In summary, FYM was more effective than C.A.N in increasing the vegetative growth and yield, Vitamin A and C, while slightly reducing the accumulation of nitrates of *Solanum villosum* plants grown in Keiyo district of the Rift Valley than C.A.N. The small-scale farmer, who may not afford inorganic fertilizers such as C.A.N, could use FYM in the production of good quality *Solanum villosum.* The traditional method of prolonged boiling with 1 or 2 water discharges, while depleting the bitter anti-nutrient compounds such as nitrates, also depleted essential vitamin content of *Solanum villosum* tissues. These results indicate a serious compromise between actually available nutrients in cooked ALVs and perceived improved nutrition and food security of these vegetables.

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