# THE FOOD SECURITY STATUS AND NUTRIENT RESPONSE OF TRADITIONAL AND EXOTIC VEGETABLES IN THE MUMIAS SUGARCANE SCHEME

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**DECLARATION**

This thesis is my original work and has not been presented for a degree in any other University.

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RECOMMENDATION

This thesis has been submitted for examination with our approval as University supervisors.

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## DEDICATION

Father Fidelis F. Omuolo

Mother Rahab N. Omuolo

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## LIST OF ABBREVIATIONS

AVNET-Asia Vegetable Network

AVRDC-Asia Vegetable Research and Development Centre

FAO- Food and Agriculture organization of the United Nations.

FYM-Farmyard manure

HCDA-Horticultural Crops Development Authority

IPGRI-International Plant Genetic Resources Institute

LAI-Leaf area index

MSC-Mumias Sugar Company

MSS- Mumias Sugarcane Scheme

RFL-Recommended fertilizer level

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## ABSTRACT

A baseline study was conducted in October-November, 2000 in Mumias Sugarcane Scheme (MSS) to determine the potential of vegetables on food security of smallholder farmers. The survey covered 108 participating farmers. Effects of recommended inorganic fertilizer level and farmyard manure on growth, yield and nutritive quality of three vegetables were determined in on-farm experiments conducted during the 2000 short rains (SR) and 2001 long rains (LR). The vegetables included collard (*Brassica oleraceae* var *acephala* D.C.), an exotic leafy vegetable, and two traditional ones, cat's whiskers (*Cleome gynandra* (L.) Briq.) and amaranth (*Amaranthus lividus* L.). The vegetables were grown under two fertilizer treatments of recommended inorganic fertilizer level (RFL) at 50 kg Nitrogen (N) $ha^{-1}$ and 50 kg Phophorus pentoxide ($P_2O_5$) $ha^{-1}$ and farmyard manure (FYM) at 20 tonnes $ha^{-1}$ dry weight, and control (no fertilization). Treatments were laid out in a randomized complete block design in a split-plot arrangement with crop species and fertilizer types as main and sub-plot factors, respectively. Growth, yield, $\beta$-carotene and iron content were determined.

The results showed that the land allocated to vegetable production compared to other crops was very little. The ranking of various crops in order of importance showed that vegetables enjoy low status with traditional vegetables faring worse than exotic vegetables. Proper agronomic practices in particular fertilizer application and pest control are not well adopted. Therefore, there is little self-sufficiency of vegetables, which contributes to food insecurity. Fertilizer application whether RFL or FYM led to higher growth as shown by plant height, girth and total dry matter (TDM ) and yield in the traditional vegetables. However, collard did not show any difference in height under different fertilizers. Traditional vegetables showed higher heights under FYM at all growth stages. In all the crops, FYM led to higher fresh leaf yields compared to RFL. Among the crop species, collard produced higher fresh leaf yields than traditional vegetables in the SR, however, the yields of the three crops were same in the LR. Generally, higher fresh leaf yields were realized during the SR in all the crops. Fertilizer application did not affect both $\beta$-carotene and iron contents. $\beta$-carotene and iron contents did not differ among the crops. Fertilizer use should be encouraged to improve growth and yield of vegetables.

# CHAPTER ONE

## 1.0 INTRODUCTION

### 1.1 Background

The Mumias Sugarcane Scheme (MSS) in western Kenya is a net food importer in general and of vegetables in particular. This is attributed to much effort being placed on production of sugarcane at the expense of food crops. Nevertheless, sugarcane has been generating little income in recent times so that the mainly peasant farmers are increasingly facing difficulties purchasing sufficient food and inputs for food crop production. This situation has led to increasing food insecurity in the area that calls for a deliberate effort to address.

Several other factors have been cited as contributing to food insecurity in the area top of which is lack of adoption of appropriate food production technologies. The continued use of indigenous technologies in some cases is not compatible with changes in demographic and edaphic realms. However, some indigenous plants that are increasingly being ignored are vital both to the local population and to its environment. Thus, it was deemed befitting to carry out an adapting and participatory action project that could contribute to food security and hence the interface nature of this study involving both biological and social sciences.

Horticultural industry is the fastest growing agricultural sub-sector in Kenya. It contributes 23% of the GDP and is the third foreign exchange earner (HCDA, 2001). The sub-sector generates over US$ 730 million locally and US$ 200 million in foreign exchange earnings. The main horticultural activities include flower, vegetable and fruit production. The area under horticultural crops in 1999 was estimated to be 276 639 ha of which 1600 ha was under flowers, 180 000 ha under vegetables and 94 000 ha under fruits. Vegetables come fifth worldwide and fourth in Africa as compared to the other major food groups in quantitative terms (FAO, 1989).

Leafy vegetables are important dietary components in almost all societies. They are important in terms of nutritional and medicinal value. In Kenya, leafy vegetables are used as soup alongside the staple maize meal dish ('ugali' or hard porridge). Leafy vegetables can also be used to generate income especially for rural women who have little control over cash and staple crops.

**1.2 Problem statement**

The government of Kenya has over the years initiated rural programmes aimed at alleviating poverty. These initiatives have mainly concentrated on the production of cash crops for export. They include tea zones, coffee estates, and rice schemes and Sugarcane Schemes among others. Mumias Sugarcane Scheme is one such area. It is alleged that MSS is an area of vegetable deficits. A survey was therefore carried out to ascertain this fact. Mumias Sugarcane Scheme is located in Butere-Mumias district of Western Kenya. The main crop grown in MSS is sugarcane, which accounts for 44% of arable land. Others are maize, the main food crop of the region, and other cereals such as sorghum and millet. Pulses, mainly common bean, and root crops for instance arrow roots and vegetables like brassicas, tomatoes, carrots, onions and local vegetables. Others include capsicums, spinach, brinjals and chillis.

Vegetables are often seen as secondary to cereals in many parts of the developing world. Farmers, policy makers and researchers often give them less attention. Consequently, vegetable production and consumption is insufficient almost everywhere in the developing world (Gura, 1996). This has contributed to food deficit and low food security. Food Agriculture Organisation

(FAO) recommends an intake of 200 g vegetables per person per day or 73 kg per person per year. This is hardly ever achieved leading to micronutrient deficiencies mainly due to lack of vitamin A. iron and iodine, the consequence of which is what is commonly referred to as "hidden hunger" (FAO, 1996). Vegetables can be very instrumental in fighting food insecurity particularly with the poorer section of rural communities that rely on them.

This research seeks to address food insecurity in MSS by looking into adoption of vegetable production technologies. It is ironic that the area is cash crop growing and hence is expected to have a higher level of development and better food security. On the contrary, the area is a net food importer. Suggested reasons for food shortages include, poor agronomy due to low adoption of better crop production technologies such as use of good quality seed (certified seed), low fertiliser usage and poor timing (mainly late) of operations such as planting and weeding (B-M report, 1999). This study will focus on the use of fertilizer and manure. The economy of MSS is agricultural based but heavily dependent on sugarcane, the lack of proper diversification leads to food insecurity especially when the sugar industry is unstable. Social constraints include insecurity in some areas, dependency syndrome, and non-participation of men in agricultural activities and lack of initiative. Other constraints include poor infrastructure (e.g. telephone and electricity).

It has been postulated that overreliance on a single cash crop, in this case sugarcane, is the major cause of food insecurity in the area. Studies such as and Barclay (1977) and Mulama (1994) have pointed out the shortcomings of the scheme such as lack of a baseline study prior to launching of the scheme and lack of review of socio-economic conditions especially with regard to vegetable utilization.

Social cultural factors of the Luhya community (*Wanga* and *Marama* sub tribes) have been cited as retrogressive in promoting vegetable production (B-M report, 1999). Men basically leave farm work for women and children without giving them financial support. Women who are barely literate, using old technologies of production, can hardly produce enough for the household leading to food insecurity.

Agronomic factors, such as poor crop variety and poor fertilization have been ranked as the highest in determining the production of horticultural crops. Like any other crop, vegetables need fertilizer to provide plant nutrients to increase their yields. Fertilizer application is necessary because of continuous cropping and soil erosion that have led to declining soil fertility and hence low productivity (Okoko et al., 1997). Fertilizer is also important in increasing the nutritional quality of crops (Harworth, 1961; Davidescu, 1974; Shuphan, 1974). However, little fertilizer is applied in MSS to the few vegetables grown.

Several studies (Imungi, 1989; Opole, 1991; Chweya, 1992) have shown that the nutrient levels of local vegetables are much higher than those of exotic vegetables. This research seeks to establish the yields and nutritive levels of exotic vegetables compared to traditional vegetables under both recommended and farmers' conditions.

European or exotic vegetables primarily tomatoes, kale and cabbages have been heavily commercialized at the expense of indigenous vegetables (Gura, 1996). Exotic vegetables are high value crops but their production costs are also high. On the other hand local vegetables are adapted to local conditions and need less stringent requirements for their production. It has not been shown which of the two categories is more profitable under farmers' conditions.

The main challenge is on adoption of better production and specifically the use of fertilizers and manure. Currently, vegetable production in rural Kenya (even Africa) in general and Mumias in particular is hampered by use of old technologies that are inconsistent with current soil fertility status and rising population (Haas and Gura. 1996). Adoption of vegetable production technologies and in particular application of fertilizers in MSS is likely to reduce dependence on vegetable imports from neighbouring districts and hence improve food security in the area.

### 1.3 Justification

Vegetables can do well, on small portions of land. In MSS, large proportions of farms are under sugarcane and cereals leaving small areas that are poorly utilised. The unused or poorly used pieces of land could be profitably used to produce vegetables for household consumption and income if inorganic fertilizer and manure are used. Vegetables take short periods of time to mature and can be used to generate income for local people pending payment from sugarcane.

Vegetables are mainly grown by women, hence they will benefit from having enough for home use and surplus for sale, thus helping this economically deprived group. Women are often active in food production as well as in taking care of the family, and are more likely than men to suffer from malnutrition. Women are especially vulnerable to malnutrition because of their heavy responsibilities coupled with the demands of bearing children (Anzaya. 1987). Vegetable growing requires low investment of capital, especially traditional ones that are well adapted to local conditions.

Most scientific research undertakings are purely biological, having little bearing on the end users (farmers). Therefore, an inter-face involving both social and biological undertakings was used in this study and was found to be adaptable and appropriate. Vegetables can be used to address malnutrition in rural areas such as MSS. A stark picture of insufficient intake of protective food and high incidence of deficiency diseases, particularly in children is a common feature in developing countries (Mtaita, 1997).

### 1.4 Objectives

The main objective of this study was to conduct verification trials to establish the effect of types of fertilizer on yields of a selected exotic and traditional vegetable species and their potential on improving food security of smallholder farmers in the MSS.

#### 1.4.1 Specific objectives

1. To identify vegetable species grown in MSS, the types and amounts of fertilizers used and yields obtained by farmers.
2. To assess the potential of vegetables on improving food security of small holder farmers in the MSS.
3. To determine the effect of recommended inorganic fertilizer level (RFL) and farmyard manure (FYM) on growth and yield of collard (*Brassica oleraceae* var *acephala* L.), cat's whiskers (*Cleome gynandra*) and amaranth (*Amaranthus lividus* L.).
4. To determine the effect of RFL and FYM on the nutritive quality (vitamin A and iron) of collard (*Brassica oleraceae* var *acephala*), cat's whiskers (*Cleome gynandra*) and amaranth (*Amaranthus lividus*).

### 1.5 Hypotheses

1. Little land is allocated is allocated for vegetable production compared to other crops.
2. The use of fertilizer in vegetable production compared to other food crops is low.

3. The use of fertilizer and manure in vegetable production will increase yields and improve nutritive quality and hence food security in MSS.
4. There will be differences in yields and nutritive quality between exotic and traditional vegetables following the use of inorganic and organic fertilizers.

# CHAPTER TWO

## 2.0 LITERATURE REVIEW

### 2.1 Vegetables

#### 2.1.1 Importance of Vegetables

A vegetable is a herbaceous plant having an edible part that is consumed fresh, steamed or boiled, salted or unsalted, alone or in combination with other foodstuffs and sometimes an ingredient in soups or stews (Duckworth, 1966; Okigbo, 1990). Vegetables are important in combating food insecurity, which has been cited as one of the major underlying causes of malnutrition (Sebit, 1994). Increased production would considerably improve food security.

Vegetables and fruits provide nutritional quality in the diets. They are the cheapest source of protein, vitamins, minerals and essential amino acids in the diets of many rural communities in Africa. In their diversity of species, forms and texture, vegetables can supplement the diet with nutrients in a way that cannot be achieved with any other major energy providing food (Attere, 1990). Nearly all vegetables are rich in carotene and vitamin C and contain significant quantities of calcium, iron and other minerals (Okigbo, 1990). Green leafy vegetables can be used as a long term intervention of vitamin A deficiency alleviation (Lapasini, 1986). In Tanzania, Mnazava (1981) recommended an olericultural intervention to the problems affecting the physiologically vulnerable groups (school-age children and women). Vegetables are used as condiments for flavouring food and improving the appetite (e.g. onion and pepper) (Okigbo, 1990). Vegetables contribute to income generation when sold locally and to foreign exchange of producing countries if they are exported (Okigbo, 1990).

Vegetables have been known to contribute to relief in emergency situations, for example, when Bangladesh suffered from cyclones in the early 1990s, Kangkong (*Ipomea aquatica*), a fast growing semi-aquatic vegetable, played a pivotal role in food supply. There have been other such cases where refugees have had their food supply improved by vegetables (Gura, 1996).

### 2.1.2 Types of Vegetables

There are two types of vegetables based on their places of origin. These are the exotic and traditional vegetables. Exotic vegetables are the ones that were introduced by traders, missionaries and settlers mainly from Europe (Mnazava, 1990). Traditional vegetables are variously referred to as local, native or indigenous. They are all categories of plants whose leaves, fruits or roots are acceptable for use as vegetables (FAO, 1988). As the origin of these vegetables may be difficult to establish, the term traditional vegetables might be more preferable as opposed to indigenous, this is because it is difficult to trace the specific place of origin of many of these vegetables.

### 2.1.3 Exotic Vegetables

Exotic vegetables have gained a foothold in Kenya and are now more popular than the traditional ones. Gura (1996) noted that in Kenya, kale/collard, an exotic vegetable, is the daily food of the poor. Their local name,"sukuma wiki", means "carry through the week". However, collard has become the vegetable of choice to go with "*Ugali*"*, the main staple food, and hence is no longer just for the poor. Table 1 gives examples of some of the more common exotic vegetables.

Prejudice is often prevalent that European type vegetables are superior to native species. Westphal (1978) asserted that the former simply have had the benefit of more prolonged and expert selection by horticultural techniques. Vegetables introduced from Europe are difficult to grow especially in the rainy seasons (Dumont. 1966). Indeed from their early introduction. their production was restricted to pockets of favourable climate where major consumers established themselves (Mnazava. 1990). These are mainly the highlands as they are cool and therefore closely mimic temperate climates. Consequently. these vegetables demand special methods of cultivation when grown in the tropics. thus making them expensive to produce (Attere. 1990). Many European vegetables do not produce seed in the tropics. The seeds of foreign vegetables are imported from temperate countries and have to be well packed in foil to prevent rapid deterioration and hence poor germination (Epenhuijsen. 1974; Attere. 1990).

* "Ugali" is a meal prepared using maize. millet or cassava flour in boiling water either individually or in combination.

Table 1. Examples of exotic vegetables grown in Kenya.

| Botanical name | Common name | Family |
|---|---|---|
| *Allium sativum* | garlic | amaryllidaceae |
| *Apium graveolens* | celery | umbelliferae |
| *Asparagus officinalis* | asparagus | liliaceae |
| *Brassica oleraceae* var *capitata* | cabbage | brassicaceae |
| *Brassica oleraceae* var *acephala* | kale/collard/borecole | brassicaceae |
| *Daucus carota* | carrot | umbelliferae |
| *Lactuca sativa* | lettuce | compositae |
| *Lycopersicon esculentum* | tomato | solanaceae |
| *Solanum tuberosum* | potato | solanaceae |
| *Spinacia oleraceae* | spinach | chenopodiaceae |

**2.1.4 Traditional Vegetables.**

Many traditional vegetables are weedy, semi-cultivated or even wild species (IPGRI. 1999). They include a large number of species that are unrelated and locally specific. but they fulfil similar functions across Africa. Okigbo (1978) classified traditional vegetable species in Africa according to their degree of domestication and usage as: wild but harvested in times of food scarcity. wild but regularly harvested. semi-wild or protected on farmland or fallow land. cultivated in various traditional and transitional farming or cropping systems. and cultivated in market gardens and specialized horticultural projects.

There are over 20 traditional leafy vegetables that are commonly used across Africa (Chweya and Eyzaguirre, 1999). Many others are known and used only locally for example in Kenya where 200 species are used as leafy vegetables. Table 2 gives examples of some of the more common traditional vegetables.

While still locally important, indigenous vegetables are in competition with exotic vegetables which are accorded higher status and greater attention by formal development processes (IPGRI, 1999). Westphal (1978) fittingly puts it thus: "the use of traditional types of vegetables in the tropics is the result of centuries of experience, of trial and error, of choice of priorities and therefore the traditional knowledge of the use of natural resources should never be underestimated".

### 2.1.5 Factors that limit the Production of Traditional Vegetables

Demographic changes and new cultural preferences are undermining their cultivation and limiting the spread of these species into urban environments (IPGRI, 1999). It was also observed that because of their patchy, fragmented and dispersed distribution in home gardens, field margins, bush, abandoned farms, or boundaries disturbed areas along roadsides and in unused urban spaces, conservation involving protected areas or a reserve is seldom feasible. Many traditional vegetables are annual. They frequently grow spontaneously in the wet season and hence their consumption is dependent on rains. Consequently, there is little attempt to cultivate them seriously. However, when consumed they formed part of the main meal (Epenhuijsen, 1974; FAO, 1989; IPGRI, 1999).

Table 2. Examples of some of the common traditional vegetables.

| Botanical name | Local names | | Family |
|---|---|---|---|
| | English | Luhya | |
| *Amaranthus spp* | amaranth/African spinach | "dodo/libokoi" | amaranthaceae |
| *Basella alba* | malabar nightshade/ indian spinach | "inderema" | bacellaceae |
| *Brassica carinata* | indigenous kale | "kanzera/sarat" | brassicaceae |
| *Cleome gynandra/ Gynandropsis gynandra* | cat's whiskers /spider flower | "tsitsaka" | capparidaceae |
| *Corchorus olitorius* | jute mallow/bush okra | "murere" | tiliaceae |
| *Crotalaria juncea* | sunnhemp | "miro" | leguminosae |
| *Cucurbita pepo* | pumpkin | "lisiebebe" | cucurbitaceae |
| *Solanum nigrum* | black nightshade | "litsutsa" | solanaceae |
| *Vigna unguiculata* | cowpea | "likhubi" | leguminosae |

### 2.1.6 Advantages of Traditional over Exotic Vegetables

Traditional vegetables are cheap to produce and are adapted to local climates. In contrast, exotic vegetables require special methods and hence are expensive for most people. They also require to be produced in cooler climates (Epenhuijsen, 1974). Traditional vegetables produce seeds without many problems. In contrast exotic vegetables fail to produce seeds unless grown at high altitudes or in cool regions. If not well packaged, such seeds deteriorate rapidly and fail to germinate (Epenhuijsen, 1974).

Many people in the rural areas prefer bitter vegetables, which are found among the traditional vegetables such as black nightshade and cat's whiskers (Epenhuijsen, 1974). In contrast, exotic vegetables lack this bitterness. Some traditional vegetables are believed to have medicinal value and are given to the sick, or to babies (Epenhuijsen, 1974; Attere, 1990). They maintain agricultural biodiversity within farming systems, and are useful for exploiting marginal areas, microenvironments and niches (IPGRI, 1999).

Traditional food plants have higher nutritional value than the exotic food plants (Muroki, 1992; Sebit, 1994). FAO (1991) compared the nutritional composition of some traditional and exotic vegetables. Among other findings it was observed that cat's whiskers and amaranth which are traditional vegetables contain more protein, vitamins A and C as well as calcium and iron, as compared to cabbage and spinach, the widely consumed exotic vegetables (Table 3).

### 2.1.7 Collard (*Brassica oleraceae* var *acephala* D.C.)

As observed earlier (see 2.3.1), collard and kale have become the vegetables of choice in virtually all parts of Kenya including MSS. Some of the reasons thought to contribute to its popularity include the ease with which it is prepared before cooking and its simple cooking requirements. This study sought to confirm whether indeed it is true that its production is more than that of traditional vegetables. The study also sought to verify whether it yields more when grown in similar agronomic conditions with traditional vegetables.

Table. 3. Nutritional composition of cat's whiskers, amaranth, cabbage and Spinach (100 g edible portion).

| Vegetable | Protein (g) | Vit. A (mg) | Vit. C (mg) | Fe (mg) |
|---|---|---|---|---|
| Cat's whiskers | 5.4-7.7 | 6.7-18.9 | 127-177 | 11.0 |
| Amaranth | 4.0-4.3 | 5.3-8.7 | 92-159 | 4.1 |
| Cabbage | 1.4-3.3 | Tr-4.8 | 20-220 | 0.5-1.9 |
| Spinach | 2.3-3.1 | 2.8-7.4 | 1-59 | 0.8-4.5 |

Source: FAO (1991). Tr = trace.

Collard and Kale belong to the family brassicaceae or the mustard family (originally cruciferae). Collard is thought to have originated from deep south of the mediterranean region because of their popularity there (Crockett, 1972). Kale was introduced in Kenya by white settlers in the highlands as a fodder crop (Ball, 1936). Collard was introduced later as a vegetable. Both kale and collard are grown from seed but kale can be grown from offshoots (suckers) and cuttings (Gallop, 1943). Vegetable kale ranks high among greens in nutritive value (Adams and Richardson, 1977). It is served as a cooked vegetable and is a good source of vitamin A. It is used extensively as a forage crop in Northern Europe.

The acephala varieties form no head and are the closest to the wild cabbage. Varieties of acephala include: Thousand headed Kale (this branches early and produces much foliage), Marrow stemmed Kale (thick succulent stems for feeding livestock), Curled Kale (crinkled leaves) and other finer-leafed cultivars used as boiled vegetables, and Collards (smooth leaves), which form a rosette at the apex of the stem, and can stand higher temperatures than Kale.

Collard is a perennial crop but is grown as an annual. It is robust, upright plant growing to 1m high with leaves divided or oval on long leaf stalks that do not form a head. Leaves are green while the pale yellow flowers are large. Cultivars of collard include 'Georgia', 'Thousand headed', 'Scotch green', 'Dwarf green' and 'Tall green'.

### 2.1.8 Cat's Whiskers (*Cleome gynandra* or *Gynandropsis gynandra*)

Cat's whiskers is a favourite vegetable of many inhabitants of MSS, however, it grows semi-wild particularly around compost heaps, old cattle pens and such like fertile portions. But this happens within a very short period during the rainy seasons. Very little effort has been made to grow it and hence little is known about factors that affect its growth, development and yield. This study sought to find out whether this crop is indeed a favourite of the local community. The possibility of growing it on ordinary fields was explored.

Cat's whiskers is also known as spider weed or spider flower because of its inflorescence. It belongs to the family *capparaceae* sub-family *cleomoideae*. It is thought to have originated in tropical Africa and South East Asia, and to have spread to other tropical and sub-tropical countries in Northern and Southern Hemispheres (Kokwaro, 1976). The natural habitat of cat's whiskers is wasteland and arable land with annual species as well as grassland (FAO, 1991).

Cat's whiskers is an erect herbaceous annual herb, which is branched and rather stout (FAO, 1991). Depending on environmental conditions, it can grow upto 1.5m in height, but usually it is 0.5-1.0 m tall. It has a long taproot with a few secondary root hairs. Pigmentation varies from green to pink or violet to purple. Each leaf has 3-7 leaflets and are alternate. Inflorescence is upto 0.3 m in length and has terminate and axillary determinate racemes bearing flowers with long pedicels. The stem petioles are often hairy. The fruit is a long stalked dry dehiscent silique.

Cat's whisker has a $C_4$ photosynthetic pathway, an adaptation mechanism that enables it to survive dry and hot environments (Ibamba and Tieszen, 1977). It grows well upto about 1000m a.s.l. in semi-arid, sub-humid and humid climates and is adapted to many soil types, but grows luxuriantly around rubbish dumps and soils supplied with organic manure (FAO, 1991).

The tender leaves or young shoots and even flowers are eaten boiled as potherb, tasty relish, stew or side dish. The leaves are rather bitter and hence cooked with other leafy vegetables such as cowpea (*Vigna spp*), amaranth and black nightshade. It is rich in vitamin A and C, calcium and iron. It contains some proteins too. FAO (1991) stated that it contains more than the recommended adult daily allowance of vitamin A and C. However, cat's whiskers leaves contain anti-nutrients such as phenolic compounds that give it a stringent taste. It is medicinal and treats arthritis, epileptic fits, and earache, relieves chest pains and facilitates childbirth (Watt and Breyer- Bradwick, 1962; Kokwaro, 1976).

### 2.1.9 Amaranth (*Amaranthus lividus* L.).

The culinary requirements of many traditional vegetables in MSS need addition of amaranth leaves. However, like cat's whiskers, amaranth grows semi-wild, with little or no agronomic care. This study sought to find out the factors that affect growth, yield and quality of amaranth with a view to promoting its production rather than depend on the wild and semi-wild sources.

Amaranth is commonly referred to as African spinach. Chinese spinach or wild spinach. Amaranth is in the family Amaranthaceae and contains many edible species (Grubben and Sloten. 1981). The origin of the various species of cultivated amaranth is not easy to trace because the wild ancestors are pantropical and cosmopolitan weeds. However it is thought that three weedy types *A. spinosus*. *A. hybridus* and *A. dubius* are tropical types whereas *A. retroflexus*. *A. viridis* and *A. lividus* are more hot season temperate weeds (Saunders and Becker. 1983). The majority of about 60 species of amaranth occurs in the wild and is regarded as weeds. Throughout the world. however. a limited number of species are cultivated and their grain and/or leaves are utilized for human and animal consumption (Saunders and Becker. 1983; Pond and Lehman. 1989).

Amaranth is classified into two categories on the basis of use. namely grain and vegetable types (Gudu. 1985). Grain amaranth forms large heads and seeds more than vegetable amaranth. Growth habits in the genus vary greatly. Some species exhibit prostrate to erect branched to unbranched growth while colour ranges from red to green with a multitude of intermediates (Kukalow et al., 1985; Gupta and Gudu, 1990). Number of florets varies with an average of 5 florets with one staminate flower surrounded by several pistillate flowers (Kauffman and Edwards. 1982). Amaranth possesses $C_4$ photosynthetic pathway.

Amaranth is used in mixtures with other indigenous vegetables notably cat's whiskers. cowpeas and black nightshade; it is hardly consumed in isolation. In Africa. amaranth has become a valuable source of human nutrition (Uzo and Okarie. 1983; Gerson. 1991). Amaranth contains protein. vitamin A and C as well as calcium and iron (Ibamba. 1973; Anon. 1984). Ochetim et al. (undated) observed that infants and children need a daily intake of amaranth leaves of 50-100g per child to alleviate night blindness. Like other greens. amaranth contains a number of anti-nutritional factors including oxalic acid, however, when it is boiled, most of it is removed.

## 2.2 Fertilizer Use on Vegetables

### 2.2.1 The Role of Fertilizer

A number of factors determine the eventual yields of crops including vegetables. These factors include nutritional status as dictated by fertilizer and manure, soil water content, weather conditions like temperature, radiation, air humidity, photoperiod, and plant genotype. Greenwood et al. (1990) reported that some of the yield variation in vegetables (at least in onion) was associated with small changes in soil water, which also greatly influenced carbon partitioning between foliage and storage roots. Excessive water and high N was confirmed by Karlen et al. (1981) to influence physiological processes in tomato that hasten fruit maturation and softening.

Lewandowska and Skapski (1977) stated that increasing rates of N increased yields of borecole kale. Nutrition may affect development directly and hence yields e.g. in apple, N affects flowering (Hill-Cottingham and Williams, 1967). Bould and Parfitt (1973) concluded that blossom numbers of apple were almost linearly related to leaf phosphorus. The nutritional status affects the expression of genetic potential, mainly through the agency of competition (between growth centers of the same plant) which can restrict development (Landsberg, 1975).

The genotype of vegetables is an important factor in determining vegetable yields e.g. the AVRDC tomato varieties grown in Philippines have recorded a high yield of 27.21 tons/ha as compared to traditional ones that have only yielded 8.25 tonnes/ha (AVNET, 1993).

The primary purpose of using fertilizer is to provide plant nutrients to increase the yields of crops grown. The need for fertilizer has been made necessary by declining soil fertility due to continuous cropping and soil erosion leading to low productivity (Okoko et al., 1997). Crop yields (both quantity and quality) are a function of the soil in which they are grown, the climate, the management factors as well as the crop in question. This may be expressed in an equation by Fitts (1959):

Yield = function (soil, crop, climate, management)

Fertilizer has a big impact on the soil variable in the production function. Fertilizer is important in increasing the nutritional quality of crops. According to Davidescu (1974), crop quality must include three types of characteristics: nutritional value according to the contents of elements with high biological value, organoleptic quality such as taste, colour, smell and consistency, and hygienic quality in terms of both absence of pathogens, toxic chemical residues and certain natural products with toxic character or inhibitors of certain physiological processes. Mineral fertilization has been found to improve the nutritional value and baking quality of wheat (Latkovics, 1974).

The yield of spinach was affected by crop variety, type of compost and fertilizer level, however the pattern between the source of fertilizer and crop variety remained unpredictable (Knorr and Vogtmann, 1983). Correct use of fertilizer can be used to improve plant resistance to diseases (Primavesi, 1974). Copper compensates the unfavourable effects of a high dressing of nitrogen and allows better crops to be obtained without fear of an attack by fungus. In beans, N stimulated growth and pigment biosynthesis while P and Mo enhanced root nodule production (Koinov and Petrov, 1976). The fertilizer responses were greater with irrigation or in wet years than under dry conditions. Nitrogen increased yield of cabbage but P and K had little effect. High amounts of K improved quality whereas N reduced it due to split heads (Vlcek and Polack, 1977).

Carbohydrate synthesis could be reduced by excess N and hence lower glucose level. Glucose is required for the synthesis of ascorbic acid, hence the latter decreases when available fertilizer nitrogen increases (Hornick and Parr, 1987). Furthermore, excess N can diminish taste and flavour, lower resistance to diseases (rust and downy mildew), lower resistance to insects (mites and aphids) and reduce biological value of plant protein (Schuphan, 1972, 1974; Knorr and Vogtmann, 1983; Linder, 1985).

Plants fertilized with $NH_4SO_4$ produced a higher incidence of blossom end rot (BER) fruits than plants fertilized with $NH_4NO_3$. N-serve nitrogen stabilizer increased the effects of ammonium nitrate in growth and yields (Lewis and Topoleski, 1981).

### 2.2.2 Effects of Different Fertilizers

Inorganic mineral fertilizers are more widely used as compared to organic manures. Indeed, the use of the former is regarded as conventional in vegetable production (Nilsson, 1979). However, Westphal (1978) stated that the best fertilizer to use on vegetables is FYM. In the absence of FYM, market refuse, compost or green manure may be used.

Nilsson (1979) pointed out that the amount of available nutrients in the soil affected the yields of cabbage and leek independent of the type of fertilizer used. The author further noted that the type of fertilizer did not affect the nutritive value, the chemical composition or storage ability of the said crops. However, Okoko and co-workers (1997) reported that compost or FYM in combination with either half or quarter of the recommended rate of inorganic fertilizer gave the highest fresh leaf yield for both *Solanum nigrum* and *Gynandropsis gynandra*. A summary of several similar studies is tabulated (Table 4).

Table 4. Effect of organic fertilizers on crop yields relative to the use of chemical fertilizers.

| Reseacher | Crop | Organic treatment effect |
|---|---|---|
| Hansen (1981) | Potatoes, carrots, | 0 |
| | Beet roots, kale | 0 |
| Haworth (1961) | Potatoes, cabbage | + |
| Kansal et al. (1981) | Spinach | - |
| Keipert et al. (1991) | Apples, beet roots, carrots | - |
| | Spinach, leeks, cabbage | - |
| Lairon et al. (1984) | Lettuce | 0 |
| Nilsson (1979) | Carrots, leeks | 0 |
| | Cabbage | - |
| Peavy and Greig (1972) | Spinach | - |
| Schuphan (1972, 1974) | Leafy vegetables | - |
| Svec and Mok (1976) | Lettuce, tomato, pepper | 0 |
| | Peas, onion, potato | 0 |
| USDA (1980) | Wheat, corn | - |
| | Oats | 0 |
| | Soybean | + |

Source: Hornick (1992).

USDA (1980) pointed out that there was insufficient evidence to prove that organically grown produce was nutritionally superior to that grown with chemical fertilizers. It is notable that traditional leafy vegetables are conspicuously missing in the various studies carried out over the years.

One problem that arises in comparative studies between organic and conventional fertlizers is the unequal nutrient levels between seasons, within and between treatments. Consequently, it is difficult to make valid comparisons of N, P and K. The average N, P and K content (%) of cattle manure (1.9, 0.6, 1.4), swine manure (2.8, 1.3, 1.2) and poultry manure (3.8, 1.9, 1.8) vary considerably (Parr and Colacicco, 1987). N, P and K levels of plant materials also vary a lot for example alfafa hay (2.5, 0.5, 2.1), grain straw (0.6, 0.2, 1.1), soybean meal (7.0, 1.2, 1.5) and bone meal (4.0, 23, 0.0) (Maga, 1983). The levels in plant materials vary with cultural, management and processing factors. Therefore it is expected that using organic manures can lead to big differences in crop responses.

### 2.2.3 Constraints on the Use of Fertilizers

Schluter and Ruigu (1985) noted that fertilizer use in Kenya is low and most of it was applied on large farms covering only about 15% of the total area under crops. Table 5 shows the estimates of fertilizer use by farm type in Kenya in 1982/83. Furthermore, even in the smallholdings most of the fertilizer (40-60%) was applied on coffee, tea and sugarcane so that only a comparatively small amount was applied on large area of the major food crops. Indeed, Ewell (1974) had earlier stated that under-utilization of fertilizer is the most likely factor to limit agricultural production in the developing countries rather than under-utilization of improved seed and water.

Organic manure is often required in large quantities. The research recommended rates of 10-20 tonnes/ha appear to be beyond what the farmers can acquire. The availability of such large amounts coupled with transportation and application is a big challenge to the farmers. However, vegetables are grown on small portions of land that require small quantities of organic manure that are within reach of small-scale farmers. Chemical fertilizer are often too expensive for the average market gardener (Westphal. 1978). The sale and supply of these fertilizers are often irregular following rainfall patterns. International soil fertility evaluation estimates that of the additional inputs in which a farmer must invest. 40-50% of the investment will be in fertilizers (Fitts. 1959). Difficulties in the use of mineral fertilizers arise from inexperience and lack of understanding among farmers of the complexities of soil fertility (Scherer. 1969).

Many farmers in MSS insist on using mineral fertilizers even when many of them cannot afford so that they end up using much less than the recommended level. However. many of them have sufficient organic manure to support the growth of vegetables. which are commonly grown on small portions of land. Since modern farming trends are geared towards maintaining a sound environment. which means use of less pesticides and mineral fertilizer. it was deemed necessary to compare the two forms of fertilizer with a view to recommending the right one for each type of vegetable i.e. exotic and traditional.

Table. 5. Estimates of fertilizer use by farm type for financial year 1982/83.

| Farm type | Fertilizer use (metric tonnes) |
| --- | --- |
| Estates | 57 900 |
| Large farms | 33 190 |
| smallholder | 67 840 |
| Total | 158 930 |

Source: Schluter and Ruigi, 1985.

## CHAPTER THREE

# 3.0 THE FOOD SECURITY STATUS OF VEGETABLES IN MUMIAS SUGARCANE SCHEME.

### 3.1 Abstract

A baseline study was conducted in October-November, 2000 in Mumias Sugarcane Scheme (MSS) to determine the potential of vegetables on food security of smallholder farmers. The survey covered 108 participating farmers. The results showed that the land allocated to vegetable production compared to other crops was very little. The ranking of various crops in order of importance showed that vegetables enjoy low status with traditional vegetables faring worse than exotic vegetables. Proper agronomic practices in particular fertilizer application and pest control are not well adopted. Therefore, there is little self-sufficiency of vegetables, which contributes to food insecurity.

### 3.2 Background

Food insecurity has been cited as one of the major underlying causes of malnutrition in the developing world (Sebit, 1994; Hass and Gura, 1996). Lack of vegetables has been one of the factors that have greatly contributed to this state of affairs. Vegetables can be used to fight food insecurity through production for home consumption and sale (Hass and Gura, 1996). They are the cheapest source of protein, vitamins, minerals and essential amino acids in the diets of many rural communities in rural Africa. The recommended vegetable intake is hardly ever achieved leading to micronutrient deficiencies mainly due to lack of vitamin A, iron and iodine, the consequence of which is what is commonly referred to as "hidden hunger" (FAO, 1996).

Some rural communities in the Third World grow very little vegetables (Chweya and Eyzaguirre, 1999). One such community is in Mumias Sugarcane Scheme (MSS) in Western Kenya. It is thought that the main reasons for vegetable shortages include poor agronomy due to low adoption of better crop production technologies such as use of good quality seed (certified seed), low fertilizer usage and poor timing (mainly late) operations such as planting and weeding (B-M report, 1999).

The promotion of vegetable production in MSS could go a long way in addressing the high level of food insecurity in the area (Chitere et al., 1999). The purpose of this study was to assess the current situation of vegetable production in MSS and its potential in alleviating food insecurity. Thus, the objectives of the study were: (i) to identify vegetable species grown in MSS and the extent of fertilizer use by farmers (ii) to assess the potential of vegetables on improving food security of smallholder farmers in the MSS. The hypotheses of the baseline study were: (i) little land is allocated is allocated for vegetable production compared to other crops and (ii) the use of fertilizer in vegetable production compared to other food crops is low.

## 3.3 Methodology

### 3.3.1 Sample Selection

A baseline survey was carried out in October-November 2000 to assess the outlook of vegetable production and consumption in MSS. The study site consisted of 3 administrative divisions of Butere-Mumias district. These divisions were Butere, Mumias and Matungu. Four locations were selected from which 15 sub-locations were picked. One village was purposely selected from each sub-location. Villages were selected on the basis of those rated as food insecure and yet with potential to improve their food security situation. They were selected with the help of extension staff of the Ministry of Agriculture. Wealth ranking of the households into four categories: very poor (40%), poor (30%), average (20%) and rich (10%) was done. Wealth ranking was done on the basis of visible wealth indicators such as type of house (grass thatched, semi-permanent and permanent) and assets owned (size of land, number and type of livestock among others). The survey covered 108 farmers randomly selected

### 3.3.2 Data Collection

The study instrument was a structured questionnaire. Four enumerators with a minimum of secondary education and able to speak both English and *Wanga* the local dialect were recruited from the area of study. The enumerators were then trained and tested. The questionnaire was pre-tested and modified.

The respondents were household heads but more emphasis was given to wives where they were present because they are the main growers of vegetables. Where responses were not clear, probing questions were encouraged. Observations were also made as part of data collection and, in some instances, to clarify some of the responses such as size of the land and the types of vegetables grown.

Data for the following factors was collected; acreage planted to food crops, types of food crops grown, types of vegetables grown (both exotics and traditional), income generated from vegetable sales, amount of land area set aside for vegetables, inputs used notably fertilizers, manures and insecticides, source of labour for vegetable production and the main problems facing vegetable production.

### 3.3.3 Data Analysis

Data collected was analyzed using SPSS (Statistical Package for Social Sciences) for windows, Standard Version Copyright SPSS Inc., 1989-1997. Descriptive statistics, specifically percentages, were used to summarize and describe the distribution of various variables.

## 3.4 Results

The baseline survey showed that most of the respondents (66.7%) owned less than 2 ha of land, 21.3% owned between 2-4 ha while only 12% owned over 4 ha. The small pieces of land (less than 4 ha) are proof that smallholder farmers predominate in the area. The most important food crop as cited by the respondents in the long rains of the year 2000 was maize (96.3%); beans closely followed as the second most important food crop (82.4%). The rest of the crops were far behind as illustrated in Table 6.

Table 6. The main food crops grown in Mumias Sugarcane Scheme in the long rains of the year 2000 in descending order of importance.

| Crop | R | % | R | % | R | % | R | % | R | % |
|---|---|---|---|---|---|---|---|---|---|---|
| Maize | 104 | 96.3 | 2 | 1.9 | - | - | - | - | 106 | 98.2 |
| Beans | 1 | 0.9 | 89 | 82.4 | 10 | 9.3 | 1 | 0.9 | 100 | 93.5 |
| Groundnuts | - | - | 1 | 0.9 | 15 | 13.9 | 2 | 1.9 | 18 | 16.7 |
| Cassava | - | - | - | 0.9 | 1 | 0.9 | 1 | 0.9 | 2 | 2.7 |
| Other crops | 1 | 0.9 | 2 | 1.9 | 7 | 6.5 | 5 | 4.6 | 15 | 13.9 |

R-Number of respondents

Among the vegetables, collard was indicated as the most important vegetable by 50% of the respondents, 17.6% cited it as the second important crop while 6.5% reported it as the third vegetable in order of importance (Table 7). Cowpea was grown by 33.3% of the respondents as the most important vegetable followed by 31.5% who grew it as the second in importance while only 12% produced it as the third in importance. Sunnhemp (*Crotalaria juncea* or "miro") was grown as the most important vegetable crop by only 1.9%, the second crop by 9.3% and as the third by 5.6% of the respondents. Cat's whiskers was produced as the first, second and third important vegetable by 0.9, 7.4 and 12% of the respondents respectively. Amaranth was grown as the first, second and third important vegetable by 0.9, 2.8 and 8.3% of the respondents respectively (Table 2). About 46% of the respondents indicated that only 0.25 of ha would be enough to produce sufficient vegetables for their families for the whole year, 43.5% reported that 0.2 ha would do while only 10.2% thought that they needed more than that.

On income generation, 57.4% of the respondents reported selling vegetables in the short rains of the year 2000, 42.6% of them did not (Table 8). Of the vegetables that were sold, 10.2% of them were exotic and only 4.6% were traditional. A paltry 18% of the respondents said they sold both types of vegetables while 25.9% did not specify the types of vegetables they sold.

Results showed that many farmers (42.6%) applied organic manure in the form of compost or farmyard manure in vegetable production (Table 9). Only 13% of the respondents applied inorganic fertilizer. A few respondents (17.6%) reported applying both organic and inorganic fertilizers. About 27% of the respondents did not apply any type of fertilizer.

Table 7. Vegetable species grown in Mumias Sugarcane Scheme in the short rains of the year 2001 in descending order of importance.

| Crop | | | | | | | | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
| | R | % | R | % | R | % | R | % | R | % |
| Collard | 54 | 50 | 19 | 17.6 | 7 | 6.5 | 6 | 5.6 | 86 | 79.6 |
| Cowpea | 36 | 33.3 | 34 | 31.5 | 13 | 12 | 8 | 7.4 | 91 | 84.3 |
| Sunhemp ("miro") | 10 | 9.3 | 23 | 21.3 | 28 | 25.9 | 5 | 4.6 | 66 | 61.1 |
| Jute plant ("murere") | 2 | 1.9 | 10 | 9.3 | 6 | 5.6 | 10 | 9.3 | 28 | 25.9 |
| Cat's whiskers | 1 | 0.9 | 8 | 7.4 | 13 | 12 | - | - | 22 | 20.4 |
| amaranth | 1 | 0.9 | 3 | 2.8 | 9 | 8.3 | 9 | 8.3 | 22 | 20.4 |

R-number of respondents

Table 8. Types of vegetables sold by smallholder farmers in Mumias Sugarcane Scheme.

| Type | Number of respondents | Percent |
|---|---|---|
| Exotic | 11 | 10.2 |
| Traditional | 5 | 4.6 |
| Both of the above | 18 | 16.7 |
| Not specified | 28 | 25.9 |
| None | 46 | 42.6 |
| Total | 108 | 100.00 |

Table 9. The types of fertilizer applied on vegetables by small-scale farmers in Mumias Sugarcane Scheme.

| Fertilizer type | Number of respondents | Percent |
|---|---|---|
| Inorganic | 14 | 13 |
| Organic | 46 | 42.6 |
| Both | 19 | 17.6 |
| None | 29 | 26.8 |
| Total | 108 | 100 |

The baseline study revealed that 31.5 % of the respondents controlled pests using chemical pesticides (Table 10) while 42.6% of them used cultural methods, which entails applying ash. On a few occasions, juice from Mexican Marigold (*Tagetis minuta*), a weed with a pungent smell is squeezed and used as insecticide. The effectiveness of these concoctions is not authenticated. Very few farmers (8%) combined the two methods of controlling pests. About 19%of the respondents did not control the pests in any way.

Table 10. Methods of pest and disease control employed in vegetable production in Mumias Sugarcane Scheme.

| Method | Number of respondents | Percent |
|---|---|---|
| Chemical | 34 | 31.5 |
| Cultural | 46 | 42.6 |
| Both | 8 | 7.4 |
| None | 20 | 18.5 |
| Total | 108 | 100 |

An overwhelming majority (94.4%) of the respondents cited the family as the source of labour for vegetable production. Women and children provided most of the labour. Only a tiny minority of the respondents employed hired labour (1.9%). Of the many problems faced by farmers in vegetable production, pests and diseases were cited by 50% of the respondents as the most serious followed by drought (26.9%), lack of inputs (22.2%), poor prices of produce (19.4%) and hailstones (16.7%) (Table 11).

Table 11. The main problems facing vegetable production as cited by smallholder farmers in Mumias Sugarcane Scheme.

| Problem | Number of respondents | Percent |
|---|---|---|
| Pest and diseases | 54 | 50.0 |
| Drought | 29 | 26.9 |
| Lack of inputs | 24 | 22.2 |
| Low prices | 21 | 19.4 |
| Hailstones | 18 | 16.7 |
| Other problems | 25 | 23.1 |

**3.5 Discussion**

The role of vegetables on food security and health status of rural communities in developing nations is crucial. Food security exists when all people at all times have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO, 1996). Vegetables are seen as secondary to cereals in many parts of the developing world and hence its production and consumption is insufficient (Gura, 1996). This relegation of vegetables denies many resource poor people what Moomaw (1979) described as man's greatest natural source of nutritional improvement through their supply of vitamins, minerals and plant proteins.

Like in any other area in the developing world, bias against vegetables is common in MSS. Mumias Sugarcane Scheme is primarily a cash crop area in sugarcane (Ochieng, 1981). Consequently, other crops are neglected. Little land is spared for the main food crops such as maize. beans and cassava. Vegetables are allocated even less land as they are treated as a subsistence crop.

Majority of the small-scale farmers (66.7%) in MSS own less than 2 hectares of land. Very little of these pieces of land are set aside for vegetable production. The observed average size of land used for vegetable production was the size of a kitchen garden. which is about 5-10 $m^2$ (0.0005-0.001 ha). The result is the never-ending shortage of vegetables especially during the dry seasons.

Hence, vegetables are imported from the neighbouring districts of Bungoma and Mt. Elgon. In this study, the majority of the respondents (46.3%) reported that only 0.1 ha would be enough to produce sufficient vegetables for their families all year round while 43.5% thought 0.2 ha would do.

According to Oomen and Grubben (1978), poor people usually consume traditional leafy vegetables like cat's whiskers, amaranth and blacknightshade. The situation in MSS is different because it is collard, an exotic vegetable that is most commonly grown and consumed. Most of the imports from the neighbouring districts comprise collard. cabbage and tomato. all exotics. Although traditional vegetables require little investment and are adapted to the local environment, they have clearly been neglected in MSS. A practice of producing traditional vegetables like any other crop has not taken root. Many people still source them from those that grow wild or semi-wild. This is in conformity to the findings of Okigbo (1978) and IPGRI (1999).

Okigbo (1990) noted that vegetables contribute to income generation when sold locally. Haas and Gura (1996) established that vegetables grown in the home garden have the double advantage of bringing self-reliance in high quality foodstuffs and higher income from selling surplus produce. Vegetables contribute to little income in MSS where 42.6% of the respondents indicated they did not sell any vegetables. Those who sold did earn very little because of small quantities produced. There is, therefore, need to promote vegetable production especially the well-adapted local varieties to improve income or at least save money used on imports. Recommended production practices, such as use of fertilizer and appropriate methods of pest and disease control in vegetable production in MSS is not well adopted leading to insufficiency of vegetables.

Proper timing of growing seasons could reduce some of the problems that limit vegetable growing in MSS. Diseases, hailstones and poor prices are some of the serious problems that occur during the long rains. Growing vegetables during the short rains would minimize these problems. A possibility of using irrigation during the dry season is likely to eliminate the problem of hailstones and low prices because the demand for vegetables usually rises sharply during this period. The use of irrigation is feasible because river Nzoia (a big river) crosses through the area as well as many smaller all season rivers and streams. Besides, the water table in MSS is high hence the possibility of using wells for farmers who are away from rivers exists.

Lack of inputs like fertilizer and chemical pesticides contribute greatly towards poor yields of vegetables. Many respondents (42.6%), however, reported that they did apply organic manure (farmyard manure or compost) while only a few (13%) applied inorganic fertilizer. Therefore, organic manure could be promoted on the basis of its availability in this area.

### 3.6 Conclusion

Based on the hypothesis that the study set out to test, it is indeed true that land set aside for vegetable production was too little for sufficient production of vegetables for home consumption let alone for sale. The status of vegetables is very low compared to the other food crops in MSS. The use of fertilizer (regardless of type) on vegetable production was found minimal relative to the recommended rate. However, there is potential for vegetables to play a bigger role in food security as shown by some farmers who made effort to sell vegetables.

There is a shortage of vegetables in general and in the dry seasons in particular. Collard, an exotic vegetable, is the most widely grown as compared to traditional vegetables. Traditional vegetables are produced using traditional methods as opposed to properly researched agronomic practices. Thus, it can be concluded that vegetable production is neglected. The results of the baseline were used to select three vegetable crops; the preferred exotic vegetable collard and two neglected traditional vegetables, cat's whiskers and amaranth to be entered into trials and demonstrations with participating farmers. The trials involved the use of inorganic manure and farmyard manure on growth, yield and nutritive quality ($\beta$-carotene) of the three vegetable crops.

CHAPTER FOUR

# 4.0 EFFECTS OF RECOMMENDED INORGANIC FERTILIZER LEVEL AND FARMYARD MANURE ON GROWTH, YIELD AND NUTRITIVE QUALITY OF COLLARD (*Brassica oleraceae* var *acephala* D.C.), CAT'S WHISKERS (*Cleome gynandra* (L.) Briq.) AND AMARANTH (*Amaranthus lividus* L.).

## 4.1 Abstract

Effects of recommended inorganic fertilizer level and farmyard manure on growth, yield and nutritive quality of three vegetables were determined in on-farm experiments conducted during the 2000 short rains (SR) and 2001 long rains (LR). The vegetables included collard (*Brassica oleraceae* var *acephala* D.C.), an exotic leafy vegetable, and two traditional ones, cat's whiskers (*Cleome gynandra* (L.) Briq.) and amaranth (*Amaranthus lividus* L.). The vegetables were grown under two fertilizer treatments of recommended inorganic fertilizer level (RFL) at 50 kg Nitrogen (N) $ha^{-1}$ and 50 kg Phophorus pentoxide ($P_2O_5$) $ha^{-1}$ and farmyard manure (FYM) at 20 tonnes $ha^{-1}$ dry weight, and control (no fertilization). Treatments were laid out in a randomized complete block design in a split-plot arrangement with crop species and fertilizer types as main and sub-plot factors, respectively. Growth, yield, $\beta$-carotene and iron content were determined. Fertilizer application whether RFL or FYM led to higher growth as shown by plant height, girth and total dry matter (TDM) and yield in the traditional vegetables. However, collard did not show any difference in height under different fertilizers. Traditional vegetables showed higher heights under FYM at all growth stages. In all the crops, FYM led to higher fresh leaf yields compared to RFL. Among the crop species, collard produced higher fresh leaf yields than

traditional vegetables in the SR, however, the yields of the three crops were same in the LR. Generally, higher fresh leaf yields were realised during the SR in all the crops. Fertilizer application did not affect both $\beta$-carotene and iron contents. $\beta$-carotene and iron contents did not differ among the crops. Fertilizer use should be encouraged to improve growth and yield of vegetables.

## 4.2 Introduction

Vegetables are often seen as secondary to cereals in many parts of the developing world where their production and consumption is insufficient (Gura, 1996). Vegetable crops provide man's greatest natural source of nutritional improvement through their supply of vitamins, minerals and plant protein (Moomaw, 1979). Food and Agriculture Organization of the United Nations (FAO) recommends an intake of 200g of vegetables per person per day (FAO, 1996). However, this is hardly ever achieved leading to micronutrient deficiencies mainly due to lack of vitamin A and Iron. The result of this is what is commonly referred to as "hidden hunger". In the past, traditional vegetables of a given area dominated the diets of the inhabitants so that different societies had different consumer habits (Mnazava, 1990). With the introduction of exotic vegetables, however, many traditional vegetables have been neglected.

Studies have revealed that traditional vegetables have higher nutritional value than exotic food vegetable plants (Sebit, 1994). For instance, cat's whiskers and amaranth contain more protein, vitamins A and C as well as calcium and iron, as compared to cabbage and spinach, the widely consumed exotic vegetables (FAO, 1991). However, presently, these crops are not grown much because of many reasons among them are undeveloped agronomic practices. Agronomic factors which can affect crop growth, yield and quality may include crop species, fertilizer type as well as its quantity and quality, plant spacing and protection against weeds and diseases. Of these factors, fertilizer type ranks high (USDA, 1980).

Fertilizers influence the growth, yield and quality of vegetables. Fertilizer packages (mineral as well as organic fertilizers) for exotics have been recommended. Although there are recommended fertilizer packages for traditional vegetables, they are not sufficiently tested especially at on-farm level. The effects of these fertilizer packages on growth, yield and quality of exotics compared to traditionals need to be determined. The objective of the study was to determine the effects of recommended inorganic fertilizer level (RFL) and farmyard manure (FYM) on growth, yield and nutritive quality ($\beta$-carotene and iron) of collard, cat's whiskers and amaranth.

**4.3 Materials and methods**

An exotic vegetable, collard (*Brassica oleraceae* var *acephala* D.C.) cultivar Georgia, and two traditional vegetables, cat's whiskers (*Cleome gynandra* (L.) Briq.) and African spinach/amaranth (*Amaranthus lividus* L.), were grown on-farm in Mumias Sugarcane Scheme (MSS) of western Kenya (1270 m above sea level, 0° 23.6` N and 34° 28` E). Mean annual pan evaporation is about 1687.1 mm (MSC, 2000). Rainfall is bimodal with the LR(LR) falling between March and June while short rains (SR) fall in the months of August to November. Mean annual precipitation is 2018.13 mm. Temperatures range from 24-33°C with a mean minimum and maximum of 14.6 and 29.7°C, respectively. The soils are classified as plinthic to ferralorthic acrisol (Jaetzold and Schimidt, 1982).

The experiments were carried out in the 2000 SR and 2001 LR. There was a change of rainfall pattern from the norm as the SR prolonged from August to mid-January while the LR delayed slightly and fell from April to July. The experimental design was randomized complete block design in a split-plot arrangement with four replicates. Crop species and fertilizers were main and sub-plot factors, respectively. The experimental plot size was 2.5m x 4m. The fertilizers were RFL and FYM. Control (an untreated check) was included. The RFL (inorganic fertilizer) was 50 kg $P_2O_5$ $ha^{-1}$ applied as triple superphosphate (TSP) with a top dress of 50 kg N $ha^{-1}$ as urea (FURP, 1988). Urea was used since it is the most readily available and commonly used form of nitrogen fertilizer in MSS. FYM was used at a rate of 20 tonnes $ha^{-1}$ (dry weight) as recommended by a previous study (Obiero, 1996).

Land preparation was done with hand hoes to fine tilth. Collard seeds were planted in a nursery for four weeks to establish the seedlings. They were transplanted at a spacing of 0.3m x 0.6m (research recommended practice). The local variety of cat's whiskers seeds were drilled thinly in shallow grooves spaced 0.45m apart and covered with soil to a depth of 0.1m. Locally cultivated amaranth seeds were similarly sowed but the grooves were 0.3m apart. Thus, there were 6 rows of cat's whiskers and 8 rows of amaranth per plot. Upon emergence, the indigenous seedlings were thinned to maintain a spacing of 0.15m within rows. All plots were kept free of weeds by two hand weedings in the course of each experiment. Insect pests, especially the aphids, and diseases were controlled as recommended in the FMHK (1989). The plants were top dressed with urea two weeks after transplanting (collard) and planting (traditional vegetables).

Data on various variables was collected upon sampling plants from the middle rows. Data on growth variables was determined at 15, 30, 45 and 60 DAP on the same plants throughout. The growth variables were height, girth and total dry matter (TDM). Five plants were chosen in each plot for determination of height and girth. Girth was measured at the base using a 0.15m rule. For TDM, only two plants were sampled from each plot. Total dry matter determination involved uprooting whole plants in the second season only. The plants for TDM determination were then put in polybags and transported to the laboratory at Kabete campus of the University of Nairobi within 24 hours. Their fresh weights were determined followed by drying at $60^0$C for 72 hours in a forced air oven (model number TV80 UL 508032, Memmert, Germany). After drying, the samples were reweighed to determine their dry weights, which is the TDM.

Fresh leaf yield was determined on five plants per plot at 30, 45, 60 and 75 DAP. This was done by plucking the lower fully expanded leaves of collard and the edible shoots of traditional vegetables. The leaves and shoots were then weighed immediately while still fresh. Three plants per plot were sampled for determination of seed yield. The plants were dried, threshed, winnowed and the seed weighed.

Nutritional quality of the leaves was ascertained once at 45 DAP during the 2001 LR. This is the flowering stage which is the time of peak nutrient content as assumed by the local consumers. Nutritional quality was determined on one plant randomly selected from each plot. It was done by determining the amounts of $\beta$-carotene (a precursor of vitamin A) and iron content. Plants for $\beta$-carotene determination were uprooted, wrapped in polybags and transported within 24 hours to the Department of Food Technology and Nutrition at the University of Nairobi for laboratory analysis.

$\beta$-carotene was determined spectrophotometrically after extracting with petroleum ether according to AOAC (1984). Iron content was also determined on the same plants in which $\beta$-carotene was determined. The samples were first dried in the oven before iron content was determined using dry ashing as a digestion technique according to AOAC (1980). Plants for seed determination were uprooted at 102 DAP during SR and at 131 DAP during the LR, dried for a day before being threshed and the seed weighed. The plots used during the first season were reused in the second season.

### 4.4 Statistical analysis

Data was subjected to analysis of variance (ANOVA) using general statistics (GENSTAT) software, PC/windows (Lawes Agricultural Trust, Rothamsted Experimental Station, 1995). Mean differences among treatments were compared using the least significant difference (LSD) procedure at 5% level of significance (Steel and Torie, 1981).

### 4.5 Results

#### 4.5.1 Plant growth

Height of collard was not affected by type of fertilizer at all sampling dates in both seasons (Fig.1). Fertilizer application led to taller plants in cat's whiskers and amaranth compared to control at all sampling dates. Of the two fertilizers, FYM led to taller plants than RFL. Generally, cat's whiskers produced the tallest plants followed by amaranth, while collard had the shortest plants. Plants grown in the LR were taller than those grown in the SR.

Fertilizer application led to increase in girth of all crops in both seasons (Fig. 2). Initially (15 and 30 DAP), fertilizer application did not affect the girth of collards. However later at 45 and 60 DAP there was no difference in girth between those grown in RFL and FYM. Farmyard manure produced thicker girths in cat's whiskers compared to RFL at all growth stages except at 15 DAP. In LR, there was no significant difference in cat's whiskers girth between plants grown in RFL and the control. In amaranth, FYM led to thicker girths at all growth stages compared to

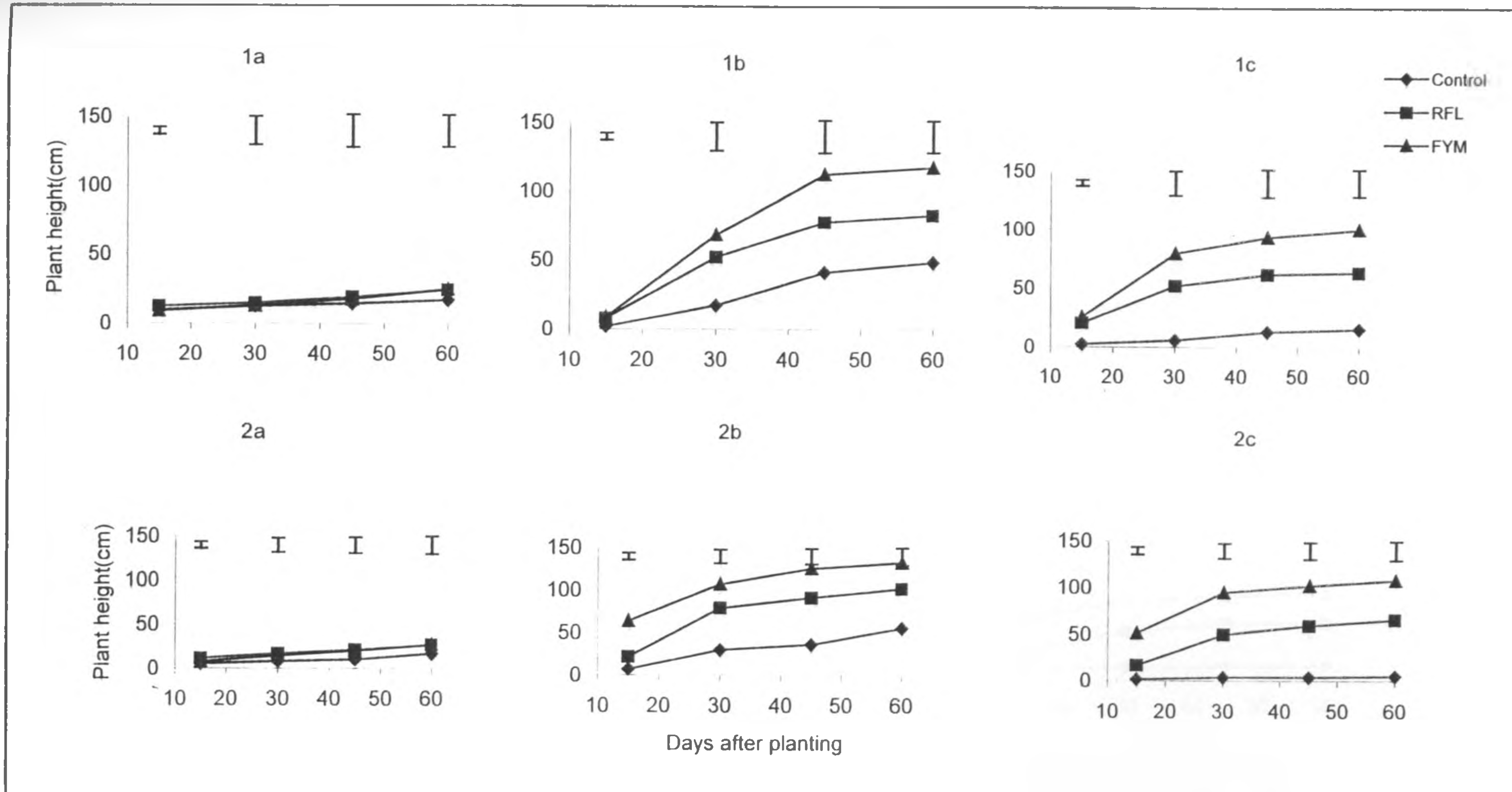


**Fig 1.** Effect of recommended inorganic fertilizer level (RFL) and farmyard manure (FYM) on height (cm) of collard (a), cat's whiskers (b) and amaranth (c) in 2000 short rains(1) and 2001 long rains(2). Vertical bars are LSD bars

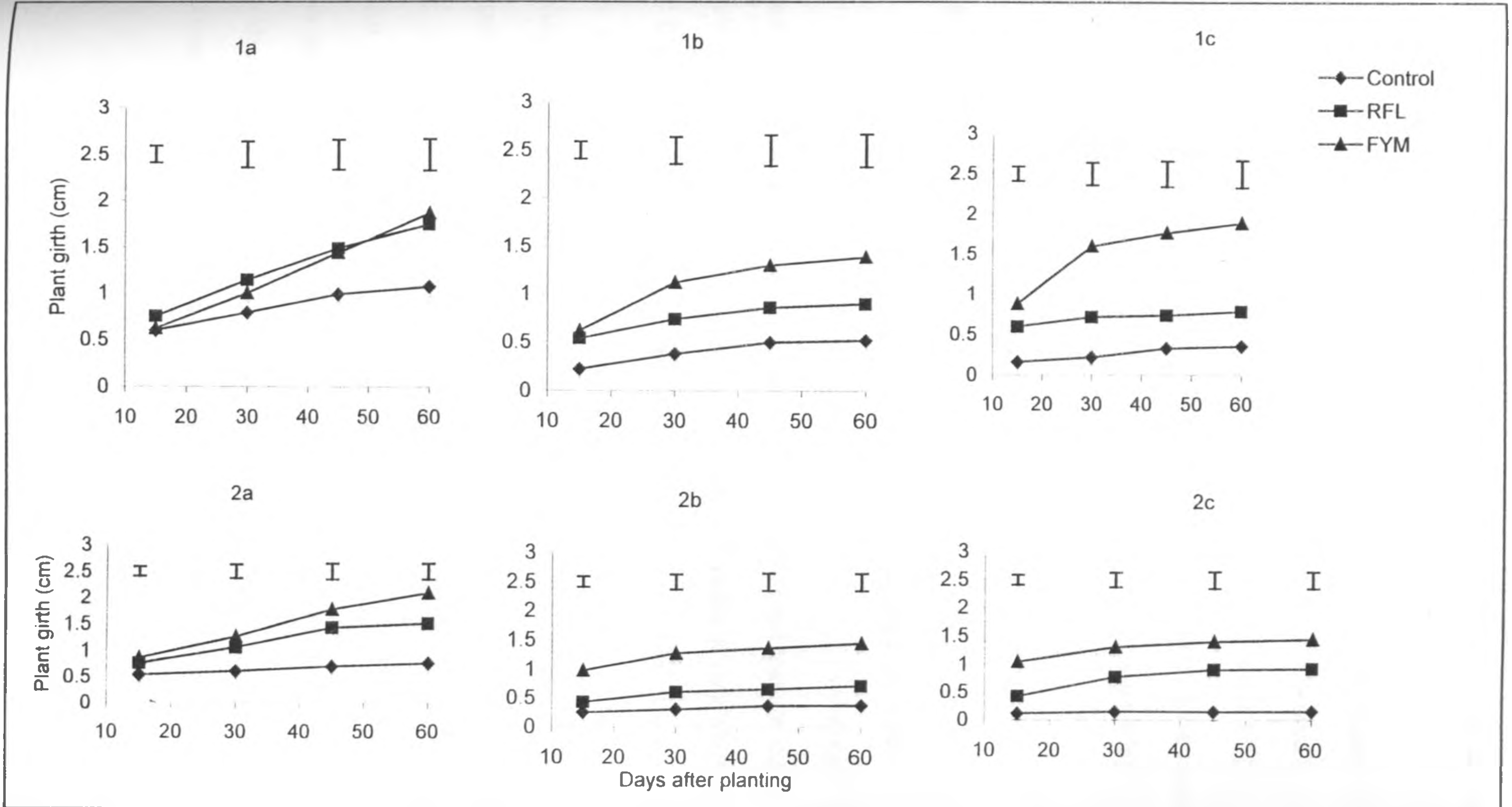


**Fig 2.** Effect of recommended inorganic fertilizer level (RFL) and farmyard manure (FYM) on plant girth (cm) of collard (a), cat's whiskers (b) and amaranth (c) in 2000 short rains(1) and 2001 long rains(2) Vertical bars are LSD bars

RFL. The control plants had the smallest girths. Plants grown in the LR had thicker girths than those grown in the SR.

Fertilizer application led to increased TDM at all growth stages (Fig. 3). Farmyard manure led to the highest TDM at all growth stages for all crops followed by RFL except at 15 DAP when the latter had no effect. Collard had the highest TDM at 15 DAP, but it was not different from cat's whiskers at 30 and 45 DAP. All the crops did not have significantly different TDM at 60 DAP. Generally, FYM le to the highest TDM. Collard had the highest TDM followed by cat's whiskers while amaranth had the least.

### 4.5.2 Yield and yield components

In the SR, the first and second harvest of fresh leaf yield of collard was not affected by fertilizer application (Fig. 4). However, increased fresh leaf yields were observed with fertilizer application in the second, third and fourth harvests. Farmyard manure led to the highest leaf yield followed by RFL and then control. The fresh leaf yields of cat's whiskers only differed at 30 DAP. Higher yields occurred with FYM, followed by RFL while the control had the lowest. No significant differences among fertilizer types were noted at 45 and 60 DAP. Amaranth produced more fresh leaf yield with only FYM treatment at 30 and 45 DAP. There were no significant differences among fertilizer types at 60 DAP.

In the LR, the harvesting period was shorter than the SR. Collard was harvested up to 60 DAP while both traditional vegetables were harvested only up to 45 DAP. The shorter lifespan was attributed to severe hailstones that occurred at 31 and 40 DAP, excessive rains and disease incidences. Fertilizer application increased leaf yields in all the plants. Although FYM gave the highest yields, the difference was not significant compared to RFL at the first harvest (30 DAP)

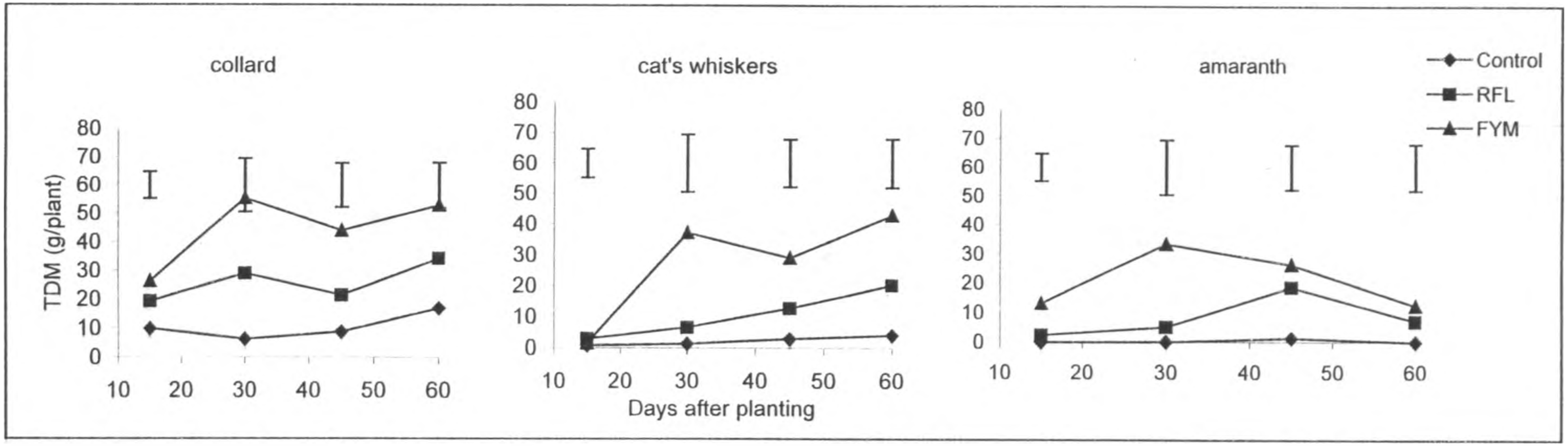


**Fig 3.** Effect of recommended inorganic fertilizer level (RFL) and farmyard manure (FYM) on total dry matter (TDM) of collard, cat's whiskers and amaranth during the 2001long rains. Vertical bars are LSD bars.

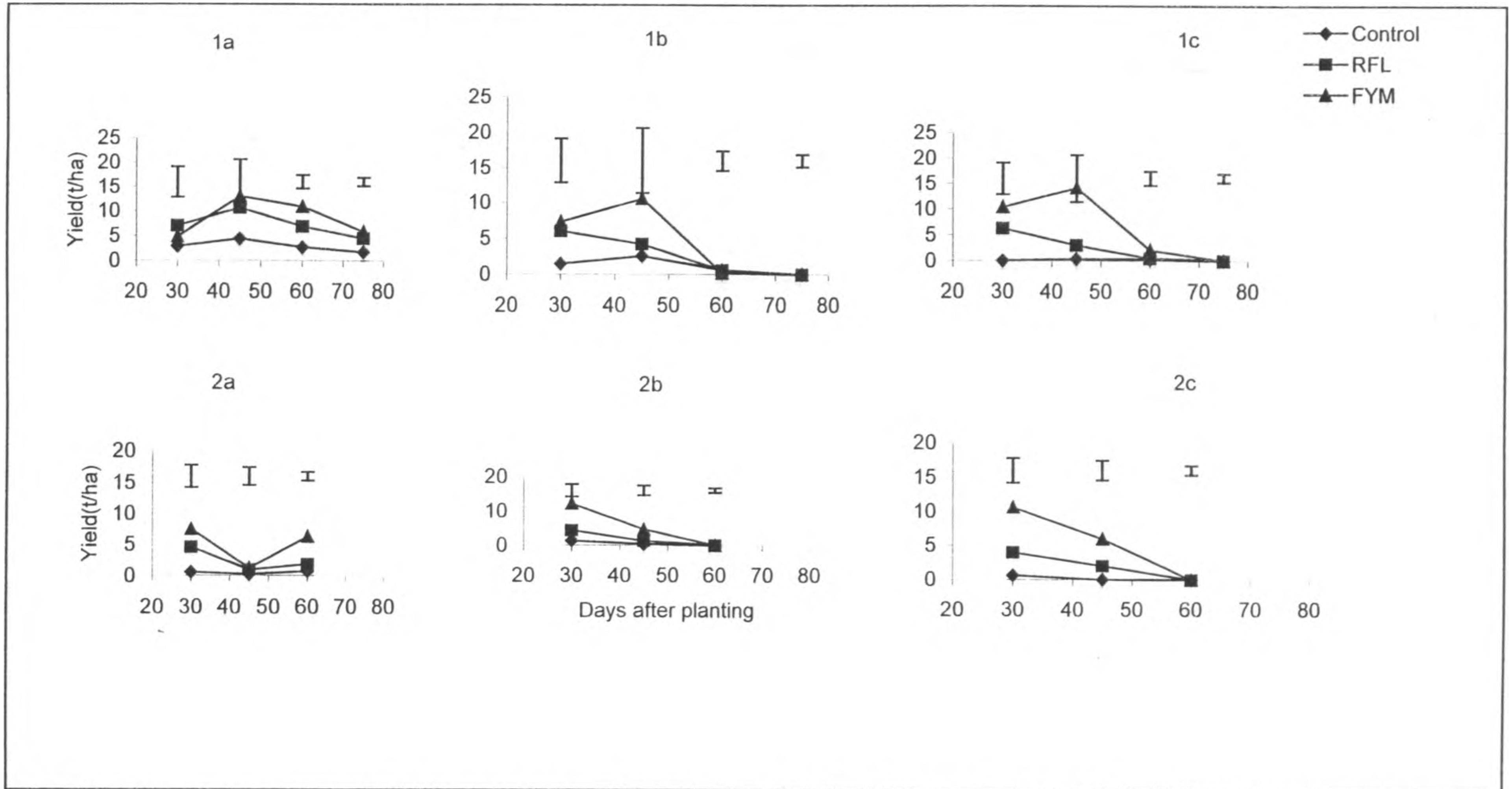


**Fig 4.** Effect of recommended inorganic fertilizer level (RFL) and farmyard manure (FYM) on fresh leaf yield (t/ha)) of collard (a), cat's whiskers (b) and amaranth (c) in 2000 short rains(1) and 2001 long rains(2). Vertical bars are LSD bars.

in collard. At 60 DAP, FYM significantly increased the leaf yield more than either RFL or control in collard. Farmyard manure led to increased fresh leaf yield of cat's whiskers and amaranth at all stages of growth. However, RFL did not significantly affect the yield of the two crop species. In the SR, collard produced more yields than both traditional vegetables, however the reverse occurred in the LR where both traditional vegetables produced slightly higher yields than collard. Among the traditional vegetables, amaranth produced more than cat's whiskers in both seasons.

In the SR, the type of fertilizer did not affect leaf production in collard (Table 12). Fertilizer application, either RFL or FYM led to production of more shoots in cat's whiskers at 30 and 45 DAP. In amaranth, fertilizer application led to production of more shoots at all measurement times. Compared to RFL, FYM led to production of more leaves and shoots. In the LR, fertilizer application led to an increase in leaf production of collard only at 60 DAP. Fertilizer application increased shoot production in cat's whiskers at all sampling dates. In amaranth, fertilizer application led to increased leaf production upto 45 DAP. By the fourth sampling date (60 DAP) amaranth had dried hence no shoots were recorded. Farmyard manure led to the most increase of shoots. Generally, leaf and shoot production was higher in the SR than in the LR.

In the SR, FYM application led to an increase in seed yield only in amaranth (Table 12). Compared to RFL, FYM led to higher seed yield. Seed yield of cat's whiskers was not affected by fertilizer type. In the LR, application of FYM led to an increase in seed yield of cat's whiskers only. Application of RFL had no effect. Fertilizer application did not affect seed yield of amaranth. Generally, higher seed yield was produced in the SR compared to the LR in both crops. Amaranth produced higher seed yield than cat's whiskers in the SR, but the reverse occurred in the LR.

### 4.5.3 Nutritive quality

Neither crop species, fertilizer application nor their interaction affected $\beta$-carotene content (Table 14). Neither crop species, fertilizer application nor their interaction affected iron content (Table 15).

## 4.6 Discussion

### 4.6.1 Plant growth

Plants are made of elements that are absorbed from soil and air. It is absorption of these elements that leads to dry weight gain and hence growth. These elements can be obtained from fertilizers (Salisbury and Ross, 1992). A soil depleted of plant nutrients requires to be replenished with fertilizer. Different fertilizer types have varying effects on unlike crops (Nilsson, 1979). In this study, results indicated that differences in fertilizer types, crop species and seasons influenced growth of the vegetable crops.

The growth of both traditional vegetables was always higher when grown in FYM as compared to RFL according to the measured plant height, girth and dry matter. It is known that organic matter supplies reserves of all essential nutrients in soil, and principally in the deeper layers where they may be absorbed more effectively than fertilizers applied in normal ways to soil surface (Olsen, 1986). In contrast, RFL supplied only two nutrients, N and P. And this may have happened in this work. Other benefits of FYM could be due to its effects on stimulating the growth and activity of heterotrophic microbial population, which in turn may affect plant growth

Table 12. Effect of recommended inorganic fertilizer level and farmyard manure on number of leaves plant per plant of collard, and number of shoots per plant of cat's whiskers and amaranth in 2000 short rains and 2001 long rains.

| Short rains | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Treatment | 15 DAP | | | 30 DAP | | | 45 DAP | | | 60 DAP | | |
| | Col | Cat | Ama | Col | Cat | Ama | Col | Cat | Ama | Col | Cat | Ama |
| Control | 5.75a | 1.35b | 0.95c | 9.50a | 3.60b | 2.70c | 9.80a | 6.50a | 7.70b | 12.1a | 6.5a | 11.10b |
| RFL | 7.30a | 5.75a | 10.20b | 1.90a | 11.95b | 17.95b | 13.00a | 10.50a | 16.0b | 16.2a | 9.40a | 17.30b |
| FYM | 5.60a | 6.85a | 12.95a | 11.10a | 25.55a | 47.45a | 13.80a | 42.20a | 139.4a | 18.4a | 45.10a | 181.50a |
| $LSD_{int}$ ($P$=0.05) | 2.04 | | | 8.78 | | | 71.73 | | | 50.26 | | |
| Long rains | | | | | | | | | | | | |
| | 15 DAP | | | 30 DAP | | | 45 DAP | | | 60 DAP | | |
| | Col | Cat | Ama | Col | Cat | Ama | Col | Cat | Ama | Col | Cat | Ama |
| Control | 6.15a | 1.60c | 0.40c | 4.85a | 3.40c | 1.45c | 5.20a | 5.30b | 1.30c | 6.40b | 2.10b | - |
| RFL | 8.80a | 6.35b | 9.20b | 7.90a | 10.40b | 20.60b | 8.60a | 10.70b | 25.6b | 8.70ab | 5.65b | - |
| FYM | 8.45a | 10.6a | 23.90a | 9.65a | 20.90a | 52.30a | 13.4a | 28.20a | 49.7a | 11.55a | 17.30a | - |
| $LSD_{int}$ ($P$=0.05) | 3.44 | | | 6.00 | | | 13.92 | | | 4.07 | | |

DAP = Days after planting, Col = Collard, Cat = Cat's whiskers, Ama = Amaranth, RFL= recommended inorganic fertilizer level, FYM = farmyard manure, $_{int}$ = interaction.
Means followed by different letters within a column are significantly different according to LSD ($P$=0.05).

Table 13. Effect of recommended inorganic fertilizer level and farmyard manure on seed yield (kg per $10m^2$ plot) of collard, cat's whiskers and amaranth in 2000 SR and 2001 long rains.

| Treatment | Short rains | | Long rains | |
|---|---|---|---|---|
| | Cat | Ama | Cat | Ama |
| Control | 0.15a | 0.24b | 0.08b | 0.00a |
| RFL | 0.79a | 0.93b | 0.46b | 0.07a |
| FYM | 0.83a | 3.20a | 1.23a | 0.40a |
| $LSD_{int}$($P$=0.05)) | 1.06 | | 0.48 | |

Col = collard, Cat = cat's whiskers, Ama = amaranth, RFL= recommended inorganic fertilizer level, FYM = farmyard manure, $_{int}$ = interaction.
Means followed by different letters within column are significantly different according to LSD ($P$=0.05).

Table 14. Effect of recommended inorganic fertilizer level and farmyard manure on $\beta$-carotene content (mg per 100 g edible portion) of collard, cat's whiskers and amaranth 2001 long rains.

| Treatment | Long rains | | | |
|---|---|---|---|---|
| | Col | Cat | Ama | Mean |
| Control | 3.47 | 9.42 | 4.08 | 5.66 |
| RFL | 4.85 | 9.61 | 6.07 | 6.84 |
| FYM | 4.02 | 12.65 | 5.79 | 7.48 |
| Mean | 4.11 | 10.56 | 5.31 | |
| $LSD_{fert}$ ($P$=0.05) | | 1.65 | | |
| $LSD_{crop}$ ($P$=0.05) | | 8.80 | | |

DAP = Days after planting, Col = Collard, Cat = cat's whiskers, Ama = amaranth, RFL= recommended inorganic fertilizer level, FYM = farmyard manure, $_{fert}$ = fertilizer, $_{crop}$ = crop.

Table 15. Effect of recommended inorganic fertilizer level and farmyard manure on iron content (mg per 100 g edible portion) of collard, cat's whiskers and amaranth in 2001 long rains.

| Treatment | Long rains | | | |
|---|---|---|---|---|
| | Col | Cat | Ama | Mean |
| Control | 38.5 | 28.1 | 38.1 | 34.9 |
| RFL | 13.7 | 30.3 | 17.0 | 20.3 |
| FYM | 38.2 | 24.2 | 22.8 | 28.4 |
| Mean | 30.1 | 27.5 | 26.0 | |
| $LSD_{fert}$ ($P$=0.05) | 18.96 | | | |
| $LSD_{crop}$ ($P$=0.05) | 48.82 | | | |

DAP = Days after planting, Col = Collard, Cat = cat's whiskers, Ama = amaranth, RFL= recommended inorganic fertilizer level, FYM = farmyard manure through the supply of biochemically important substances such as growth hormones (Hoitink and Kuter, 1986). It is possible that the structure of soil had been improved by use of FYM through making the aggregates less dense and friable so that root penetration as well as diffusion of water and solute into and out of the aggregates was improved (Avnimelech, 1986). This could have led to the increase in height, girth and dry matter upon FYM application observed in this work.

Traditional vegetables compared to collard have not benefited from selection by horticultural techniques (Westphal, 1978) and have tended to grow wild or semi-wild (Okigbo, 1978). Growing wild implies that traditional vegetables are adapted to the natural growing conditions where they rely on organic residues for their nutrient supply. Therefore, the traditional vegetables in this study exhibited better growth in FYM than in RFL at all growth stages.

**4.6.2 Yield and yield components**

The yield of a plant depends on its growth and development, which in turn depends on dry mass accumulation (Stephenson and Wilson, 1977). In collard, the effects of RFL and FYM on fresh leaf yield tended to be the same at the early harvests but later FYM led to higher yields. Cooke (1979) suggested that use of organic matter results in higher yields than use of "fertilizer only", perhaps because N from the organic source is more effective than N from fertilizer applied to soil surface. It also suggested that the yields of crops are usually higher in organic matter perhaps because the N supply is a combination of $NH_4^+$ and $NO_3^-$ (Olsen, 1986). This may have happened in this study. The benefits of use of FYM over RFL were more apparent in the traditional vegetables. These produced higher fresh leaf and seed yields when grown in FYM.

Collard has a dominant taproot with a fair share of laterals whereas cat's whiskers also has a taproot but with a smaller number of laterals. Amaranth has a fibrous and highly branched root system. These rooting characteristics may explain how under rainy conditions of the SR. collard produced thee most fresh leaf yield followed by amaranth and then cat's whiskers.

Collard was harvested four times in the SR and three times in the LR. Traditional vegetables were harvested three times in the SR and twice in the LR. This was attributed to seasonal variations. Okoko et al. (1997) reported that the yields of black nightshade and spider flower were lower in the LR than in the SR. The lower yields were attributed to the heavy and erratic rainfall accompanied with surface runoff. immediately after sowing which affected germination and crop stand. and the hailstone and bacterial wilt reduced productivity during the LR. Such conditions were also experienced in this study. It may be concluded that the conditions of the LR are not conducive for vegetable production.

**Nutritive quality**

The results of this study showed no differences in $\beta$-carotene and iron contents among collard. an exotic vegetable, cat's whiskers and amaranth. This observation is a direct contradiction of the widely held view that traditional vegetables contain more micronutrients than exotic vegetables (FAO. 1991; Muroki. 1992 and Sebit. 1994).

A possible explanation for the higher nutritional composition of traditional vegetables in other studies could be traced to the places in which they grow. Many traditional vegetables are weedy. semi-cultivated or even wild species (IPGRI. 1999). These vegetables are commonly found in field margins, bush. abandoned farms. or boundaries, disturbed areas along roadsides and in unused urban spaces. These are areas that are likely to have more nutrients owing to the fact that they are less cultivated and planted to crop that would otherwise absorb these nutrients.

The results o this study suggest that suggest that fertilizer application may not be the main factor determining vegetable nutrient composition.

It is concluded that fertilizer application whether RFL or FYM improved growth and yields of vegetables. Traditional vegetables produced high yields under FYM. Fertilizer application had no affect on $\beta$-carotene and iron contents of the leafy vegetables. The vegetables didn't differ in their $\beta$-carotene and iron contents.

## CHAPTER FIVE

## 5.0 CONCLUSIONS AND RECOMMENDATIONS

### 5.1 CONCLUSIONS

The study set out to test the hypothesis that little land is spared for vegetable production compared to other food crops. Indeed this was found to be true. Consequently, the amount of vegetables produced is too little for home consumption let alone for sale. The status of vegetables was found to be very low compared to the other food crops in MSS. The use of fertilizer on vegetable production was found to be quite minimal as compared to research recommended rates.

Thus it can be concluded that vegetable production in MSS is neglected, the preferred crops being sugarcane, the cash crop, as well as the main food crops; maize and beans. Vegetable production is undertaken mainly by women and children. There is very little adoption of better technologies leading to shortage and hence imports from neighbouring districts. Shortage of vegetables is in the dry seasons in particular. Collard, an exotic vegetable, is the most widely grown as compared to traditional vegetables. Traditional vegetables are produced using cultural methods as opposed to properly researched agronomic practices. Indeed, an agronomic package for traditional vegetables is non-existent among farmers. This is despite the fact that traditional vegetables are the ones that are well adapted to the ecology and people's culinary preference.

Fertilizer application whether RFL or FYM improves growth and yields of all crops. Both types of fertilizers are good for promotion of the growth of collard, whereas FYM enhances the growth of traditional vegetables. All crops produce the highest yields when grown with FYM. The study confirmed that traditional vegetables could be grown on soils other than very rich patches provided sufficient and well-decomposed FYM is applied. The type of fertilizer applied does not affect $\beta$-carotene and iron contents of both exotic and traditional leafy vegetables. Vegetable production gives higher yields in the short rains than in the long rains.

## 5.2 RECOMMENDATIONS

Women could be assisted to benefit from vegetable production by being taught simple but appropriate technologies like fertilizer application, use of better seed and pest control. They are the custodians of indigenous knowledge of traditional methods of growing and preparing vegetables. They should be organized into groups so that by pulling together they could share the knowledge they have and perhaps like in other regions be able to attract external donors to assist them acquire inputs to fight food insecurity.

The resource poor farmers who make up the bulk of the population may be encouraged to grow more traditional vegetables. Traditional vegetables are scarce and therefore more expensive and hence they could fetch better prices. Collard should be grown using either mineral fertilizer or organic manure while traditional vegetables should be grown in sufficient organic manure. Organic manure should be recommended as a natural slow release fertilizer that is affordable to smallholder farmers in MSS. It should be noted that the slow release fertilizers are only newly developed and hardly available in the developing world. Their availability would be at a prohibitive cost for small-scale farmers to afford. It may be recommended to grow vegetables during the short rains and in the dry seasons using irrigation, this is also when the prices are high hence more income to the farmers.

**SUMMARY**

The emerging trend in agricultural research has been to involve farmers in rural areas in an effort to come up with indigenous solutions to alleviate poverty. The researchers then come in to lend their technical expertise to the suggested solutions. This new trend moves away from the indifferent approach that has been used for a long time with little to show.

Apart from confirming what has been almost common knowledge, the baseline revealed some beliefs that are certainly retrogressive in so far as food security is concerned such as traditional vegetables could only be grown in histosols (organic soils) or their equivalents. The implication is that those without these soils (majority) make no effort to produce vegetables.

The farmers' workshop held at the site of the on-farm trials left a lasting impression on them helping to break their poor perception of vegetables as being insignificant. The trials proved that it is possible to stem the tide of vegetable imports by growing them on small plots. Different vegetables species planted in a staggered manner to ensure a continuos supply of vegetables could greatly help to ensure a ready supply of easily produced yet nutritious vegetables. It may be recommended that preparation of FYM at the farm level be encouraged in order to improve its availability and quality. With a little more effort, proper disposal of potential sources of organic manure such as kitchen waste and manure from both small and large stock could be a valuable source of manure for producing vegetables on small pieces of land.

Fertilizer application is a must practice in vegetable production as revealed by the present findings. This will go a long way in increasing productivity and hence reducing food insecurity in MSS. Traditional vegetables have a high and rising demand mainly in towns and cities. The use of FYM could allow the farmers to cash in on the emerging demand after a long spell of

neglect. It is fitting to grow collard with either of the two fertilizers (RFL and FYM) whichever is available. If implemented, these findings could go a long way in increasing vegetable production in MSS and thereby help to reduce food insecurity in the area. Perhaps a follow up study on adoption and diffusion could be recommended.

The project study was found to be innovative, adaptable and appropriate and should therefore serve, as an example of the direction agricultural research should take. The end users must be allowed to play a central role.

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## APPENDICES

APPENDIX 1. The layout plan of the on-farm trials.

BLOCK 4

| V1 | V2 | V3 |
|---|---|---|
| F1 | F2 | F0 |
| F2 | F1 | F2 |
| F0 | F0 | F1 |

BLOCK 3

| V1 | V3 | V2 |
|---|---|---|
| F0 | F0 | F0 |
| F1 | F1 | F1 |
| F2 | F2 | F2 |

BLOCK 2

| V3 | V1 | V2 |
|---|---|---|
| F2 | F0 | F0 |
| F1 | F1 | F2 |
| F0 | F2 | F1 |

BLOCK 1

| V3 | V2 | V1 |
|---|---|---|
| F0 | F0 | F2 |
| F1 | F1 | F0 |
| F2 | F2 | F1 |

V- main plots, F- sub-plots, V1- collard, V2- cat's whiskers, V3- amaranth, FO- check.

FI- recommended inorganic fertilizer level, F2- farmyard manure

APPENDIX 2. ANOVA table for effect of fertilizer type of on crop height, girth and total dry matter of collard, cat's whiskers and amaranth.

| | | Height | | Girth | | Total dry matter |
|---|---|---|---|---|---|---|
| 15 DAP Source | DF | Trial I MS | Trial II MS | Trial I MS | Trial II MS | Trial II MS |
| R | 3 | 75.95 | 107.05 | 0.235 | 0.009 | 59.39 |
| V | 2 | 1508.49** | 7970.76** | 0.587** | 0.612** | 1404.20** |
| Error 1 | 6 | 54.55 | 164.48 | 0.086 | 0.038 | 82.54 |
| T | 2 | 1769.36** | 20435.8** | 2.412** | 6.770** | 1175.58** |
| TXV | 4 | 775.97** | 5022.74** | 0.617** | 0.593** | 36.43$^{ns}$ |
| Error 2 | 18 | 70.24 | 123.24 | 0.071 | 0.081 | 82.96 |
| 30 DAP | | | | | | |
| R | 3 | 1338.5 | 1086.5 | 0.630 | 0.032 | 23.10 |
| V | 2 | 21158.7** | 52780.5** | 0.793** | 1.133** | 2148.50$^{ns}$ |
| Error 1 | 6 | 1558.50 | 935.08 | 0.124 | 0.158 | 467.70 |
| T | 2 | 27204.4** | 51073.2** | 8.975** | 12.835** | 9932.90** |
| TXV | 4 | 7217.6** | 10570.0** | 2.011** | 0.516** | 243.60 $^{ns}$ |
| Error 2 | 18 | 655.38 | 360.15 | 0.186 | 0.082 | 255.70 |
| 45 DAP | | | | | | |
| R | 3 | 2287.5 | 1866.79 | 0.981 | 0.066 | 93.40 |
| V | 2 | 55629.1** | 68134.5** | 3.096** | 4.861** | 482.1$^{ns}$ |
| Error 1 | 6 | 2293.9 | 1343.10 | 0.218 | 0.231 | 204.0 |
| T | 2 | 40495.9** | 65995.9** | 12.073** | 18.565** | 4154.7** |
| TXV | 4 | 9081.6** | 11946.6** | 1.857** | 0.384$^{ns}$ | 892.0* |
| Error 2 | 18 | 653.2 | 357.13 | 0.246 | 0.172 | 239.2 |
| 60 DAP | | | | | | |
| R | 3 | 1913.2 | 1986.8 | 1.031 | 0.099 | 304.9 |
| V | 2 | 56112.1** | 80210.6** | 6.987** | 7.321** | 5144.6** |
| Error 1 | 6 | 2161.1 | 1468.7 | 0.210 | 0.321 | 153.7 |
| T | 2 | 43872.7** | 61621.0** | 17.073** | 22.755** | 5374.0** |
| TXV | 4 | 8287.7** | 11554.9** | 1.447** | 0.297$^{ns}$ | 361.0 $^{ns}$ |
| Error 2 | 18 | 626.4 | 589.1 | 0.282 | 0.146 | 28.9 |

DF-degrees of freedom; MS-Mean square; DAP-day after planting; R-replication; T-fertilizer type; V-crop species; X-interaction; *-significance at $P \leq 0.05$; **-significance at $P \leq 0.01$; $^{ns}$-not significant.

APPENDIX 3. ANOVA table for effect of fertilizer type of on number of leaves and shoots, and fresh leaf yield of collard, cat's whiskers and amaranth.

| Number of leaves and shoots | | | | Fresh leaf yield | | |
|---|---|---|---|---|---|---|
| | | Trial I | Trial II | | Trial I | Trial II |
| 15 DAP | | | | 30 DAP | | |
| Source | DF | MS | MS | | MS | MS |
| R | 3 | 1.459 | 37.35 | | 2.79 | 14.73 |
| V | 2 | 172.02** | 390.02** | | 1.52$^{ns}$ | 9.25$^{ns}$ |
| Error 1 | 6 | 8.92 | 18.61 | | 31.165 | 3.76 |
| T | 2 | 596.61** | 2015.67** | | 123.21** | 303.806** |
| TXV | 4 | 190.61** | 623.03** | | 19.34$^{ns}$ | 11.985$^{ns}$ |
| Error 2 | 18 | 10.18 | 32.44 | | 9.910 | 7.003 |
| 30 DAP | | | | 45 DAP | | |
| R | 3 | 47.50 | 167.00 | | 2.07 | 8.375 |
| V | 2 | 2300.36** | 4913.57** | | 50.67$^{ns}$ | 10.78$^{ns}$ |
| Error 1 | 6 | 211.88 | 65.39 | | 66.66 | 2.95 |
| T | 2 | 7922.42** | 9039.07** | | 314.12** | 43.07** |
| TXV | 4 | 2456.8** | 2910.86** | | 23.38$^{ns}$ | 7.166$^{ns}$ |
| Error 2 | 18 | 162.29 | 77.43 | | 23.03 | 4.186 |
| 45 DAP | | | | 60 DAP | | |
| R | 3 | 12225.00 | 478.1 | | 4.00 | 0.885 |
| V | 2 | 3377.00$^{ns}$ | 4164.5* | | 151.31** | 34.639** |
| Error 1 | 6 | 12163.00 | 683.80 | | 5.30 | 0.885 |
| T | 2 | 59914.00** | 10630.50** | | 30.37** | 11.474** |
| TXV | 4 | 28310.00** | 2141.20** | | 20.38** | 11.474** |
| Error 2 | 18 | 11960.00 | 312.40 | | 2.57 | 0.904 |
| 60 DAP | | | | 75 DAP | | |
| R | 3 | 2580.00 | 85.77 | | 2.64 | - |
| V | 2 | 54525.00* | 1489.21** | | 65.18** | - |
| Error 1 | 6 | 7639.00 | 49.84 | | 2.64 | - |
| T | 2 | 97097.00** | 731.77** | | 5.74** | - |
| TXV | 4 | 49513.00** | 332.95** | | 5.74** | - |
| Error 2 | 18 | 4899.00 | 32.32 | | 0.568 | - |

MS-Mean square; DAP-day after planting; R-replication; T-fertilizer type; V-crop species; X-interaction; *-significance at $P \leq 0.05$; **-significance at $P \leq 0.01$; $^{ns}$-not significant.

APPENDIX 4. ANOVA table for effect of fertilizer type on seed yield of cat's whiskers and amaranth.

| Source | DF | Trial I<br>MS | Trial II<br>MS |
|---|---|---|---|
| R | 3 | 0.654 | 0.035 |
| V | 1 | 4.487* | $1.117^{ns}$ |
| Error 1 | 3 | 0.384 | 0.148 |
| T | 2 | 6.784** | 1.271** |
| TXV | 2 | 3.414* | 0.279* |
| Error 2 | 12 | 0.548 | 0.053 |

MS-Mean square; T-fertilizer type; V-crop species; X-interaction;

*-significance at $P \leq 0.05$; **-significance at $P \leq 0.01$;

$^{ns}$-not significant.

APPENDIX 5. ANOVA table for effect of fertilizer type on $\beta$-carotene and iron contents of collard, cat's whiskers and amaranth.

| | | $\beta$-carotene | Iron |
|---|---|---|---|
| Source | DF | Trial II<br>M-square | Trial II |
| R | 1 | 18.034 | 1468.771 |
| V | 2 | $141.066^{ns}$ | $53.328^{ns}$ |
| Error 1 | 2 | 25.084 | 594.342 |
| T | 2 | $10.324^{ns}$ | $642.547^{ns}$ |
| TXV | 4 | $4.703^{ns}$ | $342.445^{ns}$ |
| Error 2 | 6 | 2.729 | 360.036 |

R-replication; T-fertilizer type; V-crop species; X-interaction; $^{ns}$-not significant.

APPENDIX 6. STRUCTURED QUESTIONNAIRE

ADOPTION OF CROP PRODUCTION TECHNOLOGIES BY SMALLHOLDER FARMERS IN MUMIAS SUGARSCHEME, WESTERN KENYA

FORUM PROJECT. 2000.

SOCIOLOGY DEPARTMENT, UNIVERSITY OF NAIROBI

NAME OF FARMER.........................................................

LOCATION.................................................................

SUB-LOCATION...........................................................

VILLAGE.....................................................................

NAME OF ENUMERATOR.................................................

1. How much land do you own in acres?
2. What food crops did you grow for the long rains of the year 2000 in order of importance?
3. What vegetable crops did you grow for the short rains of the year 2000 in order of importance?
4. How much land would provide enough vegetables for your family for a period of one year?
5. Of the vegetables you planted did you sell any?
6. How did you acquire your seed?
7. What method of panting do you use?
8. Do you use any manure or fertilizer?
9. If yes, which one?
10. How do you control pests and diseases?
11. Who provides labour for vegetable production?
12. Which other problems do you encounter in vegetable production?