EFFECTS OF PROPAGATION METHOD AND DEFLOWERING ON VEGETATIVE GROWTH, LEAF YIELD, PHENOLIC AND GLYCOALKALOID CONTENTS OF THREE BLACK NIGHTSHADE SELECTIONS USED AS VEGETABLE IN KENYA

A Thesis Submitted in Partial Fulfilment for the Degree of

MASTER OF SCIENCE
IN
HORTICULTURE

Department of Crop Science
Faculty of Agriculture
College of Agriculture and Veterinary Sciences
University of Nairobi
1992
DEDICATION

To my Mother, Brother and Sisters.
DECLARATION

I, Celestina Ng'ondi Mwafusi, declare that this is my own work and has not been presented for a degree in any other University.

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My sincere gratitude and appreciation go to my supervisors, Prof. J. A. Chweya and Prof. J. K. Imungi for their invaluable guidance, advice, suggestions and comments throughout the study and during the write up of this thesis.

I do appreciate the help of the technicians in the Department of Crop Science, Mr. Wainaina and Mr. Ngethe and Mr. Mitheka of Food Technology and Nutrition Department.

Special thanks to Emmaculate M. Munyao for her effort and patience in typing this work.

I am sincerely grateful to DAAD (German Academic Exchange Services) and the University of Nairobi for the financial support without which this study would not have been carried out.

Lastly, special thanks to my mother, brother, sisters and friends for their encouragement and constant prayers. Above all may God be praised and God bless you all.
ABSTRACT

Two experiments were carried out between August 1990 and May 1991 at the Field Station, University of Nairobi, Kabete Campus, to study the effects of propagation methods and deflowering on vegetative growth, leaf yield and some quality aspects of black nightshade (Solanum spp). In the first experiment, the three selections of the vegetable were studied and the plants were either deflowered or not. These formed six treatments which were set in a randomised complete block design. In the second experiment, two methods of propagation (seed and vegetative) were studied and the plants were either deflowered or not. These together with the three selections of the vegetable formed twelve treatments set in a split-plot design.

Vegetative growth was assessed by measuring the plant height and spread and counting the number of branches per plant while fresh and dry weights of the edible portions in Kg/ha were used to assess the yield. Leaves were analysed for total phenolics and glycoalkaloid contents.

Seed propagation led to taller plants with a wider spread, more number of branches and a higher leaf yield than vegetative propagation. Solanum pseudonigrum non-serrated type showed a more vigorous growth and higher leaf yield than the other two selections. Deflowering resulted in shorter and less spreading
plants, which however, had more branches and a higher leaf yield.

Vegetative propagation significantly decreased the phenolic contents during the early stages of growth and increased the glycoalkaloid contents of the leaves. Deflowering was found to decrease the accumulation of phenolic compounds but had no significant effect on the total glycoalkaloid content of the leaves.

Propagating *S. pseudonigrum* non-serrated type vegetatively gave taller plants with significantly fewer branches and lower leaf yields than seed propagated plants. The same applied to vegetatively propagated *S. nigrum* plants which however, had higher leaf yields than the two types of *S. pseudonigrum*. Vegetative propagation of *S. pseudonigrum* serrated type significantly reduced the plants height and branching and hence the leaf yields.

Propagating the black nightshade through seed therefore leads to a more vigorous vegetative growth and hence higher leaf yield.
INTRODUCTION

Vegetables are important components of the human diet as they contain significant amounts of essential nutrients (Goddard and Mathews, 1979). According to Grubben (1977), vegetables constitute one of the main sources of protective nutrients: vitamins and minerals. They also provide variety to staple foods and afford a low level of calories.

Based on the edible portion, vegetables can be divided into leafy, seed, flower, fruit, stem and root vegetables. Leafy vegetables are important in human nutrition as a source of vitamins and minerals and dietary fibre (Thompson and Kelly, 1952; Grubben, 1977). Dark green leafy vegetables are particularly rich in vitamin A, Vitamin C, calcium and iron (Grubben, 1977; Imungi, 1984).

Vegetables can be divided into two groups on the basis of their origins: exotic and indigenous vegetables. In Kenya, the former group includes temperate vegetables like carrots (Daucas carota), cabbages (Brassica oleracea var. capitata), and tomatoes (Lycopersicon esculentum), while the latter group includes the Black nightshade (Solanum nigrum), spider flower or cleome (Gynandropsis gynandra), African spinach (Amaranthus hybridus) and cowpea leaves (Vigna unguiculata). Exotic vegetables require special conditions for proper growth and development, while indigenous vegetables because of their tropical adaptation to the
growing conditions, have the ability to withstand numerous pests and diseases.

The black nightshade has a wide ecological adaptability worldwide and is a popular vegetable throughout the tropics (Holm et al., 1977; Omta and Fortuin, 1980). In Kenya it is one of the most common indigenous leafy vegetables, being incorporated in soups or in side dishes. The leaves of the black nightshade are also used for medicinal purposes. Maundu (1990) mentioned that fresh leaves are used for treatment of scabies in Uganda and wounds in China. In the Phillipines, the raw leaves are applied to the skin to restore body pigment, while cooked leaves are eaten as a relief for persistent headache in India (Maundu 1990).

The black nightshade grows wild in bushes, forests and along roadsides. Although there is limited domesticated cultivation in homegardens, the plants are commonly found growing as weeds. The leaves are harvested either for home consumption or for sale in markets. Leaves are commonly found selling in urban markets especially in Kisii, Kakamega, Mombasa and Nairobi.

Available literature indicates that the black nightshade is commonly propagated from seeds, although cuttings may also be used (Epenhuijzen, 1974; Tindall, 1983; Maundu, 1990). However, no agronomic studies have been done on this and, therefore, little information exists on the effect of method of propagation on yield.
and quality of the leaf of different selections.

Deflowering has been used to extend the vegetative growth period of some flowering plants and therefore increase leaf production (Salisbury and Ross, 1978). Such information does not, however, seem to exist on the vegetable black nightshade.

Nutrient data on local green leafy vegetables indicate that the black nightshade is a good source of essential nutrients such as \( \beta \)-carotene; vitamin C, folic acid, iron and calcium (Gomez, 1981). Protein contents of the leaves have also been observed to be of high nutritive value thereby justifying their role in traditional dietary preparations in different communities in the world (Fafunso and Basir, 1976). Despite their high nutritive quality and increasing popularity, the black nightshade leaf vegetables have a bitter taste which remains even after cooking. Such bitterness has been attributed to presence of phenolic compounds and/or glycoalkaloids in other bitter tasting leafy vegetables (Sinden and Deahl, 1976). Work done so far indicates presence of phenolic compounds in the black nightshade leaves at levels of upto 718-1500mg/100g dry matter (Murage, 1989). However, no information exists on the levels of glycoalkaloids in the leaves.

This study was therefore designed to achieve the following
objectives:

i) To determine the effects of propagation method and deflowering on the vegetative growth and leaf yield of black nightshade selections.

ii) To determine the effects of propagation method and deflowering on the total phenolics and glycoalkaloid contents of the leaves of the black nightshade selections.
2. LITERATURE REVIEW

2.1 Botanical Description

The black nightshade (Solanum nigrum L.) is a member of the family solanaceae (Kokwaro, 1976). It is a plant of the tropics and subtropics named by the great eighteenth century Swedish botanist; Linnaeus (Maundu, 1990). In Kenya it is known by various names: Black nightshade (English); Mnavu (Kiswahili), Osuga (Luo); Managu (Kikuyu); Kitulu (Kikamba) Ndunda (Kitaita); Namasaka (Bukusu) and Rinagu (Ekegusii).

Various variants of the plant species form a taxonomic complex comprising three groups: Solanum nigrum L.; S. pseudonigrum Mtoto Ined. and S. eldoretti Mtoto. ined (Mtotomwema, 1987). These have few morphological differences: S. nigrum has blackish purple fruits, S. pseudonigrum orange fruits and S. eldoretti green fruits when mature. Apart from the S. eldoretti being slightly hairy on the stems and leaves, the three groups are relatively similar in other botanical aspects (Mtotomwema, 1987). On the basis of leaf shape, S. pseudonigrum can be divided into serrated and non-serrated types.

The black nightshade is a low-spreading to erect herbaceous plant, commonly found as a weed in cultivated fields, in weedy plant communities, under trees and along fences. Tindall (1983)
describes it as an annual herb which grows up to 75 cm high, branching and spreading to 120 cm wide. It has relatively thin stems which often have a purple tinge. The leaves are alternate, simple or ovate and are borne horizontally with acute tips. The flowers, which are either white or yellow are small and hung in clusters on a stalk from the stem internodes. The fruits, small and orange or black in colour are multiseeded berries which are spherical in shape. Each fruit contains about 20-30 seeds and are borne in clusters of 4-7 and which often fall prematurely (Epenhuijsen, 1974; Tindall, 1983).

The black nightshade grows well in soils high in organic matter content and thrives well during wet seasons (Tindall, 1983). The root system is sensitive to low moisture levels and exposure to full sun is generally beneficial to growth. However, the plants tolerate a reasonable level of shading. The optimum temperatures for growth lies between 20-30°C, while the optimum altitudes range from sea level to 2300 m. Most types appear to be insensitive to daylength (Tindall, 1983).

2.2. Cultural Practices.

The black nightshade is first raised in a nursery before being transplanted into the field (Epenhuijsen, 1974; Tindall, 1983). The seeds are sown in boxes or seedbeds, and transplanted three weeks after seedling emergence (Epenhuijsen, 1974).
Not much work has been done on plant density. However, a spacing of 30cm x 30cm has been used in the field (Omta and Fortuin, 1980; Murage, 1989; Opole et al. 1991). A spacing of 60cm between rows and 40-50cm between plants can also be used (Tindall, 1983).

In most reports, especially from West Africa, manure has been used as a source of nutrition for the plants (Epinhuijsen, 1974; Opole et al., 1991). However, chemical fertilizers can also be used. A complete fertilizer can be used before sowing followed by top dressings with a nitrogenous fertilizer like CAN (26%N) (Tindall, 1983; Murage, 1989). Work by Murage (1989) on effects of Nitrogen on the growth and leaf yield of Solanum nigrum showed that topdressing with CAN (26%N) at 5g/plant significantly affected the vegetative growth of the plant and hence, the leaf yield. In further experiments with manures and artificial fertilizers, Farm Yard Manure was found to give better results than application of inorganic DAP at the rate of 200kg/ha recommended for many exotic vegetable (Opole et al., 1991).

The black nightshade plants are sensitive to drought therefore irrigation is required during dry periods (Tindall, 1983). There are no available recommendations on cultural practices of this crop in Kenya.

2.3 Propagation and Plant Growth

Propagation is a production technique which is of utmost
importance because of its positive contribution to the final yield of any crop (Chweya, 1976). Adriance and Brison (1979), defined plant propagation as the multiplication of plants. The basic objectives of plant propagation are to achieve an increase in number and to preserve the essential characteristics of the plant. This may be achieved sexually by seed or asexually using specialised vegetative structures, layering, cuttings or grafting (Janick et al., 1981).

Most vegetables are commonly propagated using seed. Therefore little information exists on propagation of vegetables asexually. The black nightshade is commonly propagated by seed though cuttings may also be used (Epenhuijsen, 1974; Tindall, 1983; Maundu, 1990). From available literature, there is no information recorded on propagation by cuttings. A few cases have, however, been noticed where the vegetable was grown from cuttings (Authors observation). Such plants thrived well especially during the wet season, and seemed to lead to a faster establishment and earlier shoot production.

Seed propagation is the most common means of propagating plants (Janick et al, 1981). It is one of the major methods by which plants reproduce in nature and one of the most efficient and widely used propagation method of cultivated crops. It is inexpensive and offers a convenient means of storing plants over long periods of time. Apart from being easy to transport over long
distances, seeds enable 'starting' of disease-free plants. The success of propagation by seed depends on the viability of the seed and other environmental conditions that would inhibit germination (Hartman and Kester, 1983).

Seed propagation, however, has the disadvantage of genetic segregation in heterozygous plants, which leads to loss of genetic characteristics. This is very important especially where some desirable characteristics of a plant need to be preserved. This problem is however, overcome by use of vegetative propagation.

Vegetative propagation involves regeneration of missing plant parts eliminating problems of seed dormancy and allows for easy propagation of vegetables that produce few viable seeds like potatoes and garlic (Splittstoesser, 1984). Apart from enabling perpetuation of heterozygous plants without alteration of their genetic characteristics, the main advantage of this method lies in the elimination of the juvenile phase and shortening of the time to reach reproductive maturity (Janick et al., 1981; Hartman and Kester, 1983). Vegetative propagation may also be easier and faster than seed propagation.

Available literature indicates that vegetative propagation has been successful on other vegetables. Maynard (1990), comparing propagation of rhubarb by seed and cuttings found that the former led to higher yields, although the petiole colour of vegetatively
propagated rhubarb was superior. Working with cabbage, Uyen et al. (1985) observed that yields from the vegetables propagated by cuttings were 25 percent higher than those from seed-propagated transplants. This could be primarily due to decreased transplant shock of vegetatively produced transplants and hence better plant vigor.

Propagation by cuttings is a cheap and convenient method for plant species that strike roots easily (Adriance and Brison, 1979). Root formation, however, seems to be influenced by the type and nature of cuttings. Reureni and Raviv (1981) observed that the number of leaves retained on the cuttings affected the speed and percentage of rooting of plants.

Apart from the nutritional status of the cutting, the stock plant age also affects rooting. Working on frazer fir, Hinesley and Blazid (1980), observed that rooting of stem cuttings decreased with stock plant age from 5 to 12 years. Plants 5 years of age were recommended since they led to better rooting. The rooting medium used also has a direct effect on rooting of cuttings and later plant survival. This was observed by Lal and Danu (1985), while propagating carnations by cuttings. The authors found that best rooting and highest plant survival were obtained using sand as the rooting medium. Hartman and Kester (1983) suggests that sandy medium is the most suitable for formation of roots in various plant species.
Rooting hormones have been used to enhance rooting of cuttings. The commonly used rooting hormones are Indole-acetic Acid (IAA) and Indole-Butyric Acid (IBA). The latter has been found to achieve the highest rooting percentage and survival rates (Bassiri et al., 1985; Dwivedi et al., 1985; Gur et al, 1986).

2.4 Vegetative growth

Vegetative growth involves the development of stems and leaves. These are dependent largely on the amount of sugars synthesised and the amounts of nitrates or ammonium-nitrogen absorbed and assimilated with sugars to form proteins (Edmond, 1975). Vegetative growth can be determined by measuring the plant height, leafyness spread (canopy) and number of branches. Various factors have been known to affect the vegetative growth of plants. Among these are light, soil temperature, moisture and soil fertility. Among the soil nutrients, nitrogen is the most essential for promotion of vegetative growth (Salisbury and Ross, 1978). It has also been observed that plant height may be affected by genetic and environmental factors such as light intensity, as well as cultural practices (Kohl and Nelson, 1963; Gianfagna et al., 1986).

2.4.1 Propagation & Vegetative Growth

Juvenility is the period in plant growth between seedling
emergence and flowering. It exhibits vigorous vegetative growth during which plants can compete better leading to higher yields (Splittstoesser, 1984). According to Wilkins (1984), transition from juvenile to adult form appears to be associated with changes in the apex of the plant, while the base remains in juvenile condition. Cuttings from the base of ivy plants were found to develop into juvenile plants, while those from the tip developed into mature plants (Leopold and Kriedemann, 1975). Vegetative propagation eliminates the juvenile stage, leading to faster establishment and earlier reproductive maturity. This is, however, an advantage only when production of fruits or seeds is desired (Leopold and Kriedemann, 1975).

In many plants, there exists a competition between the vegetative and the reproductive organs, such that once flowering begins, vegetative growth stops (Salisbury and Ross, 1978; Splittstoesser, 1984). This is due to the diversion of food reserves from the leaves to the developing fruits and flowers.

A study with Gynandropsis gynandra showed that during the reproductive phase, vegetative growth declined and leaves senesce rapidly. However pinching of the terminal shoot before flowering tends to promote auxiliary shoot development and prolonged vegetative growth (Waithaka and Chweya, 1991). In general, factors that stimulate shoot growth retard flower, tuber and fruit development. High N-fertilization in tomatoes has been observed to
cause luxuriant stem and leaf growth, leading to reduced fruit development (Salisbury and Ross, 1978). Working with chillies (Capsicum spp), Roychoadhury et al. (1990) showed that high N-concentration increased vegetative growth, which resulted in maximum fruit yield. N-deficiency however led to reduced growth and delayed flowering.

Available literature does not seem to contain either report on the effects of mode of propagation or plant cultural manipulations on the vegetative growth of black nightshade. Studies on other crops have however, revealed that cultural practices such as defoliation and debudding have an effect on the vegetative growth of plants. Chweya (1985) working with kales, showed that defoliation affected the vegetative growth of kale plants leading to decreased plant height and stem weight. In okra, Olasantan (1980) showed that apical debudding led to increased vegetative development and reduced plant height.

2.4.2 Deflowering and Vegetative Growth

As it has been mentioned above in most flowering plants, there exists a competition between the reproductive and vegetative organs such that once flowering begins vegetative growth declines (Splittstoesser, 1984). This finally leads to a lower leaf yield than expected. Black nightshade tends to flower very early (5-8 weeks), and therefore has a short juvenile period (Author's
observation). This is undesirable since the growth period of the leaves and shoot tips which usually command a higher market value than flowering shoots is shortened, leading to a lower economic value of the plants as vegetable source.

Removal of flowers has been practiced as a technique for maintaining vegetative growth of some flowering plants (Salisbury and Ross, 1978). No information is, however, available relating the effect of deflowering on vegetative growth and yield of the black nightshade. Literature available on other vegetable crops however, indicates that there exists a positive correlation between deblossoming of plants and their growth and yield. Studies by Rao and Bhati (1990) indicate that prevention of fruit production (deblossoming) in the tomato leads to a higher relative growth rate and accumulation of more photosynthates in the vegetative parts. Further work on tomatoes by Nyabundi and Hsiao (1989), showed that vegetative growth fully compensated for the forfeited fruit growth in deflowered plants such that the biomass of the above ground vegetative organs doubled.

In soybeans, removal of flowerbuds led to a delay of senescence (Leopold and Kriedmann, 1975). Similar results were obtained from experiments with tobacco, where deflowering encouraged leaf production (Salisbury and Ross, 1978). Work by Pandy and Singh (1981), however, showed that removal of flowers promoted further production of flowers in pigeon peas leading to a
higher seed yield. Experiments on bell pepper (Capsicum spp) and French beans (Phaseolus vulgaris) showed that removal of flowers and developing fruits prior to transplanting stimulated plant growth and increased yields in bell pepper (Singh and nettle, 1962), while in French beans the process led to increased weight of the vegetative parts (Wein et al., 1973).

2.5 Nutritional Quality

In the tropics, numerous wild and cultivated plants are used as leafy vegetables in soups (Grubben, 1977). Edible species of green leafy vegetables (GLV) which include the black nightshade are a rich source of essential nutrients, and their use as dietary supplement to the food staples of tropical countries is receiving more attention (Gomez, 1981; Oke, 1973). Nutrient data on these vegetables indicate that they are good sources of B-carotene, Vitamin C, folic acid, riboflavin, iron and calcium (Gomez, 1981). Protein samples from the edible leaves also have a high nutritive value which seems to justify their traditional role in the dietary pattern of the various communities (Fafunso and Basir, 1976).

Little work has been done on the nutritive quality of the black nightshade. However, available literature indicates presence of some compounds in the leaves which tend to give the vegetable an astringent bitter taste. Such bitterness has been associated with presence of phenolic compounds and/or glycoalkaloids in
studies with other bitter tasting vegetables (Sinden et al, 1976).

2.6.1 Total Phenolics

Polyphenols (phenolic compounds) are a group of compounds which commonly occur naturally in many plants (Singleton, 1981, Butler, 1988). They include compounds like safrole, coumarins, anthocyanins, flavanoids and tannins. Out of these, only tannins are of importance as antinutrients (Strumeyer and Malin, 1975; Singleton, 1981; Butler, 1988). The functional group of polyphenols is a hydroxyl attached to one of the carbon atoms of a benzene ring (Hulse et al., 1980).

According to Janick et al. (1981), tannins are astringent substances occurring in small amounts in most plant tissues. Their usefulness to plants may be obscure. However, they may be by-products of plant metabolism or may have some antiseptic properties (Hulse et al., 1980; Janick et al, 1981). On the basis of their structure and reactivity towards hydrolysing agents like enzymes and dilute acids, tannins are further subdivided into hydrolysable and condensed tannins (Ribereau-Gayou, 1972; Strumeyer and Malin, 1975). Working with grain sorghum, Strumeyer and Malin (1975) showed that tannins appear to be responsible for the astringency of many plant materials and decrease the nutritive value when present in the diet or in high levels in certain foodstuffs, due to their ability to bind and precipitate proteins on the tongue (Haslam, 1974).
The taste and stability of many edible fruits and fruit products are dependent on the type and concentration of tannins present (Haslam, 1974). Astringency, tactile sensation which is perceived as a drying puckering feeling throughout the oral cavity is due in part to the presence of tannins and related polyphenols (Haslam, 1974; Strumeyer and Malin, 1975; Singleton, 1981). The physiology of astringency sensation is believed to result from the interaction of the natural polyphenols with salivary proteins and glycoproteins in the mouth (Goldstein and Swain, 1963; 1965).

Phenolic compounds have also been associated with flavour in foods. Mondy et al (1971) suggested that bitterness and astringency in potatoes were related to their phenolic content. However, Sinden and Deahl (1976) working with potatoes found that the correlations between phenolic contents and bitterness were not significant. Work on selected phenolics in wine showed that astringency and bitterness are produced primarily by flavonoid phenolic compounds, most of which are extracted from the skins and seeds of grapes during fermentation (Robichaud and Noble, 1990).

Tannins have also been reported in legume crops (Elias et al, 1979; Laurena et al., 1984; Mohan et al., 1986). Working on beans, Elias et al. (1979) observed high levels of tannins and other related polyphenols in the seedcoat and suggested that these can react with proteins and decrease digestibility and therefore quality. Similarly, Laurena et al (1984), observed high levels of
condensed tannins in cowpea seeds which may be nutritionally harmful. Analysis of the pigeonpea plants showed that the bark of the plant and the leaves contained higher proportions of phenolic acids than the stem (Nahar et al., 1989). Experiments on chickpea seeds also showed that wilt resistant seeds released more phenols than seeds of the wilt susceptible variety (Mohan et al., 1986).

Recent research indicates presence of some phenolic compounds in the black nightshade leaves. Working on the effects of nitrogen rates on phenolic contents, Murage (1989) observed levels of up to 718-1500mg/100g dry matter. No work has, however, been done on the relationship between phenolic contents and age of the plant.

In general, little work has been done on polyphenols in vegetables compared to other crops like cereals and legumes. Some studies on eggplant (Solanum melongena), have shown presence of phenolic compounds within the fruits, which may be responsible for the discoloration of the cut fruits (Ramasnamy and Rege, 1975; Bajaj et al., 1981).

2.5.2 Glycoalkaloids

Glycoalkaloids belong to a group of compounds known as alkaloids, which are a class of nitrogenous bases notable for the profound physiological responses they produce in the animal
Kingdom. For most, their function is obscure, although some have medicinal properties (Janick et al., 1981; Coulthate, 1989).

Glycoalkaloids occur in many plants of the Solanaceae family such as potato, tomato, peppers and the eggplant (Bajaj et al., 1979). According to the same authors, some work has been done on Solanum spp. especially on wild species due to the importance of glycoalkaloids as raw materials for the synthesis of hormones. However, little work has been done on the glycoalkaloid contents of edible species such as vegetable black nightshade.

Studies on different potato cultivars showed that some tubers contain the cholinesterase inhibitor, solanine, a glycoalkaloid highly toxic and which can cause severe haemolytic damage in the gastrointestinal tract, and neurological disorders (Hulse et al., 1980). An upper limit of 20mg/100g on fresh weight basis is recommended in potatoes for human consumption (Maga, 1980). Potato tubers containing more than this level have also been found to possess a bitter off-flavour, directly correlated with their glycoalkaloid contents, and may cause toxic effects when consumed (Bajaj et al., 1979, Coxon et al., 1979). Administration of X-solanin in amounts greater than 2.8 mg/kg body weight has been shown to produce toxic effects in humans (Jadhav and Salunkhe, 1975).
3. MATERIALS AND METHODS

Two experiments were carried out between August 1990 and May 1991 at the Field Station, University of Nairobi, Kabete Campus, with the aim of determining the effect of propagation methods and deflowering on growth, yield and some quality attributes of some selections black nightshade leaves.

3.1 Experimental Site

The study site lies on an altitude of 1940m above sea level with an average rainfall of 1000mm per year. There are two main rainy seasons; long rains occurring between March and June and short rains occurring between October and December. The weather data during the experimental period are shown in Appendix 1. However mean monthly maximum and minimum temperatures were 19.9°C and 15.8°C while the mean monthly maximum and minimum rainfall were 281.4 and 0.4 mm respectively.

The site is under nitosol unit according to FAO/UNESCO classification (FAO/UNESCO, 1974). These soils are deep, well drained and very resistant to soil erosion. They have a darkbrown colour with a thick, acid topsoil. The soils are known as Kikuyu friable clay, and are derived from tertiary trachytic lava (Siderus, 1970).

3.2 Planting Materials

Three selections of the vegetable black nightshade were used
throughout the experiment. Seeds and leafy cuttings 15 centimetres long were obtained from the Kenya Energy and Environmental Organization (KENGO) Project at Kabete Campus, Field Station, from flowering plants that were about four months old.

3.3 Treatments and Experimental Design

In the first experiment, the treatments consisted of three selections of black nightshade which were either deflowered or not. These gave 6 treatment combinations which were set in a randomized complete block design and replicated thrice. Each block had six plots of size 4m x 3m.

In the second experiment, two methods of propagation (seeds and cuttings) the three selections of black nightshade and either deflowering or not gave 12 treatments. These were laid out in a split plot design with three replicates. The selections formed the main plots each of 24m x 3m while deflowering or not and the method of propagation combinations formed the subplots each measuring 2m x 3m.

In both experiments, deflowering began as soon as flowers were formed and continued up to the end of the experiment.
3.4 Cultural Practices

3.4.1 Nursery

a) Preliminary Experiment

This was carried out with the aim of rooting cuttings. A medium of sand-soil mixture in the ratio of 1:1 was put in three propagating boxes which were covered to maintain high humidity. Cuttings from four month old plants were set in three boxes at a spacing of 5cm x 15cm. The three selections of the black nightshade were set in each of the three propagating boxes. Watering was done once per day.

b) Experiment 1:

Seedlings were raised in a nursery seedbed before being transplanted into the field. Seeds of each selection were sown on a (2 X 1)m² fine-tilthed seed-bed, in furrows about 2cm deep and 15cm apart. They were thinly covered with a layer of soil. Watering was done immediately and subsequently twice each day using a watering can. This was reduced to once a day a week prior to transplanting, to harden the plants.

c) Experiment 2:

Seedlings were raised in the nursery as in experiment I. Cuttings were set in vermiculite in polythene sleeves two weeks after the seeds were sown. Stem cuttings 15cm long, were obtained from four month old plants. Four cuttings were planted per sleeve. All the flowers, flowerbuds, and excess
leaves were removed. Watering was done immediately and subsequently each morning using a watering can. The frequency was reduced to once every two days one week before transplanting to harden the plants. Only rooted cuttings were transplanted four weeks after setting.

3.4.2 Field Preparation and Transplanting

In both experiments, the field was harrowed twice and plots marked out one week before transplanting. Irrigation was done a day prior to transplanting.

The seedlings were transplanted when six weeks old and cuttings when four weeks old. A spacing of 40cm between plants and 60cm between rows was used giving a plant density of 41, 667 plants per hectare. Diammonium phosphate (18%N 46% P₂O₅) was used at a rate of 2g per plant together with 2g of Furadan per plant for control of nematodes.

3.4.3 Other Practices

Plants in the field were topdressed with CAN (21%N) at a rate of 20g/m² two weeks after transplanting. Deflowering of plants commenced as soon as plants started flowering. Irrigation was carried out using overhead sprinklers to supplement the rains. Plots were kept weed free manually throughout the experimental period.
3.4.4 Pests and Diseases

Incidences of moles were observed in the first experiment. These were controlled using traps. Aphids (Aphis gossypii) and leafhoppers (Bemisia tabaci) were controlled by spraying Rogor L 40 (5ml in 2L water) once every two weeks for four weeks. In the second experiment, bacterial canker was observed at later stages of plant growth, but no control measures were undertaken since the disease is seedborne.

3.5 Determinations of Growth Indicators

Five plants per plot were randomly selected and tagged to be used for determination of plant height, spread and number of branches per plant. 8 plants in an area of 1.92m² per experimental plot were marked for yield determination. Data were collected at 4, 6, 8, 10 and 12 weeks after transplanting.

3.5.1 Determination of Plant Height and Spread, and Number of Branches per plant

The heights of five plants per treatment were measured in centimetres using a ruler at each harvest and mean height calculated.

The plant spread was determined by measuring and averaging canopy width of five plants per treatment.

The total number of auxiliary branches from five plants per plot were counted and the mean number of branches per plant calculated.
3.5.2. Determination of Leaf Yield

Plants from an area of 1.92m² on each experimental plot were periodically harvested by picking the edible portions (soft shoot tips which were 5-10cm long and larger leaves). They were weighed before they were ovendried to constant weight at 70°C for 48 hours to determine the dry weights. Both weights were expressed as kg per hectare.

3.6 Analytical Methods

Fresh samples harvested at random from each plot were taken to the laboratory of Department of Food Technology and Nutrition and analysed for total phenolics and total glycoalkaloid contents.

3.6.1 Determination of Total Phenolics

Total phenolics were determined at six weeks after transplanting by the Folin-Denis Method (Burns, 1963) with slight modification where fresh material was used instead of dry material. One gram of fresh material was ground in a motor with some distilled water, then the suspension made to 100ml in a conical flask. After standing for about 10-15minutes, 10ml of the supernatant were taken and mixed with 2ml of Folin-Denis Reagent and 5ml of a supersaturated sodium carbonate solution in a 100ml volumetric flask containing between 50-75ml of distilled water. The suspension was made to volume with distilled water. The mixture was thoroughly shaken and left to stand at room temperature for at least 40 minutes. The absorbance was then determined at 725nm on
a Beckman model 25 spectrophotometer. From a standard curve of pure gallic acid, the total phenolic contents were calculated as equivalent milligram gallic acid per 100gm dry weight.

3.6.2 Determination of Total Glycoalkaloids (TGA)

Total Glycoalkaloids (TGA) were determined by the method of Coxon et al (1979) with slight modifications where during extraction glasswool was used instead of celite 545. Ten grams of fresh material were blended with 90ml distilled water, then the suspension decanted into a conical flask. The cutter head was rinsed with 10ml of distilled water and 42ml of 3.5M dilute sulphuric acid. Contents of flask were shaken and left to stand for 15 minutes before being filtered under vacuum. A 30ml aliquot of filtrate was hydrolysed by heating on a thermostated water bath at 90°C for 2 hours before being extracted with chloroform, and evaporated to dryness at 40°C on a rotary film evaporator. The glycoalkaloid content was then determined by quantification as a Bromothymol blue complex using a calorimeter (model 725) at 620 nm.

From a standard curve of pure solanidine, the TGA contents were calculated as equivalent milligram solanidine per 100gm fresh weight.

3.7 Data Analysis

Analysis of variance (ANOVA) was used to analyse the data obtained from the two experiments. Means were separated by least significance Difference (LSD) and Duncan multiple range test methods as described by Steel and Torrie (1981) and Gomez and Gomez (1984) at 5% probability level.
4.0 RESULTS

4.1 Rooting of Cuttings

Among the cuttings set in the propagating boxes in a sand-soil medium, only 20% of them rooted. Of the three selections/species studied, Solanum nigrum showed the best rooting. Cuttings set in vermiculite media rooted successfully with less than 10% drying up.

4.2 Effect of Propagation Method on Vegetative growth and Leaf Yields.

Propagation method had a significant effect on plant height in the fourth week after transplanting. Figure 1 shows that mean height of plants propagated by cuttings was significantly higher than that of the control plants during early growth. However, this reversed six weeks after transplanting. Seed propagated plants tended to be taller during later stages of plant growth, although not significantly.

Propagation method significantly affected plant spread from the sixth week after transplanting (Figure 2). Seed propagation produced plants with a significantly wider canopy than vegetative propagation.

The effect of propagation on branching of the plants was significant during the sixth, eight, tenth and twelfth week after transplanting. Figure 3 shows that, in both methods of propagation
Fig. 1. Effect of propagation method on plant height of the black nightshade. Vertical bar on each mean is LSD = 0.05.
Fig. 2. Effect of propagation method on plant spread of black nightshade. Vertical bar on each mean is LSD = 0.05
the number of branches increased with plant growth up to the eighth week after transplanting. However, plants raised from seeds had significantly more branches than those raised from cuttings.

The leaf yield was significantly affected by propagation method during the first ten weeks after transplanting. Figure 4 shows that seed propagation led to a significantly higher leaf yield, which increased with plant age up to ten weeks after transplanting, followed thereafter by a slight decrease. The decrease was however not significant. The total cumulative leaf yield for seed propagated plants was 529.1 kg/ha, while that of vegetatively propagated plants was 380.9 kg/ha.
Fig. 3. Effect of propagation method on average number of branches of black nightshade. Vertical bar on each mean is LSD = 0.05.
Fig. 4. Effect of propagation method on mean leaf yield of black nightshade. Vertical bar on each mean is LSD = 0.05.

- • Vegetatively propagated.
- X Seed propagated.
4.3 Vegetative growth and leaf yield of the three selections of black nightshade as influenced by plant age.

In both experiments, the three types significantly differed in their plant heights, spread, branching and leaf yield.

As shown in Figures 5, 6, 7, and 8, Solanum Pseudonigrum non-serrated type had significantly taller plants, highest number of auxiliary branches, especially during the later stages of growth, and the highest total cumulative yield. It outyielded S. pseudonigrum serrated type by 30% and S. nigrum by 50% in experiment one. S. nigrum had significantly shorter plants than the other two types in the first experiment. In both experiments, S. pseudonigrum serrated type had a significantly lower spread than the other two types.
Fig. 5. Effect of plant age on the plant height of three selections of black nightshade. Vertical bar on each mean is LSD = 0.05.
Fig. 6. Canopy spread of three selections of black nightshade. Vertical bar on each mean is LSD = 0.05.
Fig. 7. Effect of plant age on branching of three selections of black nightshade. Vertical bar on each mean is LSD = 0.05.
Fig. 8. Effect of plant age on leaf yield of three selections of black nightshade. Vertical bar on each mean is LSD = 0.05.
4.4 Effect of Deflowering on Vegetative growth and Leaf Yield

Experiment 1

Deflowering did not have any significant effect on the spread and height of plants, however there was a significant increase in branching twelve weeks after transplanting (Figure 9). Leaf yield increased up to the tenth week after transplanting for both deflowered and non-deflowered plants but decreased thereafter (Figure 10). The total cumulative leaf yield was higher for the deflowered plants (2154.4 kg/ha) than for the non-deflowered plants (2035.1 kg/ha). The difference was however not significant.

Experiment 2

Although deflowering significantly reduced canopy spread (Figure 11), there was no significant effect on the height and the branching of the plants. Its effect on the leaf yield per hectare was significant at later stages of plant growth.
Fig. 9. Effect of deflowering on the average number of branches of black nightshade. Vertical bar on each mean is LSD = 0.05.
Fig. 10. Effect of deflowering on the leaf yield of black nightshade. Vertical bar on each mean is LSD = 0.05.
Fig. 11. Effect of deflowering on the spread of black nightshade. Vertical bar on each mean is LSD = 0.05.
Interactions between propagation method and selections on vegetative growth and leaf yield

The interaction between propagation method and selection on plant height was significant ten weeks after transplanting. Propagating *S. pseudonigrum* non-serrated type and *S. nigrum* by cuttings led to taller plants than those propagated by seeds, while propagating *S. pseudonigrum* serrated type by cuttings significantly reduced the height of the plants (Figure 12).

Interaction between propagation method and selection on branching was significant six weeks after transplanting. At this time, plants propagated through seed branched more than those propagated by cuttings. Vegetative propagation of both selections of *Solanum pseudonigrum* led to significantly fewer branches, while, for *S. nigrum* plants, decrease in branching was not significant (Figure 13).

The interaction of propagation method and types on leaf yield was significant four weeks after transplanting. Vegetative propagation led to a significantly lower leaf yield than seed propagation for both *S. pseudonigrum* selections (serrated and non-serrated) while for *S. nigrum* a higher leaf yield was obtained (Figure 14).

Interactions between types and deflowering, propagation and deflowering, type and propagation, type and propagation and deflowering were not significant.
Fig. 12. Interaction between selections and propagation method on plant height (Exp. II). Means with the same letter are not significantly different (p<0.05) according to DMRT.
Fig. 13. Interaction between selections and propagation method on number of branches (Exp. II).

* Means with the same letter are not significantly different (p<0.05) according to DMRT.
Mean Leaf Yield (Kg/ha)

Fig. 14. Interaction between selections and propagation method on leaf yield (Exp. II).

*Means with the same letter are not significantly different (p<0.05) according to DMRT.
4.6.0 Effect of Propagation Method, Deflowering and selections on the Nutritional quality.

4.6.1 Total Phenolics

Propagation method had a significant effect on the total phenolic contents in the leaves especially six weeks after transplanting. Vegetatively propagated plants gave leaves with significantly less phenolic contents during early stages of plant growth but these increased as the plants grew older (Figure 15). The average phenolic content over the season for vegetatively and seed propagated were 2857.8 mg gallic acid/100g dry wt and 2846.3 mg Gallic acid/100g dry weight respectively.

The effect of deflowering on phenolic contents in the leaves was significant at ten and twelve weeks after transplanting. As seen in Figure 16, leaves from plants not deflowered contained higher amounts of phenolic compounds than those from deflowered plants throughout the experimental period. Deflowering significantly reduced the levels of phenolics in the leaves, at the later stages of plant growth.

The three types of black nightshade did not differ significantly in their phenolic contents. Figure 17, however shows that *Solanum pseudonigrum* serrated type seemed to have the highest phenolic contents from eight weeks after transplanting onwards, although it had the lowest contents at six weeks after transplanting.
Fig. 15. Effect of propagation method on phenolic content of black nightshade. Vertical bar on each mean is LSD = 0.05.
Fig. 16. Effect of deflowering on phenolic content of black nightshade. Vertical bar on each mean is LSD = 0.05.
Fig. 17. Effect of plant age on the phenolic content of various selections of black nightshade. Vertical bar on each mean is LSD = 0.05.
The interaction between types and propagation method on the phenolic contents was significant eight weeks after transplanting.

Figure 18 shows that leaves from vegetatively propagated plants of *S. pseudonigrum* serrated type and *S. nigrum* had higher phenolic contents while those from *S. pseudonigrum* non-serrated plants, had lower amounts than seed propagated ones. Among the three types, vegetatively propagated *S. pseudonigrum* serrated type contained the highest phenolic contents.

Interactions between types and deflowering, propagation method and deflowering, and types, propagation method and deflowering were not significant.

Irrespective of the method of propagation, deflowering and selection, phenolic content reached a peak at 10 weeks after transplanting.
Fig. 18. Interaction between selections and propagation method on phenolic content. *Means with the same letter are not significantly different (p<0.05) according to DMRT.
4.6.2 Total Glycoalkaloid Content

The three types did not significantly differ in their glycoalkaloid contents in the leaves. However, the effect of propagation method on the total glycoalkaloid contents was significant. Leaves from plants vegetatively propagated contained significantly higher amounts of glycoalkaloids than those from seed propagated ones (Figure 18).

The total glycoalkaloid contents of the black nightshade leaves ranged from 109.8mg TGA/100g to 133.9mg TGA/100g on fresh weight basis as seen in Figure 19.

The effect of deflowering on glycoalkaloid contents was not significant. Although the interaction between types and propagation method, types and deflowering and propagation method and deflowering were not significant, their three way interaction was (Figure 20). Among the seed propagated plants, deflowering decreased the TGA contents in the leaves of both types of S. pseudonigrum while in the S. nigrum the TGA contents increased. The reverse was true in the vegetatively propagated plants. Deflowering increased the glycoalkaloid contents in the leaves of both types of S. pseudonigrum and decreased those of S. nigrum leaves.
Fig. 19. Effect of propagation method on glycoalkaloid content.

*Means with the same letter are not significantly different (p<0.05) according to DMRT.
Fig. 20 Glycoalkaloid contents of three selections of black nightshade.
*Means with the same letter are not significantly different (p<0.05) according to DMRT.
Fig. 21. Interactions between propagation method, selections, and deflowering on glycoalkaloid content.
5.0 DISCUSSION

5.1. Effect of Propagation Method on Vegetative growth and Leaf Yield.

From the results, it's evident that sexually propagated plants were taller with a wider spread and more number of branches and therefore a more vigorous vegetative growth than the vegetatively propagated plants. This led to a higher leaf yield. These results are in agreement with the findings of Maynard (1990), who reported higher yields from seed propagated rhubarb plants than from those vegetatively propagated. The difference in vegetative growth could probably be attributed to the fact that cuttings were obtained from mature plants which were four months old. Vegetative propagation eliminates the juvenile period of plants leading to an earlier reproductive maturity (Leopold and Kriedmann, 1975; Hartman and Kester, 1983). It has also been reported that in the spiderflower (GynandrOPSIS gynandra), during the reproductive phase vegetative growth declines and leaves senescence very quickly (Waithaka and Chweya, 1991).

In this study, vegetatively propagated plants were already flowering at transplanting, therefore deflowering started immediately. Seed propagated plants remained juvenile longer and started flowering between two and four weeks after transplanting. This could have been the reason why the vegetative growth of plants propagated by cuttings was not as high as that of seed propagated plants, therefore leading to lower leaf yields.
From this study, seed propagation would be more ideal for the local farmer since it leads to a higher vegetative growth and hence higher leaf yields. Seed propagation has also been known to offer easy transport of propagules over long distances and a convenient means of storing plants over long periods of time (Hartman and Kester, 1983).

5.2 Effect of Deflowering on Vegetative Growth and Leaf Yield

The results indicate that deflowering significantly altered vegetative growth and leaf yield of the plants. Removal of flowers seemed to lead to shorter and less spreading plants. However, it led to a higher number of branches and a higher cumulative leaf yield. These results seem to suggest a possible relationship between deflowering, and the plant height and spread. From available literature, no information exists on this relationship and this could be an interesting area of further research. The results of this study, however agree with those obtained from experiments with strawberry plants where inflorescence removal increased the number of runners (Choma et al., 1982).

Removal of flowers has been found to prolong vegetative growth in some flowering plants (Salisbury and Ross, 1978). This seems to explain the possible source of the higher cumulative leaf yield obtained from the deflowered plants. In many plants, there exists a competition between the vegetative and reproductive processes
such that once flowering begins, the vegetative growth stops (Salisbury an Ross, 1978; Splittstoesser, 1984). Therefore, since the black nightshade produces many flowers, these probably compete with vegetative organs, leading to a less vegetative growth and thereby low leaf yield per hectare.

Although in both experiments total cumulative leaf yields were higher for deflowered than for non-deflowered plants, there is a possibility that this difference in yields would have been much higher had the weather been favourable than that prevailing during the growing season. Records indicate that yields of upto 4.2 tons/ha have been obtained (Tindall, 1983) as compared to the maximum of 0.81tonnes per hectare obtained in this study. In the second experiment, the low leaf yield of both deflowered and not-deflowered plants could have been caused by growth retardation as a result of water stress and disease infestation. There were no rains during the early plant growth (total rainfall was 0.4mm/month), and the irrigation pump had broken down. Plants were also infested by bacterial canker which could have been transmitted through seed. This could have contributed to poor growth of the plants.

5.3 Effect of types on the vegetative growth and leaf yield

The three types of the black nightshade differed in their vegetative growth and leaf yield. Solanum pseudonigrum non-serrated type had taller plants, with more spreading and branching
habit than the other two types and thus had a higher leaf yield. This was probably due to differences in their genetic make up and possible different response to the environmental and cultural practices. It therefore seems like *S. pseudonigrum* (non serrated) would perform better in environmental conditions of Kabete and other similar areas when compared to the other two selections. Other workers including Mtotomwema (1987), have however reported existence of other selections of the black nightshade not used in this study. This therefore calls for a similar study including all the available selections of black nightshade.

5.4 Effect of Propagation Method Deflowering and Types on the Nutritional Quality

5.4.1 Total phenolics

Plants propagated vegetatively had significantly lower amounts of phenolics than those propagated by seeds during the early stages of growth. This seems to imply that the method of propagation might have an influence on the synthesis and/or accumulation of phenolics. Phenolic compounds are by products of plant metabolism and might not be involved directly in the metabolic pathways for growth and reproduction (Street..et al., 1972, Janick ..et al., 1981, Butler, 1988).

Deflowering seemed to lead to a lower accumulation of phenolic contents in the leaves. Newly formed berries of the black nightshade together with new leaves constitute a sink for the
photosynthates (Omta and Fortiun, 1980). Since leaves were continuously being harvested, deflowering removed the source of photosynthates, therefore leading to a decrease in the photosynthetic rate (Azon - Bieto, 1983). This might have led to a decrease in phenolic contents since they have been known to be by-products of plant metabolism.

The three types of the black nightshade differed in their phenolic content over the growing season, with S. pseudonigrum serrated type having the highest contents (2736mg/100g dry wt) followed by S. pseudonigrum non serrated type (2658 mg/100g dry wt) while S. nigrum had the least (2588mg/100g dry wt). These are however, much higher than those recorded could be due to disease infestation and effect of drought during the growing period. Murage (1989) working on S. nigrum recorded levels of upto 1500mg/100g dry wt.

These vegetables are usually cooked with a lot of water and therefore there is a possibility of reduction in these compounds during cooking. Mondy et al (1971) working with bitterness in potatoes found that the phenolic contents which were thought to cause bitterness in green potato tubers were markedly lowered by cooking. However, no records on the solubility of phenolic compounds in water were available. Dilution with water during cooking and decanting of the cooking water reduce these bitter compounds.
The method of propagation did not seem to have a direct relationship with the phenolic contents of the three selections of the vegetable. Vegetatively propagated *S. pseudonigrum* serrated type, however seemed to contain the highest phenolic contents while vegetatively propagated *S. pseudonigrum* non-serrated contained the least.

5.4.2 Glycoalkaloid Content

The method of propagation seemed to significantly affect the glycoalkaloid contents of black nightshade. Vegetatively propagated plants seemed to have higher amounts of glycoalkaloids than the seed-propagated plants. This could probably be due to the differences in age of the propagules. Cuttings were obtained from plants which were four months old and therefore mature. There is a possibility that these plants had accumulated high levels of these compounds as they aged and therefore their levels were already high in the cuttings. It should however, be noted that, analysis was only done once during the growing season and thus the trend of these compounds with plant growth is not known.

The three selections of this vegetable contained varying amounts of total glycoalkaloid contents in their leaves. *Solanum nigrum* had the highest (133.9mg TGA per 100g fresh weight), followed by *S. pseudonigrum* non-serrated type (132.6mg TGA per 100g fresh weight) while *S. pseudonigrum* serated type had the least (109.8mgTGA/100g fresh weight). These were however not
significantly different.

Although deflowering did not have any effect on the glycoalkaloid contents of the leaves, the deflowered plants contained less of these compounds compared to the non deflowered ones.

Removal of flowers and the methods of propagation showed varied responses among the three types of the black nightshade. Deflowering seed propagated plants decreased the TGA contents in the leaves of both types of *S. pseudonigrum* while it increased those of *S. nigrum*. On the contrary among the vegetatively propagated plants, deflowering increased the glycoalkaloid contents in the leaves of both types *S. pseudonigrum* and decreased those of *S. nigrum* leaves. It implies that a possible relationship exists between removal of flowers and propagation of these plants. However, no information has been found on such a relationship in vegetable crops.

Glycoalkaloids have been known to occur in many plants of the solanaceae family (Bajaj et al., 1979). Their function is not fully understood, although some have medicinal properties (Janick et al., 1979, Coultate, 1989). In potato tubers, glycoalkaloids have been associated with the bitter off-flavour found in greened tubers. Contents of up to 20-40mg solanine/100g fresh weight have been reported (Schumphan, 1985). An upper limit of 20mg
Solanine/100g fresh weight is allowed in potatoes for human consumption. The glycoalkaloid contents of the black nightshade leaves seem to be high. These together with phenolic compounds tend to give the vegetables a bitter taste which remains even on cooking.

In potatoes, glycoalkaloids have been known to be fairly insoluble in water and are heat stable, therefore none is lost during normal cooking, however, they are poorly absorbed in the gastro intestinal tract (Coultate, 1989). Their poor absorption might therefore cater for the high levels in the vegetables and probably reduce the danger of toxicity.
6.0 CONCLUSIONS AND SUGGESTIONS FOR FURTHER RESEARCH

Conclusion

Plants propagated by seeds were more vigorous in their vegetative growth and finally had a higher cumulative leaf yield. Since the value of the vegetable lies in the edible portion, that is, the leaves and the soft shoot tips, it is recommended that farmers from areas with soil and climatic conditions similar to those of Kabete propagate their vegetables using seeds. These however need to be clean seed to avoid the danger of seedborne diseases like bacterial canker. Vegetative propagation is more labour intensive.

Though deflowering led to production of more branches and a higher total cumulative leaf yield it is a tedious process requiring much labour. Since black nightshade plant produces many flowers and can be harvested over a period of three months, a lot of labour would be required to cope with the work. In this experiment, deflowering was carried out every two days, and took about four hours to deflower an area of 96m². This would be laborious and therefore expensive for a farmer. Therefore, it would not be an advantage for local farmers to adopt it as its effects do not lead to a significant increase in the yields, compared to non deflowering.

Of the three types used S. pseudonigrum non-serrated type showed a more vigorous vegetative growth and higher cumulative
yield. It should, however be noted also that it contained the highest phenolic contents among the seed propagated plants. Other types of the black nightshade like S. eldorettii also exist which were not used in the experiment. It is therefore recommended that more research be carried out on this vegetable using a wide range of different selections of black nightshade germplasm available.

Propagating the black nightshade by seeds seemed to lower the amounts of glycoalkaloid contents in the leaves. However, deflowering did not have any significant effect on these compounds in the leaves.

Propagation of the black nightshade by seed seemed to lead to higher phenolic content in the leaves during the early stages of growth, but lower contents during later stages of growth. These compounds reach a peak at 10 weeks after transplanting. Deflowering led to less accumulation of these compounds in the leaves.

Suggestions for Further Research Work

It would be useful to carry out trials on agronomic practices such as spacing, water relations, shading, fertilizer levels and harvesting frequency so as to enable the farmers to optimize productivity and quality of the crop. Similar work will need to be done with more selections of black nightshades. Work should be carried out at different sites in order to determine which types are suited to the different climatic and edaphic environments.
The leaves are usually cooked before consumption. It would be useful to study the effect of cooking on nutritional quality of the leaves.

The glycoalkaloid contents were determined at one harvest only. Changes of total glycoalkaloids with plant age should also be investigated.
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Appendix 1: Mean monthly weather record - field station, Kabete between July, 1990 and May, 1991

<table>
<thead>
<tr>
<th>Month</th>
<th>Mean radiation</th>
<th>Mean sunshine</th>
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### Appendix 2: Analyses of variance (ANOVA) table

**Appendix 2.1: ANOVA for the Effect of Deflowering on Vegetative growth and Leaf Yield (Kg/ha)**

(Exp.1)

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* F-ratio significant at P<0.05 and ** F-ratio significant at P<0.01 respectively. The rest not significant (n.s)
Appendix 2.2 ANOVA for the Effect of Propagation Method and Deflowering on vegetative growth and leaf yield and quality of Black Nightshade (kg/ha)

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* - ** F-ratio significant at P<0.05 and P<0.01 respectively. The rest not significant (n.s)
Appendix 2.3: ANOVA for Total Glycoalkaloid contents in the leaves.

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