ENHANCED GROWTH AND YIELD OF AFRICAN NIGHTSHADE (*Solanum scabrum* Mill.) AND SPIDER PLANT (*Cleome gynandra* L.) THROUGH SOLE AND INTEGRATED NUTRIENT MANAGEMENT

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DEDICATION

I hereby wish to dedicate this work to my dad and mum and all farmers involving themselves in the production of African Traditional Vegetables.

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I wish to express my heartfelt gratitude to my parents; Sammy and Emmy Chumo. They enthused and enhanced my interest in academic and never ceased their support. Special thanks go to my brother Felix K. Ng'etich for his ceaseless support he accorded to me during this course of study. I wish to express my sincere thanks to Prof. Joseph N. Aguyoh and Dr. Joshua O. Ogweno for their valued academic guidance and support throughout the study period. The entire staff in the Department of Crops, Horticulture and Soils and in particular Mr. George Morara are chiefly acknowledged for their awesome support. Defined thanks go to Ms. J. Kiplagat for providing interminable moral support and encouragement. Finally, all praise is due to Almighty God, who gave me strength and good state of health especially when I was carrying out all the labor-intensive work during project implementation session.

ABSTRACT

African leafy vegetables provide adequate amounts of crude fiber, carotene (a precursor of vitamin A), vitamin C, riboflavin, folic acid and mineral salts. Most of the African vegetables have been domesticated and cultivated but information on their sustainable fertility requirements are scanty. The soil fertility in the region has declined over time in most smallholder farms. However, few farmers can afford the inorganic fertilizers while the use of manure alone may be limited by its slow nutrient release. Among the options available for increasing the production is integrating the use of inorganic nitrogen fertilizer with farmyard manure (FYM). The objective of the study was to evaluate the effects of integrated application of farmyard manure and nitrogen fertilizer levels on growth and yield of African nightshade (*Solanum scabrum* Mill.) and spider plant (*Cleome gynandra* L.). Field trials were conducted at Horticulture Research and Teaching Field, Egerton University, Njoro, Kenya from April to July (trial 1), and August to November, 2009 (trial 2). The experiment was carried out in split-plot arranged in randomized complete block design, replicated thrice. The main plot treatments were farmyard manure (FYM) levels at the rates of 0, 7.5, 11.3 and 15 tha^{-1} and the sub-plot treatments were nitrogen levels at the rates of 0, 100, 150 and 200 kg Nha^{-1}. Standard cultural practices were undertaken to maintain the plants from planting to end of data collection. Parameters studied included growth and yield aspects. Data collected was subjected to Analysis of Variance (ANOVA) and mean separation performed using Duncan Multiple Range Test (DMRT) at 0.05 level of significance. The results showed that, 7.5 tha^{-1} of FYM and 150 kg Nha^{-1} of CAN increased fresh yield of African nightshade by 62% while 11.3 tha^{-1} of FYM and 150 kg Nha^{-1} of CAN fertilizer rates enhanced the spider plants fresh yield by 64% compared to the control. The higher treatment combination significantly increased African nightshade's plant height by 64%, number of branches by 34%, leaf area by 59%, leaf area index by 89%, number of leaves by 77% and above ground biomass by 62%. While in spider plant, the number of leaves was increased by 63%, branches number by 67%, internodes length by 70% and leaf area index by 85% compared to the control. Chlorophyll and stomatal conductance showed an increasing trend with increase in treatment levels. The study recommends that application of 7.5 tha^{-1} of FYM and 150 kg Nha^{-1} of CAN and 11.3 tha^{-1} of FYM and 150 kg Nha^{-1} of CAN fertilizer rates for better productivity of African nightshade and spider plants respectively. The research provides valuable information to farmers and, if well utilized, can enhance the productivity of African nightshade and spider plant.

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LIST OF ABBREVIATIONS AND ACRONYMS

CAN	Calcium Ammonium Nitrate
CG	*Cleome gynandra* L.
DAP	Days after Planting
DMRT	Duncan's Multiple Range Test
FYM_1	Farmyard manure level (control)
FYM_2	Farmyard manure level (7.5 tha^{-1})
FYM_3	Farmyard manure level (11.3tha^{-1})
FYM_4	Farmyard manure level (15 tha^{-1})
g_s	Stomatal Conductance (mmol $m^{-2}s^{-1}$)
ISTA	International Seed Testing Association
Kg Nha^{-1}	Kilogram of Nitrogen per Hectare
LA	Leaf Area
LAI	Leaf Area Index
N	Nitrogenous fertilizer (26%CAN)
N_1	Nitrogen Level 1(0kg Nha^{-1})
N_2	Nitrogen Level 2 (100 kg Nha^{-1})
N_3	Nitrogen Level 3(150 kg Nha^{-1})
N_4	Nitrogen Level 4 (200 kg Nha^{-1})
P	Phosphorus
SAS	Statistical Analysis System
SS	*Solanum scabrum* Mill.
tha^{-1}	Tonnes per Hectare
TSP	Triple Super Phosphate

CHAPTER ONE
INTRODUCTION

1.1 Background Information

Traditional vegetables supply abundant amounts of protein, vitamins, calories and minerals that could help alleviate problems of malnutrition, poverty and lack of food in developing countries (Burgess *et al.*, 1998). These vegetables represent cheap but quality nutrition for large parts of the population in both rural and urban areas (Chweya and Eyzaguirre, 1999). Hence traditional vegetables can serve as an indispensable constituent of human diet supplying the body with minerals, vitamins and certain hormone precursors, in addition to protein and energy (Edmonds and Chweya, 1997; Fleuret, 1979). The most important traditional vegetables in Kenya include *Amaranthus* spp, *Solanum nigrum, Solanum scabrum, Cleome gynandra, Crotolaria brevidens* and *Vigna unguiculata* (Opiyo, 2004). With the introduction of exotic vegetables in Kenya, utilization of traditional vegetables declined hence narrowing down the vegetable food base and subsequently reduced vitamins, minerals and protein sources, which are usually available in vegetables (Chweya and Mnzava, 1997). However, many of these inexpensive nutritive indigenous plants are yet to be adequately studied and utilized.

Traditional vegetables are all categories of plants whose leaves, fruits or roots are acceptable and used as vegetables by urban and rural communities through custom habits and traditions (FAO, 1988). Traditional vegetables are defined as having been originally domesticated or cultivated in Africa for the last few centuries (Edmonds and Chweya, 1997). African traditional vegetables often have the advantage over exotic vegetables of being adapted to local growing conditions (Chweya and Eyzaguirre, 1999). They require fewer production inputs, they mature faster and some have longer total harvesting period than that of many exotic vegetables (Schippers, 2000). They also serve as a reliable source of food and income, because they grow rapidly even under adverse environmental conditions, and their diversity permits production across different seasons (Muchiri, 2004).

African nightshade (*Solanum scabrum* Mill.) and spider plant (*Cleome gynandra* L.) are among important traditional leafy vegetables consumed by various rural communities (Chweya and Mnzava, 1997). They serve as a reliable source of food providing families with variety of diets there by helping in ensuring stability in household food security (Mingochi and Luchen, 1995). These vegetables are good sources of nutrients such as vitamin A, vitamin C, protein as

well as minerals, such as iron, calcium, phosphorus and zinc (Akubugwo *et al.,* 2007; Mwajumwa, *et al.*, 1991). Besides being used for human consumption, African nightshade leaves serves as fodder and browse for domestic herbivorous animals (Fontem and Schippers, 2004).

Traditional vegetable exhibits various medicinal properties. According to Son *et al.* (2003) and Pereez *et al.* (1998) extract from nightshade fruits have anti-tumour and neuro-pharmacological properties and can be used as an antioxidant and cancer chemo preventive matter. Spider plant is also used for medicinal purposes (Edmonds and Chweya, 1997). The concoction made from their leaves is believed to treat scurvy and marasmus, while the sap from pounded leaves is squeezed into ears, nostrils and eyes to treat epileptic fits and recurrent malaria (Opole *et al.*, 1995).

Decline in consumption of traditional vegetables was due to a shift towards exotic vegetables, which were thought to be of higher nutritional and social values as well as high yielding (Fenwick *et al.*, 1990). Fenwick *et al.* (1990) further stated that the decline in the use of traditional vegetables in the tropics was due to the belief that the bitter species are poisonous. However, a problem of environmental degradation, shortage of arable land, high moisture requirements, diseases, pests and high production cost have reduced the reliability of exotic vegetables and has narrowed down the vegetable food base of most households especially the resource poor families (Mwai *et al.,* 2007). In addition, Maundu *et al.* (1999) indicated that lack of fertilizer use is one of the key constrain in improving traditional vegetable production in most Kenyan communities.

Increased crop productivity is the aim of every producer and cannot be achieved without effective nutrient management (Wolf, 1999). Knowledge on nutrient elements and the required amounts are essential for optimum growth and yield of any particular crop (Rao *et al.*, 1998). Fertilizers supply the soil with nutrients, compensate for nutrient losses and maintain or improve the fertility of soil (Makinde, 2007). The amounts of the nutrients needed to be added to the soils vary depending on the crop being grown and the initial nutrient content of the soil (Khadija, 2006).

In many cultivated soils nitrogen is inadequate necessitating its addition in the form of fertilizers (Khadija, 2006). The use of inorganic fertilizer alone has not been helpful in crop production because it aggravates degradation of soil, though they contribute to higher yield in comparison with organic manure alone (Makinde, 2007; Sharma and Mittra, 1991). The

degradation is brought about by loss of organic matter which consequently results in soil acidity, nutrient imbalance and finally low crop yields (Ayoola and Makinde, 2007). Response of crops to applied fertilizer depends on soil organic matter and their impact on the soil. The quantity of soil organic matter depends on the quantity of organic material which can be introduced into the soil either by natural returns through roots, stubbles, sloughed-off root nodules and root exudates or by artificial application in the form of organic manure which can otherwise be called organic fertilizer (Agboola and Omueti, 1982).

Crop residues and animal manures cannot meet crop nutrients' demand over large areas because of the limited quantities available, the low nutrients content and the high labor demands for processing and application (Palm *et al.*, 1997). Nevertheless, the need to improve and maintain the environmental conditions as well as reducing the cost of inorganic fertilizers and their amounts going into the soils, organic fertilizer material should be advocated for use by farmers (Seifritz, 1982). In addition, application of organic manures not only improves the soil microbial properties which enhance mineralization of nutrients, but also help in sustaining cropping system through better nutrient recycling, improvement of soil structure and increasing soil water - holding capacity (Belay *et al.*, 2001).

There are several options for restoring and maintaining soil fertility for instance by integrating organic and inorganic fertilizers, recycling part of the nutrients through use of manures or decomposed crop residues in the field so as to offset the nutrient removed by crops in the field and those which are lost via volatilization, leaching and run off (Kihanda, 1996). The use of integrated organic manure and mineral fertilizers has been shown to be a sound soil fertility management strategy in many countries of the world (Lombin *et al.*, 1991). This is because it aims at alleviating the limiting nutrients and improves their availability from the soil reserves. Integrated nutrient use also can influence the nutrient availability through interactions with the mineral soil in complex cations and reducing the P sorption capacity of the soil (Palm *et al.*, 1997).

The present study is aimed at enhancing the productivity of African nightshade (*Solanum scabrum*) and spider plant (*Cleome gynandra*) by integrating farmyard manure and nitrogen fertilizer to optimize on their growth and fresh yield.

1.2 Statement of the Problem

The production of traditional vegetables is to a greater extent constrained by inadequacy of scientific knowledge on production and limited information on fertilization requirements which enhances high and sustainable crop yield. Despite their importance, traditional vegetables have received limited research attention in terms of their horticultural production package and utilization as food crops in favour of exotic. Initially people shifted into consumption of exotic vegetables neglecting indigenous ones despite the fact that they are superior in terms of nutritive value as well as ease of production. A recent realization by Kenyans, particularly on importance of traditional African vegetables in terms of high nutritional and medicinal values has led to an increased demand in their consumption particularly in the urban population. This therefore calls for enhanced production to meet the recent increasing demand. In some farms in Kenya, the continuous use of synthetic fertilizer alone has led to the degradation of soil; loss of organic matter resulting in soil acidity, decrease of soil microbes, nutrient imbalances and low vegetable crop yields. On the other hand, most farms not only use low amounts of inorganic fertilizers that are not sufficient for crop production but also have small amounts of organic resources that may not be sufficient for sustainable production. Therefore the use of integrated nutrient fertility management can offers the best alternative to increasing vegetable production at the farm level.

1.3 Justification

Continuous cultivation with little or no fertilizer application has often been associated with a decline in soil fertility with subsequent reduction in crop yields (Kihanda, 1996). Nitrogen is an important plant nutrient that is required in fairly large amount and is a major soil nutrient limiting factor in crop production (Rao *et al.*, 1998). Intensive use of inorganic fertilizers is hazardous to our environment and human health (Ayoola and Makinde, 2007). The increase in the use of inorganic fertilizers globally calls for a speedy intervention where high and sustainable crop yields can be obtained and maintained by integrating nitrogen fertilizer with locally available farmyard manure (Minde *et al.*, 2008). Since inorganic fertilizers are expensive for the resource poor farmers who often utilize indigenous vegetables (Jansen Van Rensburg *et al.*, 2004), it is still possible to increase production by supplementing them with farmyard manure. With the onset of the market economy and modernization of agriculture in Africa, attention has been given to crops that offer a potential for urban and export market. As a result, exotic vegetables became more prestigious than traditional vegetables and conventional agronomy has,

to a large extent, concentrated on conserving the genetic resources and promotion of exotic rather than traditional vegetables (Sato *et al.*, 2002; Maundu *et al.*, 1999). However, most local vegetables are well adapted to harsh climatic conditions and are resistant to pest and diseases as compared to the introduced exotic vegetable which have been found to be not only difficult to grow under harsh climatic condition but tends to require high input levels (Jansen van Rensburg *et al.*, 2004; Chweya and Eyzaguirre, 1999). Hence there is need to develop appropriate and sustainable ways of vegetable production so as to benefit resource poor farmers and also meet the current market demands of traditional vegetables.

1.4 Objectives

1.4.1 General Objective

The general objective of this study was to determine the influence of sole and integrated application of farmyard manure and nitrogen fertilizer in enhancing the productivity of African nightshade and spider plant.

1.4.2 Specific Objectives

1. To determine the effect of nitrogen levels on growth and yield of African nightshade and spider plant.
2. To determine the effect of farmyard manure levels on growth and yield of African nightshade and spider plant.

1.5 Hypotheses

1. H_o: Nitrogen levels have no effect on growth and yield of African nightshade and spider plant.
2. H_o: Farmyard manure levels have no effect on growth and yield of African nightshade and spider plant.

CHAPTER TWO
LITERATURE REVIEW

2.1 African Nightshade

2.1.1 Taxonomy and Botany

African nightshade belongs to the family *Solanaceae*, and the genus is *Solanum*. The genus contains many essential vegetables and fruits such as potatoes, tomatoes, chillies, green and red peppers, cape gooseberries as well as ornamentals such as Petunia. It is composed of 90 genera and 2000 to 3000 species that are widely distributed throughout tropical and temperate regions and from sea level to altitude over 3500 m above the sea level (Edmonds, 1997). Within this family, *Solanum* constitutes the largest and most complex genus. The generic name *Solanum* is generally considered to be derived from the Latin word *Solamen* which refers to the quieting or sedative effects associated with many of the species (Edmonds, 1997). Other species in the *Solanum nigrum* complex that are commonly found in Africa include *Solanum gracile, Solanum villosum, Solanum nodiflorum* (*S. americanum*), *Solanum nigrum* and *Solanum retroflexum* (Edmonds and Chweya, 1997).

Solanum scabrum belongs to the section *Solanum* and is closely related to the *Solanum nigrum* complex (Edmonds and Chweya, 1997), however clearly distinguishable from *Solanum nigrum* L. by molecular markers like Rapid Molecular Markers, Amplified Fragment-Length Polymorphism (AFLP) Markers and Simple Sequence Repeat (SSR) loci Markers (Olet *et al.*, 2005; Dehmer and Hammer, 2004). Morphologically, *Solanum scabrum* can be easily identified by its relatively large broadly ovoid dark purple berries of a diameter of 15–17 mm that do not drop at maturity. It exhibits vigorously growing broad leaves and strong stems with distinct dented wings. The flowers are either dark purple and have brown anthers (Berinyuy *et al.*, 2002 ; Schippers, 2000). Several synonyms for the species are documented e.g. *Solanum guineense* Mill., *Solanum melanocerasum* All., *Solanum nigrum* var. guineense L., *Solanum tinctorum* Welw. (Schippers, 1996).

Solanum scabrum is native to the warm humid forest belt of West and Central Africa (Fontem and Schippers, 2004) and cultivated in more than 20 African countries (Berinyuy *et al.*, 2002). It is one of the most important leafy vegetables in both West and Central Africa (Olet *et al.*, 2005 and Fontem and Schippers, 2004). Farmers in most parts of West Africa prefer *Salanum scabrum*. because of its potential for intercropping and multiple harvesting per cropping

cycle, the availability of market chains, the low pest control requirements, and the low input requirements (Mkabwa *et al.*, 2008).

2.1.2. Horticultural Production Field Practices

Solanum scabrum is raised by either direct sowing or from the nursery for about one month from sowing to transplanting (Schippers, 2002).The plant grows on a wide range of soil types, but thrive best on fertile soils, especially those high in nitrogen and phosphorous (Muchiri, 2004; FAO 1988; Holm *et al.*, 1977). Consequently, soils with high organic matter content are preferred by African nightshade (Schippers, 2002). Sandy loams to friable clay soils with a pH range of 6.0-6.5 are particularly suitable for these plants. *Solanum scabrum.* is intolerant to water stress. An annual rainfall of 500-1200 mm is needed for optimum growth (Edmonds and Chweya, 1997). The optimal temperature regime varies between 20°C and 30°C, but most species will also grow within a range of 15°C to 35°C (Schippers, 2002).

African nightshade species are ready for harvest when the plants reach a height above 15 cm by cutting the entire shoot to encourage lateral shoots that can be harvested in 7-14 day intervals (Fontem and Schippers, 2004; Maundu *et al.*, 1999 and Edmonds and Chweya, 1997). This stage is usually reached four to six weeks after transplanting (Mwai and Schippers, 2008; Schippers, 2000; Chweya, 1997). Moreover, complete harvesting by uprooting the whole plant is also practiced, either as a form of thinning or if a close spacing of plants is chosen and enough suitable land is available, the entire crop is uprooted (Schippers, 2002). Cumulative fresh leaf yields of up to 12-20 t ha^{-1} per growing season are possible (Edmonds and Chweya, 1997). Edmonds and Chweya (1997) reported a total leaf yield of 5 tha^{-1} obtained from six sequential harvests when *Solanum americanum* species were spaced 60 cm x 10 cm apart.

2.1.3 Utilization of African Nightshade

African nightshades serve as a reliable source of food and income, because their diversity permits production across different seasons (Muchiri, 2004; Chweya and Eyzaguirre, 1999). They are often cultivated in small kitchen garden and occasionally collected from wild for domestic use (Maundu *et al.*, 1999). The African nightshade leaves and tender shoots are widely used as vegetable throughout the world and have provided a food source since early times especially during famine (Henderson, 1974). *Solanum scabrum* has higher protein content in its leaves than other leafy vegetables in the section of *Solanum* (Jacoby, 2003).

Among Kenyan communities, leaves of nightshades are first boiled in water, after which the cooking water is replaced with milk, and boiled again for a short period. The resulting product is compressed and left to dry and ferment for a few days. It is then served with cassava and fresh leafy vegetables (Edmonds and Chweya, 1997; Schippers, 2000).

Berries of some black nightshade species are eaten because they are sweet when ripe (Manoko and Van Der Weerden, 2004). However berries of *Solanum scabrum* are not eaten (Berinyuy *et al.*, 2002). Research shows that *Solanum scabrum* serves as a source of dyes because of its remarkable high anthocyanin concentrations of 8.1-13.9 g kg^{-1} fresh yield (Cornelia and Stefan, 2007; Fontem and Schippers, 2004). Furthermore, *Solanum scabrum*. can be used as fodder for cattle and goats (Fontem and Schippers, 2004).

2.1.4 Nutritive Value of *Solanum scabrum* Mill. Leaves

Most of the studies so far conducted to investigate the nutritive value of African nightshade have shown that this species is among the high nutritive value vegetable known. For instance 100gms fresh leaf of *Solanum scabrum* contains 83-91% water; 2.8-5.8 g protein, 90-442 mg calcium, 1.0-4.2 mg iron; 75 mg phosphorus; 29-400 mg nitrate; 0.6-14 g crude fiber; 0.8 g fat; 3.5-5.0 g carbohydrate; 3.3-8.8 g ash; calories 38 kcal; 3.3-5.0 g carbohydrates;1.7 - 11.6 mg beta carotene; 20-158 mg ascorbic acid as well as appreciable amounts of methionine which is an amino acid scarce in other vegetables. Besides that, the leaves contain 58.8-98.5 mg oxalic acid; 29-400 mg nitrates and 29-400 mg total phenols (Edmonds and Chweya, 1997). Moreover the berries contain high amounts of iron, calcium, vitamin B and appreciable amounts of vitamin C and carotene (Fortuin and Omta, 1980).

2.1.5 Role and Potential of African Nightshades in Health Promotion

Traditional vegetables exhibit various medicinal properties which are used throughout the world to treat a variety of illnesses; many of these could have great potential in medical research, especially those species that might have anti-carcinogenic properties (Rajesh *et al.*, 2002). In India *Solanum scabrum*. mixed with other herbal medicines has hepato-protective effect in cirrhotic patients (Sarwat *et al.*, 1995). This protective effect is attributed to the diuretic, anti-inflammatory, anti-oxidative, and immune-modulating properties of their component herbs (Fallah *et al.*, 2005). The leaves also protect against hepatitis B virus infection on consumption (De Silva *et al.*, 2003). Furthermore, they are used to heal stomach-ache, open wounds and are known to possess hypotensive effect (Ye, 1984). Studies have demonstrated that aerial parts of

Solanum scabrum. have the ability to decrease the secretion of gastric acid, pepsin level and stimulate mucus secretion (Akthar and Munir, 1989). An extract from pounded leaves and fruits are used to treat tonsillitis (Maundu *et al.*, 1999). In Tanzania the juice extracted from *Solanum americanum* leaves is used to treat chronic conjunctivitis (Manoko and Van Der Weerden, 2004).

The berries possess various medicinal properties such as sedative, diaphoretic, diuretic, expectorant and are useful in treating the disease of liver, heart and eyes and are also effective against piles, fever and dysentery (Rastogi and Mehrotra, 1991). Son *et al.* (2003) and Perez *et al.* (1998) reported that extract of its berries have anti-tumor and neuropharmacological properties and it can be used as an anti-oxidant and cancer chemo-preventive matter. The anti-ulcerogenic effects of the methanolic extract of *Solanum nigrum* berries on aspirin induced ulceration in rats with respect to antioxidant status in the gastric mucosa ulcers have been investigated. Oxygen free radicals considered to be important factors in the pathogenesis of gastric ulcer was reduced drastically showing that *solanum nigrum* L. berries may exert its gastroprotective effect by a free radical scavenging action and hence considered as therapeutic potential in the treatment of gastric diseases (Mallika and Shyamala, 2004). In Kenya, unripe fruits of *Solanum villosum* are applied to aching teeth (Maundu *et al.*, 1999). Besides its importance, *Solanum nigrum* is known for its toxicity because it contains solanine, a neurotoxic glyco alkaloid (Abbas *et al.*, 1998).

2.2 Spider Plant

2.2.1 Taxonomy and Botany

Spider plant (*Cleome gynandra* L.) belongs to the family *Capparaceae*, subfamily *Cleomoideae*. The family contains about 700 - 800 species, divided into 45 genera (Kokwaro, 1994; Kuhn, 1988). The genus *Cleome*, with over 200 species (Bruinsma, 1985), consists of highly polymorphic herbaceous plants. The species is thought to have originated in tropical Africa and Southeast Asia, and to have spread to other tropical and subtropical countries in the Northern and Southern hemispheres (Kokwaro, 1976). The *Cleome* genus is widely distributed in the drier parts of the tropics and subtropics, but occurs mostly in Africa. It is also found in countries in Asia, Africa and the Americas, where it grows and is regarded as a weed (Kuhn, 1988).

Spider plant is an erect herbaceous annual herb, which is branched and can grow up to 1.5 m in height depending on environmental conditions (Chweya and Mnzava, 1997). It has a

long tap root, with a few secondary roots with root hairs. Stems and leaf petioles are thickly glandular and rarely glabrous (Chweya and Mnzava, 1997). They exhibit variable pigmentations, from green to pink, or violet to purple. Leaves are alternate, digitately palmate and petiolate. Each leaf has 3-7 leaflets, but most commonly 5 (rarely 3-4), which are pinnately dissected and sessile (Chweya and Mnzava, 1997). They vary from obovate to elliptic in shape, and are usually 2-10 cm long and 2-4 cm wide. They are sparsely hairy, but this is variable, and they have finely toothed margins or round ends. The petioles are 3-23 cm long, the cotyledonary leaves have single leaflets, and leaves are oppositely arranged on the stem. Inflorescence is quite showy, and is usually up to 30 cm in length. The fruit is a long-stalked, dry, dehiscent silique, which is a spindle-shaped capsule measuring up to 12 cm long and 8-10 mm wide. The capsules are green, turn yellow when ripe, and dehisce easily when dry, to release seeds that measure 1.0-1.5 mm in diameter (Chweya and Mnzava, 1997).

2.2.2 Horticultural Production and Field Practices

Cleome gynandra plants are propagated by seed. Seeds are sown directly in a well prepared seedbed. Seedlings do not withstand transplanting, because their root systems consist of taproots with very few laterals. Harvesting starts when the plants reach a height of about 15 cm. They can be harvested by uprooting whole plants, or by topping, cutting back to ground level, or picking individual leaves or leafy branches at frequent intervals. It has been established that frequent picking and deflowering encourages lateral growth, thus extending the harvesting period. Harvesting starts 4-6 weeks after seedling emergence and can last 4-5 weeks (Chweya and Mnzava, 1997). Spider plant is adapted to a wide range of environmental conditions. It grows well from 0-2400 meters above the sea level. And grows in both area of low and high temperatures but thrives best from 18 to 25°C. Plants do not grow well under shade, as they require high light intensity. The species is a C_4 plant, and hence combines efficient water utilization with high photosynthetic capacity at high temperatures (Imbamba, 1976). The species requires soils with high organic matter content and adequate mineral reserves. It's commonly found growing on fertile soils, especially in those mixed with animal manure, or with homestead refuse. Application of 200 g Diammonium Phosphate (46% P_2O_5, 18% N) m^{-2} at planting is recommended to give plants early good start (Chweya and Mnzava, 1997). Plants can grow on a wide range of soils, as long as they are deep and well drained, with a pH range of 5.5-7.0. The soil types range from sandy loam to clay loams (Chweya and Mnzava, 1997).

2.2.3 Utilization of Spider Plant

Spider plant is used as a vegetable where the tender shoots and leaves are boiled and eaten as herb, tasty relish, stew or side dish. The high fiber content of the leaves enables them to be stored for a long time (Opole *et al.*, 1995). The fresh leaves are also used as ingredients in other mashed foods, and the dried leaves are ground and incorporated in weaning foods (Mathenge, 1995). The vegetable is a rich source of protein, and the leaves contain over and above the normal recommended adult daily allowance of vitamins A and C and the minerals calcium and iron (Arnold *et al.*, 1985).

2.2.4 Nutritive Value of Spider Plant Leaves

The plant is highly nutritious leafy vegetable for instance fresh edible portion contains 3.1 - 7.7% proteins and vitamin A and C (Abe and Imbamba, 1997). It also contains 4.4 - 6.4% carbohydrates levels, 1.3 - 1.4% crude fibre, 213 - 434 mg calcium, 86 mg magnesium, 12 mg phosphorus, 1 - 11mg iron, 0.46 mg copper, 6.7 - 18.9 mg β-carotene, 0.76 mg zinc and 127 - 484 mg ascorbic acid (Chweya and Mnzava, 1997). Chweya (1995) reported that the plant's nutritional value varies with soil fertility, environment, plant type, plant age and the production techniques used. The amount of ascorbic acid lost increases with cooking time, and can reach 81% if the vegetable is cooked for 15 minutes in 8 volumes of water (Mathooko and Imungi, 1994).

2.2.5 Role and Potential of Spider Plant in Health Promotion

Indigenous knowledge possessed by rural women in Kenya indicates that spider plant has several medicinal uses (Opole *et al.*, 1995). In some communities, it is believed that regular consumption of the leaves by expectant women eases childbirth by reducing the length of labor, helps them to regain health faster and stimulates milk production in lactating mothers (Chewya and Mnzava, 1997; Kokwaro, 1976). The concoction made from the leaves is believed to treat scurvy and marasmus, while the sap from pounded leaves is squeezed into ears, nostrils and eyes to treat epileptic fits and recurrent malaria (Opole *et al.*, 1995). Sap from leaves has been used as an analgesic particularly for head ache, epileptic fits and ear ache. Bruised leaves, which are rubefacent and vesicant, are also used to treat neuralgia, rheumatism and other localized pains (Narendhirakannan *et al.*, 2005).

Apart from medicinal values, spider plant has been observed to have insecticidal, anti-feedant and pest repellent characteristics (Verma and Pandey, 1987). The leaves have anti-tick,

repellent and acaricidal properties to larvae, nymphs and adult ticks (*Rhipicephalus appendiculatus*) (Chandel *et al.*, 1987). The plant has anti-feedant action against the tobacco caterpillar, while the extract from the mature seeds is toxic to brinjal aphid and larvae of American bollworm (*Heliothis armigera*), and lipids from the seeds can be used in soap manufacture (Verma and Pandey, 1987).

2.3 Role of Nitrogen on Plant Growth

Enhanced crop production cannot be achieved without effective nutrient management (Wolf, 1999). Knowledge on nutrient elements, their amounts is essential for optimum growth of any particular crop. Nutrients are applied in form of organic and inorganic fertilizers. Nitrogen, phosphorus and potassium are the three nutrients that most often limit crop production (Rao *et al.*, 1998). Sanjuan *et al.* (2003) defined fertilizers as organic and inorganic materials, which are applied to soil and which provide essential nutrients for growing plants, usually by absorption through the plant roots. Fertilizers supply the soil with nutrients, compensate for nutrient losses and maintain or improve the fertility of soil. The amounts of the nutrients needed to be added to the soils vary depending on the crop being grown and the initial nutrient content of the soil (Khadija, 2006).

Nitrogen is an essential nutrient which is a determining factor in crop production. It is a constituent of many organic compounds, nucleic acids and protein compounds (Sanjuan *et al.*, 2003). Nitrogen affects growth and yield of leafy vegetables through its effect on cell division, expansion, and elongation (Onyango, 2002). Nitrogen also plays a role in chlorophyll synthesis and hence the process of photosynthesis and carbon dioxide assimilation (Jasso-Chaverria *et al.*, 2005).

Nitrogen occurs in soil in organic and inorganic forms (Jones, 2003; Powers and Mc Sorley, 2000). Plants absorb nitrogen mainly in the nitrate (NO_3^-) and ammonium (NH_4^+) forms, both of which are metabolised by plants. The uptake of nitrate and ammonium by plants is influenced by temperature, soil water availability, microbial activities and soil reaction (Tisdale *et al.*, 1985). Nitrogen is more responsible for plant growth than any other element (Splittstoesser, 1990). It stimulates vegetative growth resulting in large stems and leaves. It also influences crop quality. Nitrogen deficiency results in poor growth rate (Jones, 2003). Plants suffering from nitrogen deficiency mature earlier and the vegetative growth stage are shortened (Wolf, 1999). Nitrogen deficiencies are most common in mineral soils that are subject to

leaching. Excess nitrogen results in lush plants with soft tissue and subsequent lateness in maturity (Wolf, 1999).

2.4 Efficacy of Integrated Nutrient Application

Organic fertilizers are substances containing nutrients, derived from the remains or as a by-product of an organism. Organic manure improves soil moisture holding capacity (Lotfollahi, 2005), and soil microbial properties (Belay *et al.*, 2001). For instance, organic fertilizers are naturally rich in nitrogen, phosphorus, and potassium, the three major nutrients needed in plant growth including various micronutrients (Kaur *et al.*, 2005). However nutrient release from organic fertilizer is too slow to compensate for the removal of nutrients by agricultural production and to meet crop requirements (Sharma and Mittra, 1991). On the other hand, inorganic fertilizers are synthetically produced and can provide plants with an immediate desired supply of nutrients.

The use of inorganic fertilizers alone has not been helpful under intensive agriculture because it aggravates soil degradation (Sharma and Mittra, 1991). The degradation is brought about by loss of organic matter which consequently results in soil acidity, nutrient imbalance and low crop yield. However organic fertilizers are normally insufficient in amounts to meet the crop demand (Smaling *et al.*, 1997). Crop residues and animal manures cannot meet crop nutrients demand over large areas because of the limited quantities available, the low nutrients content and the high labour demands for processing and application (Palm *et al.*, 1997).

Experiments on manures and fertilizers conducted in several countries reveal that neither chemical fertilizers alone, nor organic sources used exclusively, can sustain the productivity of soils under highly intensive cropping systems (Bokhtiar and Sakurai, 2005). Subbiah *et al.* (1985) obtained higher yields of tomato and eggplant with combined use of farmyard manure and inorganic fertilizers. The integrated use of urea and poultry manure also resulted in a higher nutrient uptake (Jose *et al.*, 1988). Jablonska, (1990) reported that the combined use of farmyard manure and nitrogen resulted in higher yield of tomato, eggplant and pepper than either nitrogen fertilizer or farmyard manure used alone. Hosmani (1993) also reported higher yield of chili with integrated use of chemical and organic fertilizers than with the use of either of these separately.

High and sustained crop yield could be obtained with judicious and balanced NPK fertilization combined with organic matter amendments (Makinde *et al.*, 2001). Evaluation of application of organic and inorganic fertilizers in a mint (*Mentha arvensis*) and mustard

(*Brassica juncea*) cropping sequence showed that integrated supply of plant nutrients through farmyard manure and fertilizer NPK, along with Sesbania green manuring, played a significant role in sustaining soil fertility and crop productivity (Chand *et al.*, 2006).

Application of organic materials alone or in combination with inorganic fertilizer helps in proper nutrition and maintenance of soil fertility (Salim *et al.*, 1988). Hussain *et al.* (1988) reported that organic manures increased the efficiency of chemical fertilizers. Beneficial effects of farm yard manure on crop production through improved fertility and physical property of soil is an established fact (Singh and Sarivastore, 1997). Merinyo (1996) also reported that application of nitrogen (150 kg Nha^{-1}) in combination with farmyard at the rate of 10 tha^{-1} greatly influenced the yield of *Solanum nigrum* L. Wakene *et al.* (2001) reported a consistent increase on yield of maize with increased levels of nitrogen phosphorus potassium (NPK) fertilizers and farmyard manure interaction upon complementary application.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Experimental Site

The study was conducted at Horticulture Research and Teaching Field, Egerton University, Rift-valley Province, Njoro, District, Kenya. The farm lies at a latitude of 0° 23' south, longitude 35°35' East and 2238 m above sea level. The area falls in agro-ecological zone Lower Highland 3 (Jaetzold and Schmidt, 1983). The experimental site receives mean annual rainfall of 1200 mm. The distribution of rain is bimodal with long rains between April and August and short rains between October and December yearly. Soils at the site are vintric mollic andosols (Kinyanjui, 1979). The temperatures in the field lied between 10.2 and 22.0°C.

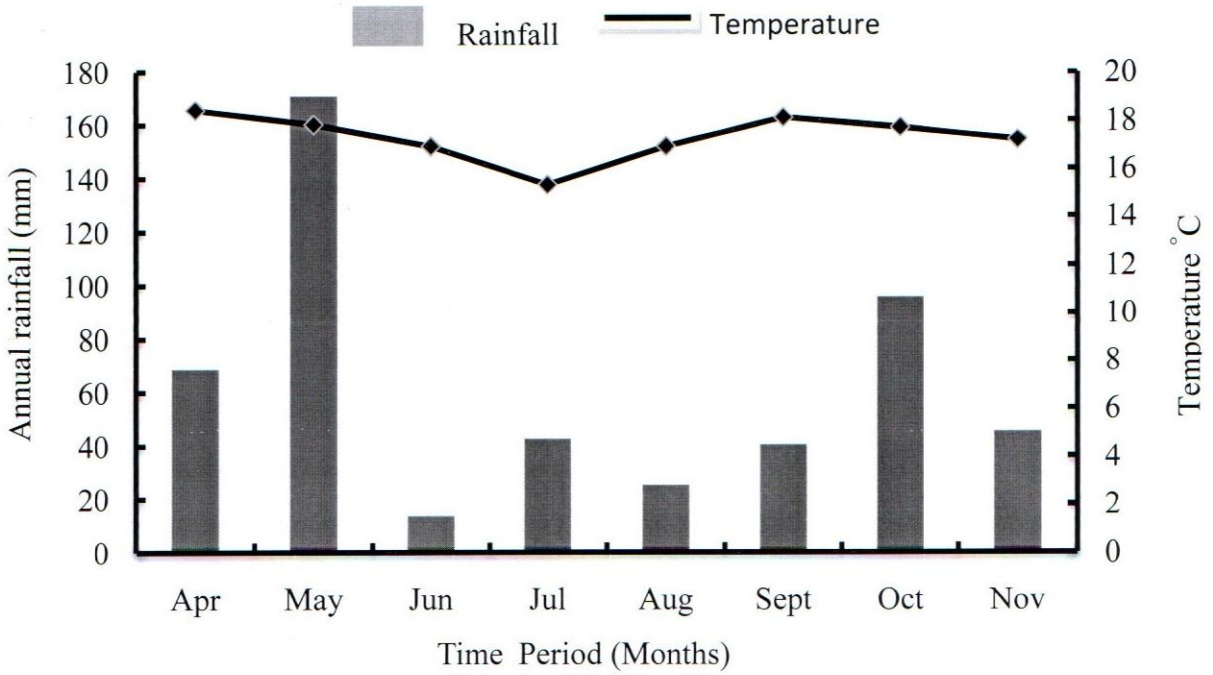


Figure 1. Rainfall and Temperature Data for Egerton University Tatton Farm during the Study Period (Source- Egerton University Engineering Meteorological Station, 2009).

The total amount of rainfall received at experimental site for trial 1(April -July 2009) and trial 2 (August -November 2009) were 296.2 mm and 207.3 mm respectively. During the period of study, the rains over the two trials were erratic and minimal. The highest amounts (171 and 96 mm) of rainfall that were received during the months of May and October were greater by 57% and 46% compared to their means (74 and 51 mm) in trial 1 and 2 respectively (Figure 1).

Consequently, the lowest amounts (13.7 and 25.2 mm) of rainfalls recorded during the months of June and August was lower by 81% and 51% compared to their means in trial 1 and 2 respectively. The mean maximum temperatures for trial 1 and 2 were 24.52 °C and 24.4 °C respectively while the mean minimum temperature for trial 1 and 2 were 9.56 °C and 9.62 °C respectively. The mean temperatures for trial 1 and 2 were 17.04 °C and 17.02 °C respectively (Figure 1).

3.2 Experimental Design and Treatment Application

Two experiments were carried out and the layout for each experiment was split plots embedded in a randomized complete block design (SPRCBD), with three replications. The experimental layout covered an area of 27.5 m by 16.5 m and each vegetable type covered an area measuring 8.5 m by 8.5 m per block. The main plot measured 8.5 m by 1.5 m (12.75 m^2) and sub plot (Figure 3) measuring 1.5 m by 1.5 m (2.25 m^2). Spacing was done at an inter-row of 30 cm and intra-row of 30 cm. Inter-plot were spaced at 0.5 m and 1m path separated individual main blocks. Deep ditches between plots were constructed to avoid movement of nitrogen.

Taking into consideration that farmyard manure and initial soil analysis had 1.33% and 0.21% nitrogen, 11.3 tha^{-1} of FYM and 150 kg Nha^{-1} of CAN respectively were used as the recommended rates (Mauyo *et al.*, 2008 and Khadija, 2006). On the basis of a fore mentioned rates, 0, 7.5, 11.3 and 15 t ha^{-1} (0, 1.6, 2.5 and 3.5 kg/plot) of farmyard manure was used as main plot treatments in this study. They were incorporated into the plots two weeks before planting. Similarly, 0 kg Nha^{-1}, 100 kg Nha^{-1}, 150 kg $Nha^{-1}$and 200 kg Nha^{-1} (0, 86, 129 and 172 g) from CAN was applied as subplot factor in a series of two splits. The first and the second splits were applied at the third and fifth week respectively after germination at rates of 0, 43.1, 64.5 and 86.4 g /plot.

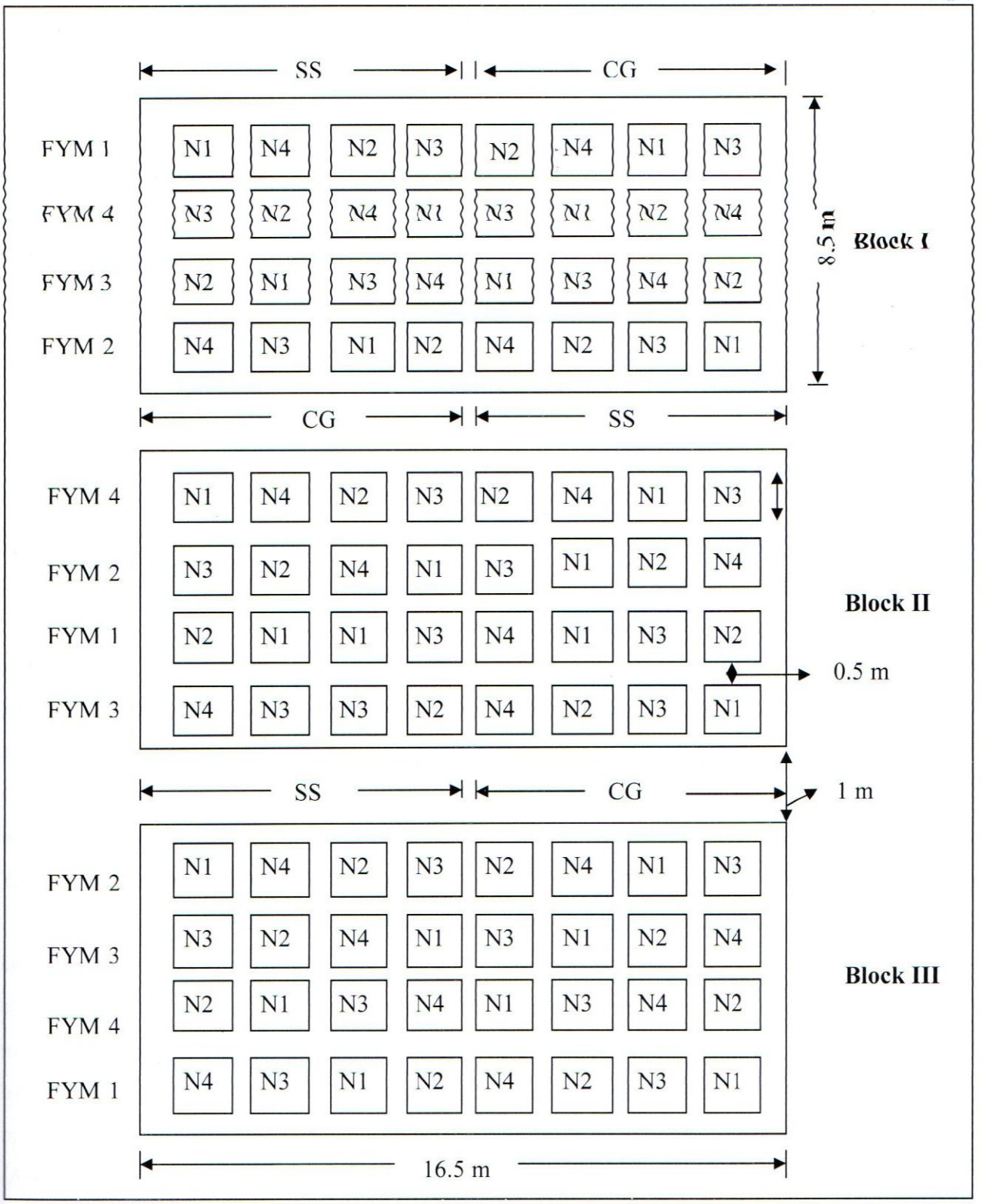


Figure 2. The Experimental Layout Showing Treatment Combination for both *Solanum scabrum* Mill. and *Cleome gynandra* L.

Where:

FYM 1-Farmyard manure level 1 (0 t ha^{-1});FYM 2- Farmyard manure level 2 (7.5 t ha^{-1}); FYM 3-Farmyard manure level 3 (11.3 t ha^{-1}); FYM4 -Farmyard manure level 4 (15 t ha^{-1}); N_1- Nitrogen level1(control); N_2 - Nitrogen level 2 (100 kg Nha^{-1}); N_3 -Nitrogen level 3 (150 kg Nha^{-1}); N_4-Nitrogen level 4 (200 kg Nha^{-1});SS- *Solanum scabrum* and CG- *Cleome gynandra*.

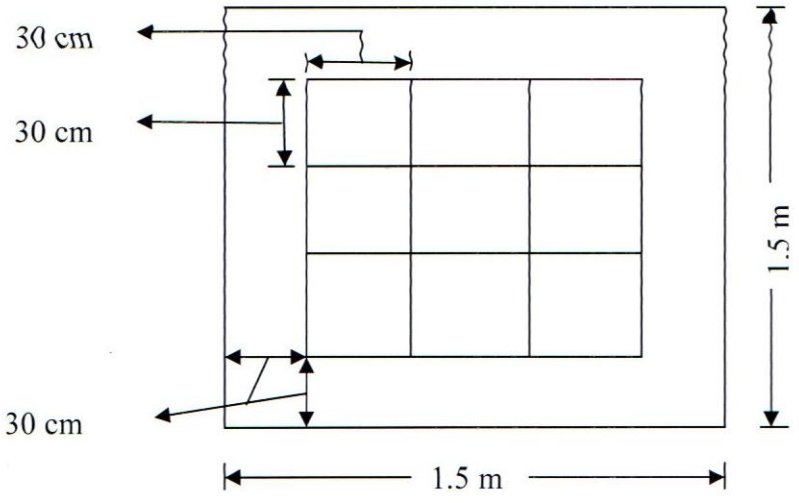


Figure 3. Layout of Experimental Unit

3.3 Planting Materials

Seeds of African nightshade (*Solanum scabrum*) and spider plant (*Cleome gynandra*) were obtained from Kenya Seed Company Depot, Nakuru.

3.4 Soil and Manure Nutrient Analysis

Soil and manure analysis was performed before the commencement of field experiments and at the end of experiments, soils were sampled and their major (N, P and K) nutrient composition analyzed. The soil pH was measured using pH meter (Fisher Accument ®). Total nitrogen for soils and farmyard manure was determined following Kjeldah method as described by Okalebo *et al.* (2002). Available potassium, magnesium, calcium and magnesium from soil, manure and plant tissues were determined by use of Atomic Absorption Spectrophotometer (AAS) as described by Okalebo *et al.* (2002). Available P was determined calorimetrically using Spectrophotometer (Novaspec® II). All tests were performed at Egerton University Soil Analysis Laboratory as shown in the tables 1 and 2.

Table 1. Initial Soil Analysis from the Experimental Site

Parameters	Composition
pH (H_2O)	5.32
pH (KCl)	5.82
Total N (%)	0.21
Available P (%)	0.14
Exchangeable K (%)	0.12
Exchangeable Fe (%)	0.21
Exchangeable Ca (mg/100g dry soil)	62.60
Exchangeable Mg (mg/100g dry soil)	21.81

Table 2. Chemical Composition of Farmyard Manure

Parameter	Composition
pH(H_2O)	7.16
pH(KCl)	6.76
Total N (%)	1.33
Available P (%)	0.23
Exchangeable K (%)	2.38
Exchangeable Fe (%)	0.14
Exchangeable Ca (%)	0.78
Exchangeable Mg (%)	0.38

3.5 Land Preparation and Planting

Land preparation was done two months before sowing by clearing the weeds followed by ploughing. The field was then harrowed to create a suitable tilth. Beds were then raised 30 cm high ensuring that inter-plot spacing were maintained. Farmyard manure at 0 t ha^{-1}, 7.5 t ha^{-1}, 11.3 t $ha^{-1}$and 15 t ha^{-1} (0, 1.6, 2.5 and 3.5 kg/plot) levels was incorporated two weeks before sowing. This was done by weighing the dried manure using weighing scale and then spreading them on sub-plots and lightly working them into the soil (0-15 cm deep) with the hoe. Leveling was done using a rake to create a fine tilth. Drip irrigation system was then laid down running across all the plots to supply water evenly to all plots.

Triple superphosphate (TSP) fertilizer was thoroughly mixed with the soil along the furrows to avoid direct contact with seeds, at the rate of 200 kg ha^{-1} (Abukutsa, 2007). *Solanum scabrum* and *Cleome gynandra* seeds sourced from Kenya Seed Company, Nakuru was sown directly at an intra-spacing of 30 cm and the interspacing of 30 cm giving a plant population of 71,111 plants ha^{-1}(Mauyo *et al.*, 2008; Opiyo, 2004). During sowing, ten seeds were placed at the sixteen positions in the sub-plots according to recommended spacing. They were then covered with a thin layer of soil to ensure maximum germination. The population of seeds per plot of 2.25 m^{-2} during planting was approximately 160 seeds. *Cleome gynandra* L. and *Solanum scabrum* germinated after 6 and 9 days respectively giving a germination percentage of over 90%.

3.6 Routine Management Practices

Supplementary watering was done through drip lines while weeding commenced immediately after germination to ensure that the field was weed free by use of a hoe and by uprooting. Thinning out of weak plants was done three weeks after germination to leave only healthy vigorous growing plants on all the plots. Each sub-subplot remained with 16 plants to give a population density of 7 plants per m^2.

Among the pests observed in spider plants were green aphids (*Myzus persicae*), nematodes (*Meloidogyne* spp.) green vegetable bugs (*Nezara* spp.) cabbage sawfly (*Athalia* spp.). Cutworms (*Argotis segentum*) were observed at early stages of growth while black aphids (*Aphididae* spp.) were observed later on African nightshade. These pests were controlled by use of a broad spectrum insecticide (Carbosulfan®) after every ten days.

3.7 Data Collection

3.7.1 Growth Measurements

Four inner plants out of sixteen plants per plot were used for data collection at the 7^{th} week after planting. Plant height was measured from the ground level to the tip of the longest stem. The number of leaves and branches were counted before the first harvest. Internode length between the 3^{rd} and 4^{th} internodes was measured using a ruler. Stem base diameter was measured using vanier caliper.

3.7.2 Yield Measurements

Leaf harvesting began a week after the last split application of calcium ammonium nitrate on 50^{th} day after planting for both trials and continued at an interval of 10 days (50^{th}, 60^{th}, 70^{th},

80th, 90th and 100th DAP) until each experiment trial was terminated. Total leaf vegetable yield for each treatment was obtained by summing up the leaf yield from each given treatment at different leaf harvesting intervals. Leaf harvesting was done by decapitating the shoots of four plants at twenty centimeters height followed by removal of tender side/lateral shoots from the main stem on subsequent harvest. For spider plant, tender shoots from the main stem and lateral branches were harvested. The fresh and leaf dry yield were measured using sensitive balance to ensure accuracy at all harvesting intervals. Total yield of harvested leaves from each plot was converted to yield in tons per hectare. Similarly total above ground biomass for both plants used for fresh yield production were measured in terms of fresh and dry yield and later converted to tones per hectare. The dried leaves from the first harvest were kept for proximate analysis for both trials.

3.7.3 Leaf Area

The fourth leaf from each of the four inner plants per plot was identified and their lengths and widths measured using 30 cm ruler at 50 DAP before the first harvesting. The leaf area was then determined using the following formula as described by Pearcy *et al.* (1989).

Leaf Area = (Length x Width) (0.67).

3.7.4 Leaf Area Index (LAI)

Leaf Area Index for the two crops was computed using average leaf area obtained multiplied by the total number of leaves divided by the ground area from which the leaves were obtained (Pearcy *et al.*, 1989).

LAI = (Leaf Area / Land surface area occupied by the plants from where the leaf area was obtained)

3.7.5 Photosynthesis Measurements

The fourth leaf from each of the four inner plants was used to determine the chlorophyll content per plot. The SPAD (Minolta SPAD 502® Meter) was used to measure chlorophyll content of a tagged leaf before each harvesting session (50th, 60th, 70th, 80thand 90th days after planting). It measures chlorophyll content through remote sensing without destruction of leaf tissue. Chlorophyll meter (SPAD) Chlorophyll content of each plot was gotten by averaging the four readings from each plant.

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3.7.6 Stomatal Conductance Measurements

The fourth leaf from each of the four inner plants was used in measurement of stomatal conductance (mmol $m^{-1}s^{-1}$) using the Decagon SC-1® Leaf Porometer before each harvest till the fourth harvest. Measurements were taken from 50^{th}, 60^{th}, 70^{th} and 80^{th} days after planting. Since light is responsible for stomatal opening, measurements were taken on a clear part of the day all through.

3.8 Statistical Analysis

The data was subjected to analysis of variance using the General Linear Model for a split-plot to obtain the P value of the effect of the model for each treatment using Proc GLM code of SAS-computer software (SAS Institute 1999; Version 8.1). The treatments which were found to be significant were separated using Duncan's Multiple Range Test (DMRT) at ($P \leq 0.05$). The treatments that had noticeable interaction effect were separated using MSTATC computer software.

The linear model fitted for the experiment was:

$Y_{ijk} = \mu + \rho_i + \alpha_j + \gamma_{ij} + \beta_k + (\alpha\beta)_{jk} + \varepsilon_{ijk}$

$i = 1, 2, 3; j = 1, 2, 3, 4$ $k = 1,2,3,4$

Where;

Y_{ijk} is crop response,

μ is grand mean,

ρ_i is i^{th} blocking effect,

α_j is effect of farmyard manure level,

γ_{ij} is main plot error (error a),

β_k is k^{th} effect of nitrogen levels,

$(\alpha\beta)_{jk}$ is effect of interaction between farmyard manure and nitrogen levels,

ε_{ijk} is random error component (error b) and γ_{ij} and ε_{ijk} were normally and independently distributed about zero means with a common variance σ^2.

CHAPTER FOUR

RESULTS

4.1 Selected Nutrient Properties of Soil and Plant Tissues

4.1.1 Effects of Farmyard Manure and Nitrogen Levels on Selected Nutrients of Soils Grown with African Nightshade

Residual nitrogen (%N) and phosphorus (mg P per 100g of dry soil) from the soil was significantly affected by farmyard manure levels that were applied at P≤0.05. The control was significantly lower by 25% (N) and 10% (K) compared to the soil that were subjected to highest (15 t ha^{-1}) level of farmyard manure. Addition of farmyard manure did not influence residual phosphorus in the soil (Table 3). Apart from phosphorus, nitrogen fertilizer significantly influenced the retention of both nitrogen and potassium in the soil at the end of the experiments at P≤0.05. Increase in the levels of nitrogenous fertilizer, led to increase in the residual N and K by 25% and 6% respectively compared to the control (Table 3). There were no significant interactions between farmyard manure and inorganic nitrogen in influencing residual nitrogen, phosphorus and potassium at P≤0.05 (Table 4).

Table 3. Effects of Farmyard Manure and Nitrogen Levels on Selected Nutrients of Soils Grown with African Nightshade

	Residual Soil Nutrients		
	%	mg per 100g of dry soil	
	N	P	K
FYM Levels			
0 t ha^{-1}	0.12b*	1.86	79.7b
7.5 t ha^{-1}	0.15a	1.95	82.3b
11.3 t ha^{-1}	0.18a	2.05	84.4a
15.0 t ha^{-1}	0.16a	2.25	89.5a
N Levels			
0 kg Nha^{-1}	0.12b*	1.60	76.79b
100 kg Nha^{-1}	0.15b	1.93	75.05b
150 kg Nha^{-1}	0.17a	2.34	86.13a
200 kg Nha^{-1}	0.16a	2.18	85.85a

*Means followed by the same letters or no letters within a column of either farmyard manure or nitrogen levels are not significantly different according to Duncan's Multiple Range Test at P≤0.05.

FYM - Farmyard Manure, N - Nitrogen, P - Phosphorus and K - Potassium.

Table 4 Interaction Effects of Farmyard Manure and Nitrogen Levels on Selected Nutrients in the Soils Grown with African Nightshade

		Residual Soil Nutrients		
		%	mg per 100g of dry soil	
FYM Levels	N Levels	N	P	K
0 t ha^{-1}	0 kg Nha^{-1}	0.1*	2.6	69.8
	100 kg Nha^{-1}	0.1	1.6	61.8
	150 kg Nha^{-1}	0.1	1.6	77.8
	200 kg Nha^{-1}	0.1	1.5	85.9
7.5 t ha^{-1}	0 kg Nha^{-1}	0.1	2.1	78.0
	100 kg Nha^{-1}	0.2	2.1	79.6
	150 kg Nha^{-1}	0.2	1.8	82.9
	200 kg Nha^{-1}	0.2	2.1	77.3
11.3 t ha^{-1}	0 kg Nha^{-1}	0.2	2.3	62.2
	100 kg Nha^{-1}	0.2	1.9	99.6
	150 kg Nha^{-1}	0.2	1.9	93.4
	200 kg Nha^{-1}	0.2	2.4	82.4
15.0 t ha^{-1}	0 kg Nha^{-1}	0.1	2.2	97.1
	100 kg Nha^{-1}	0.2	2.0	89.1
	150 kg Nha^{-1}	0.2	2.0	90.3
	200 kg Nha^{-1}	0.2	2.6	81.6

*Means followed by no letters within columns are not significantly different according to Duncan's Multiple Range Test at $P \leq 0.05$.

FYM - Farmyard Manure, N - Nitrogen, P - Phosphorus and K - Potassium.

4.1.2 Effects of Farmyard Manure and Nitrogen Levels on Selected Leaf Nutrients of African Nightshade

The application of increasing levels of manure generally influenced the accumulation of selected mineral composition in the plant tissue (Table 5). Increase in the levels of farmyard manure, led to increase in accumulation of nitrogen (N), phosphorus (P), potassium (K), calcium (Ca) and Magnesium (Mg) while iron in the leaf tissue were not influenced. However, nitrogen fertilizer levels had the same effect as farmyard manure in influencing the accumulation of mineral elements in the leaves (Table 5).

Table 5. Effects of Farmyard Manure and Nitrogen Levels on Selected Leaf Nutrients of African Nightshade

	Selected Leaf Nutrient Properties					
	%	mg per 100g of dry leaf sample				
	N	P	K	Ca	Fe	Mg
FYM Levels						
0 t ha^{-1}	2.6c*	244.5b	341.7b	405.6b	95.9	283.1b
7.5 t ha^{-1}	2.8b	255.5a	365.3b	493.5ab	100.7	283.1a
11.3 t ha^{-1}	3.1a	297.8a	428.6a	445.8a	99.7	279.5a
15.0 t ha^{-1}	3.2a	269.8a	437.8a	536.5a	95.3	311.0a
N Levels						
0 kg Nha^{-1}	2.6b*	241.2b	337.1c	466.1ab	95.6	283.5b
100 kg Nha^{-1}	3.2a	267.1b	372.4a	436.6b	99.4	296.6a
150 kg Nha^{-1}	2.9a	254.5a	385.9a	470.5ab	101.2	302.9a
200 kg Nha^{-1}	3.0a	304.9a	398.0a	508.6a	95.5	302.8a

*Means followed by the same letters or no letters within a column of farmyard manure or nitrogen levels are not significantly different according to Duncan's Multiple Range Test at $P \leq 0.05$.

FYM - Farmyard Manure N - Nitrogen, P - Phosphorus, K - Potassium, Ca - Calcium, Fe - Iron and Mg - Magnesium.

4.1.3 Interaction Effects of Farmyard Manure and Nitrogen Levels on Selected Leaf Nutrients of African Nightshade

There were noticeable interaction between manure and nitrogen levels in influencing nitrogen, phosphorus and magnesium in the plant tissues. The combination of higher levels farmyard manure and nitrogenous fertilizer increased accumulation of nitrogen and phosphorus in African nightshade leaves than the control (Table 6). Plants that received complementary application of 15 t ha^{-1} of farmyard manure and 200 kg Nha^{-1} accumulated greater amount of nitrogen and phosphorus by 41% and 44% respectively compared to the control. Potassium, calcium and iron were not influenced by interaction of farmyard manure and nitrogen fertilizer on African nightshade leaves (Table 6).

Table 6. Effects of Farmyard Manure and Nitrogen Levels on Selected Leaf Nutrients of African Nightshade

		Selected Leaf Nutrient Composition					
		%	mg per 100g of dry soil				
FYM Levels	N Levels	N	P	K	Ca	Fe	Mg
0 t ha^{-1}	0 kg Nha^{-1}	2.1e*	163.9b	281.9	541.3	88.6	280.0b
	100 kg Nha^{-1}	2.3de	280.1ab	449.4	550.0	98.4	285.6b
	150 kg Nha^{-1}	2.3de	247.1ab	478.6	527.3	108.6	317.2a
	200 kg Nha^{-1}	2.4de	287.0ab	504.3	527.3	88.0	316.1a
7.5 t ha^{-1}	0 kg Nha^{-1}	2.5cde	192.1b	381.6	442.0	105.7	221.3c
	100 kg Nha^{-1}	3.4ab	267.4ab	464.0	555.3	92.8	302.1b
	150 kg Nha^{-1}	3.5ab	278.4ab	248.7	449.3	104.4	268.4b
	200 kg Nha^{-1}	3.4ab	284.3ab	367.0	527.3	99.7	340.5a
11.3 t ha^{-1}	0 kg Nha^{-1}	3.0bcd	308.6ab	317.8	431.3	99.1	276.9b
	100 kg Nha^{-1}	2.3abc	271.3ab	521.1	469.3	110.4	293.2ab
	150 kg Nha^{-1}	2.4de	257.2ab	546.4	441.3	99.7	296.7ab
	200 kg Nha^{-1}	3.8a	354.1a	365.7	280.6	89.7	251.4b
15.0 t ha^{-1}	0 kg Nha^{-1}	2.9bcd	300.3ab	367.0	450.0	88.8	305.7a
	100 kg Nha^{-1}	3.0ab	249.8ab	375.0	460.0	96.0	305.7a
	150 kg Nha^{-1}	3.4ab	235.1ab	270.0	464.0	92.2	329.2a
	200 kg Nha^{-1}	3.6ab	294.1ab	355.0	409.3	104.4	303.3a

*Means followed by the same letters or no letters within a column are not significantly different according to Duncan's Multiple Range Test at $P \leq 0.05$.

FYM - Farmyard Manure, N - Nitrogen, P - Phosphorus, K - Potassium, Ca - Calcium, Fe - Iron and Mg - Magnesium.

4.1.4 Effects of Farmyard Manure and Nitrogen Levels on Selected Nutrients of Soils Grown with Spider Plant

Residual nitrogen, phosphorus and potassium were significantly affected by farmyard manure levels (Table 7). Total residual nitrogen (N), phosphorus (P) and potassium (K) from soil subjected to highest (15 t ha^{-1}) farmyard manure was significantly higher by 57, 22 and 41% respectively compared to the plots that received no source of nutrient (control). However, the effect of inorganic nitrogen was similar to that of farmyard manure in influencing retention of N, P and K (Table 7). There were no noticeable interaction effects between farmyard manure and nitrogen fertilizer in influencing the retention of N, P and K nutrients in the soil (Table 8).

Table 7. Effects of Farmyard Manure and Nitrogen Levels on Selected Nutrients in the Soils Grown with Spider Plant

	Residual Soil Nutrients		
	%	mg per 100g of dry soil	
	N	P	K
FYM Levels			
0 t ha^{-1}	0.06b*	2.02b	50.80c
7.5 t ha^{-1}	0.13a	2.02b	62.05b
11.3 t ha^{-1}	0.14a	2.65a	74.75a
15.0 t ha^{-1}	0.14a	2.48a	79.94a
N Levels			
0 kg Nha^{-1}	0.06b*	2.10b	51.41c
100 kg Nha^{-1}	0.13a	2.71a	62.00b
150 kg Nha^{-1}	0.12a	2.88a	70.47a
200 kg Nha^{-1}	0.14a	2.68a	69.65a

*Means followed by the same letters or no letters within a column of either farmyard manure or nitrogen levels are not significantly different according to Duncan's Multiple Range Test at $P \leq 0.05$.

FYM - Farmyard Manure, N - Nitrogen, P - Phosphorus and K - Potassium.

Table 8. Interaction effects of Farmyard Manure and Nitrogen Levels on Selected Nutrients in the Soils Grown with Spider Plant

		Residual Soil Nutrients		
		%	mg per 100g of dry soil	
FYM Levels	N Levels	N	P	K
0 t ha^{-1}	0 kg Nha^{-1}	0.1*	1.4	57.1
	100 kg Nha^{-1}	0.1	1.5	54.4
	150 kg Nha^{-1}	0.2	2.0	69.5
	200 kg Nha^{-1}	0.2	2.1	87.1
7.5 t ha^{-1}	0 kg Nha^{-1}	0.1	2.0	88.3
	100 kg Nha^{-1}	0.1	2.3	53.9
	150 kg Nha^{-1}	0.1	1.8	72.0
	200 kg Nha^{-1}	0.1	1.5	84.8
11.3 t ha^{-1}	0 kg Nha^{-1}	0.1	2.4	51.5
	100 kg Nha^{-1}	0.2	2.7	50.4
	150 kg Nha^{-1}	0.2	1.8	65.3
	200 kg Nha^{-1}	0.1	2.5	59.8
15.0 t ha^{-1}	0 kg Nha^{-1}	0.1	2.5	61.0
	100 kg Nha^{-1}	0.2	2.2	56.9
	150 kg Nha^{-1}	0.1	1.8	75.0
	200 kg Nha^{-1}	0.2	2.4	86.8

*Means followed by no letters within columns are not significantly different according to Duncan's Multiple Range Test at $P \leq 0.05$.

FYM - Farmyard Manure, N - Nitrogen, P - Phosphorus and K - Potassium.

4.1.5 Effects of Farmyard Manure and Nitrogen Levels on Selected Leaf Nutrients of Spider Plant

Farmyard manure varied in influencing the accumulation of selected mineral elements in the spider plant leaf samples. Elements that were analysed are nitrogen, phosphorus, potassium, calcium, iron and magnesium. Nitrogen, potassium and magnesium were observed to increase with increase in manure levels (Table 9). Plants that were subjected to 15 t ha^{-1} of farmyard manure accumulated nitrogen in the leaf tissue by 27% when evaluated against control. Potassium and magnesium was as high as 807.2 and 304.9 mg/100 g dry leaf sample. Farmyard manure levels had no significant effect on phosphorus, calcium and iron quantity in the spider plant leaf tissues. However, the effect of nitrogen fertilizer was similar to that of manure level. Phosphorus, calcium and magnesium were also not affected by nitrogen fertilizer. Plants that were treated with 200 kg Nha^{-1} increased potassium and magnesium in the plant tissue by 20% and 9% compared to the control (Table 9).

Table 9. Effects of Farmyard Manure and Nitrogen Levels Selected Leaf Nutrient Properties of Spider Plant

	Selected Leaf Nutrient Properties					
	%	mg per 100g of dry plant tissue				
	N	P	K	Ca	Fe	Mg
FYM Levels						
0 t ha^{-1}	1.3c*	321.8	590.7c	669.5	75.1	241.2b
7.5 t ha^{-1}	1.8b	371.7	610.1c	597.5	84.8	267.1b
11.3 t ha^{-1}	2.1a	298.3	668.3b	638.8	79.2	254.5b
15.0 t ha^{-1}	1.8b	366.5	807.2a	644.3	81.6	304.9a
N Levels						
0 kg Nha^{-1}	1.3bc*	353.9	586.6c	602.5	73.6	246.6b
100 kg Nha^{-1}	1.6c	325.7	681.0b	643.8	76.9	323.1a
150 kg Nha^{-1}	2.0a	330.6	670.0b	642.8	99.5	313.9ab
200 kg Nha^{-1}	1.7b	348.5	738.8a	661.0	130.7	325.9a

*Means followed by the same letters or no letters within a column of either farmyard manure or nitrogen levels are not significantly different according to Duncan's Multiple Range Test at $P \leq 0.05$.

FYM - Farmyard Manure, N - Nitrogen, P - Phosphorus and K - Potassium.

4.1.6 Interaction Effects of Farmyard manure and Nitrogen Levels on Selected Leaf Nutrients of Spider Plant

There were noticeable interaction effects between farmyard manure and nitrogen levels in influencing accumulation of total nitrogen (N), potassium (K) and magnesium (Mg) at $P \leq 0.05$. Plants that received the highest (15 t ha^{-1}) combination of farmyard manure and 150 kg Nha^{-1} accumulated the increased amount of nitrogen by 38% compared with the control treatment (Table 10). There were no interaction effects that could be attributed to the application of the combined farmyard manure and inorganic nitrogen on potassium and magnesium (Table 10).

Table 10. Interaction Effects of Farmyard Manure and Nitrogen Levels on Selected Leaf Nutrients of Spider Plant

		Selected Leaf Nutrient Properties					
		%	mg per 100g of dry plant tissue				
FYM Levels	N Levels	N	P	K	Ca	Fe	Mg
0 t ha^{-1}	0 kg Nha^{-1}	1.3d*	354.5	619.8c	600.6	75.1	246.9d
	100 kg Nha^{-1}	1.8bcd	279.2	672.6bcd	620.6	86.8	321.1abc
	150 kg Nha^{-1}	1.3d	318.8	539.8d	642.0	67.7	312.6abc
	200 kg Nha^{-1}	0.9d	334.9	630.6bcd	734.6	70.8	319.6abc
7.5 t ha^{-1}	0 kg Nha^{-1}	2.0ab	382.3	559.7cd	518.6	72.2	275.1abc
	100 kg Nha^{-1}	1.6cd	349.4	685.9bcd	743.3	82.2	297.0abc
	150 kg Nha^{-1}	1.7bcd	377.6	595.8 c	544.6	95.5	332.5abc
	200 kg Nha^{-1}	2.0ab	377.6	678.8bcd	583.3	89.3	321.5abc
11.3 t ha^{-1}	0 kg Nha^{-1}	2.2ab	311.7	513.2c	589.3	75.1	332.7abc
	100 kg Nha^{-1}	1.5cd	315.6	723.1bcd	562.6	75.3	346.7ab
	150 kg Nha^{-1}	2.6a	249.8	663.3bcd	760.0	76.4	368.5a
	200 kg Nha^{-1}	1.3abc	317.6	773.6ab	643.3	90.2	339.2abc
15.0 t ha^{-1}	0 kg Nha^{-1}	1.3d	367.0	753.7abc	601.3	72.2	366.0cd
	100 kg Nha^{-1}	1.5cd	358.8	642.1bcd	648.6	63.3	327.4abc
	150 kg Nha^{-1}	2.4a	376.4	961.0a	644.6	78.4	307.8abc
	200 kg Nha^{-1}	2.1ab	364.0	772.0bcd	682.6	72.6	323.2abc

*Means followed by the same letters or no letters within columns are not significantly different according to Duncan's Multiple Range Test at $P \leq 0.05$.

FYM - Farmyard Manure, N - Nitrogen, P - Phosphorus and K - Potassium.

4.2 African Nightshade

4.2.1 Effects of Farmyard Manure and Nitrogen Levels on Growth Parameters of African Nightshade

Response of African nightshade growth parameters to levels of farmyard manure varied in both trials. In trial 1, there was no significant effect of manure levels in all growth parameters except the leaf area which increased by 35% compared to the control. However in the second trial, increase in the rates of manure, increased the magnitude of all the growth parameters. Plants that received highest level of farmyard manure of between 11.3 t ha^{-1}-15 t ha^{-1} were significantly taller by 50% while the number of leaves was increased by 41% compared to the control. Leaf area index was also increased by 48% at 15 t ha^{-1} of manure. The control generally was significantly lower in all the growth parameters (Table 11).

As observed with the manure, increase in the levels of nitrogen fertilizers also led to an enhanced growth of all growth parameters of African nightshade in both trials apart from plant height in the first trial. There was no statistical difference between plants subjected to 150 kg Nha^{-1} and 200 kg Nha^{-1} in nearly all growth parameters at $P \leq 0.05$ apart from leaf area index in the second trial. Plants that were subjected to 200 kg Nha^{-1} were taller by 27% while the number of leaves increased by 47% compared to the control in the second trial. The highest rate (200 kg Nha^{-1}) of nitrogen increased the leaf area index by 50% and 58% in trial 1 and trial 2 respectively compared to the control (Table 11).

Table 11. Effects of Farmyard Manure and Nitrogen Levels on Growth Parameters of African Nightshade

	Growth Parameters											
	Trial 1[z]						Trial 2					
	PH(cm)	NL	NB	IL(cm)	LA(cm^2)	LAI	PH(cm)	NL	NB	IL(cm)	LA(cm^2)	LAI
FYM Levels												
0 t ha^{-1}	7.8*	18.3	6.0	2.1	43.1b	0.6	15.3c	26.2c	9.5c	2.1b	98.4c	1.9c
7.5 t ha^{-1}	9.4	23.5	7.5	2.6	61.1a	1.1	23.2b	33.2b	11.3bc	2.5a	139.5a	3.3b
11.3 t ha^{-1}	9.3	23.0	7.2	2.3	64.9a	1.1	29.0a	42.6a	13.1ab	2.4a	139.7a	4.2a
15.0 t ha^{-1}	9.7	25.7	7.3	2.1	66.4a	1.2	30.1a	44.5a	15.5a	2.4a	118.6b	3.7ab
N Levels												
0 kg Nha^{-1}	7.9*	18.0b	6.0b	2.1bc	46.6b	0.6b	19.6b	24.5c	8.7b	2.0b	104.2b	1.9c
100 kg Nha^{-1}	12.2	20.2b	6.5b	1.9c	58.2ab	0.8b	22.6b	33.0b	12.8a	2.1b	133.0ab	3.1b
150 kg Nha^{-1}	9.9	26.3a	7.8a	2.4ab	65.7a	1.2a	28.6a	42.3a	13.2a	2.5a	122.5a	3.6b
200 kg Nha^{-1}	9.0	26.1a	7.8a	2.6a	65.3a	1.2a	27.0a	46.7a	14.6a	2.6a	136.4a	4.6a

*Means followed by the same letters or no letters within a column of either farmyard manure or nitrogen levels are not significantly different according to Duncan's Multiple Range Test at $P \leq 0.05$.

FYM - Farmyard Manure, N - Nitrogen, PH - Plant Height, NL - Number of Leaves, NB - Number of Branches, IL - Internode Length, LA - Leaf Area and LAI - Leaf Area Index.

[z]Trial1. African nightshade planted on 5th April 2009.

Trial 2. African nightshade planted on 20th July 2009.

4.2.2 Interaction Effects of Farmyard Manure and Nitrogen Levels on Growth Parameters of African Nightshade

There were noticeable interaction between manure and nitrogenous fertilizer in influencing some African nightshades growth parameters in trials (Table 12). Among the parameters, number of leaves, number of branches, leaf area and plant height) were significant at $P \leq 0.05$. Leaf area index (LAI) from plants subjected to the highest combination of farmyard manure and nitrogenous fertilizer increased by about 88% in both trials compared to control. Plants that received the highest combination of 15 t ha^{-1} farmyard manure and 200 kg Nha^{-1} of CAN fertilizer were taller by 64% compared to the control. The mean leaf area of 134 cm^2 was recorded from plants subjected to the highest combination of the treatments. The average number of leaves as a result of interaction for plants that were treated with the highest combination of farmyard manure and nitrogen fertilizers levels was higher by 44% and 70% in trial 1 and 2 compared to the control respectively (Table 12). The number of branches increased with increase in manure and nitrogen fertilizers combinations. However, the effects of interactions were not observed on internodes length in both trials of the experiment. Generally, as the level of farmyard manure and nitrogen fertilizer increase, the magnitudes of interaction effect also increased in most of the parameters studied (Table 12).

Table 12. Interaction Effects of Farmyard Manure and Nitrogen Levels on Growth Parameters of African Nightshade

		Growth Parameters											
		Trial 1[z]						Trial 2					
FYM Levels	N Levels	PH (cm)	NL	NB	IL (cm)	LA (cm^2)	LAI	PH (cm)	NL	NB	IL	LA (cm)	LAI
0 t ha^{-1}	0 kg Nha^{-1}	5.5*	17.3b	5.0b	2.0	45.0	0.2b	13.2c	17.0f	7.6	1.9	55.0b	0.6d
	100 kg Nha^{-1}	6.2	18.6b	6.0ab	1.5	51.8	0.7ab	12.3c	23.3ef	10.3	1.9	100.0ab	1.6d
	150 kg Nha^{-1}	7.8	22.6ab	7.0ab	2.4	49.8	0.8ab	18.4cde	33.0bc	9.0	2.1	118.9ab	2.8bc
	200 kg Nha^{-1}	7.2	19.6ab	6.0ab	2.4	47.2	0.6ab	17.3de	31.6cde	11.0	2.5	118.2ab	2.6bc
7.5 t ha^{-1}	0 kg Nha^{-1}	8.4	19.0b	6.0ab	2.4	58.0	0.8ab	20.9bcd	24.0def	8.6	2.0	126.0ab	2.1bc
	100 kg Nha^{-1}	10.0	21.6ab	7.3ab	2.4	76.4	1.2ab	23.7abc	32.6cd	12.0	2.5	147.0ab	3.4ab
	150 kg Nha^{-1}	10.5	26.6ab	8.3ab	2.9	72.2	1.3ab	25.0ab	33.0bc	10.6	2.7	151.2ab	3.5abc
	200 kg Nha^{-1}	8.8	25.6ab	8.6ab	2.6	57.6	1.1ab	23.3abc	43.3abc	14.0	2.6	133.6ab	4.0abc
11.3 t ha^{-1}	0 kg Nha^{-1}	9.3	19.3b	6.0ab	2.0	36.9	0.5ab	20.6bcd	30.0de	7.6	2.0	125.8ab	2.7bc
	100 kg Nha^{-1}	6.5	19.0b	6.0ab	1.8	55.1	0.7ab	29.7ab	34.0bc	10.3	2.0	147.8a	3.5abc
	150 kg Nha^{-1}	11.5	27.0ab	8.0ab	2.6	88.0	1.7a	34.4ab	53.3a	16.6	2.6	125.0ab	4.6ab
	200 kg Nha^{-1}	9.9	28.3ab	9.0a	2.9	79.7	1.6ab	32.4ab	54.3a	18.0	2.9	159.4ab	6.1a
15.0 t ha^{-1}	0 kg Nha^{-1}	8.6	21.3ab	7.0ab	1.9	66.5	1.0ab	23.9abc	27.3ef	11.0	2.2	109.3ab	2.1bc
	100 kg Nha^{-1}	10.9	21.6ab	6.6ab	2.0	49.6	0.7ab	24.9abc	42.0abc	18.6	2.2	136.7 a	3.8abc
	150 kg Nha^{-1}	9.6	29.0ab	8.0ab	1.9	52.5	1.1ab	36.6a	51.0abc	16.6	2.6	94.0ab	3.4abc
	200 kg Nha^{-1}	9.9	31.0a	7.6ab	2.6	76.8	1.7a	35.0ab	57.6a	15.6	2.6	134.3a	5.5a

*Means followed by the same letters or no letters within columns are not significantly different according to Duncan's Multiple Range Test at $P \leq 0.05$.

FYM - Farmyard Manure, N - Nitrogen, PH - Plant Height, NL - Number of Leaves, NB - Number of Branches, IL - Internode Length, LA - Leaf Area and LAI - Leaf Area Index.

[z]Trial1. African nightshade planted on 5th April 2009.

Trial 2. African nightshade planted on 20th July 2009.

4.3 Effect of Farmyard Manure and Nitrogen Levels on African Nightshade Fresh Leaf and Dry Yield

4.3.1 Effects of Farmyard Manure and Nitrogen Levels on African Nightshade Leaf Fresh Yield

Fresh yield were considerably affected by the farmyard manure level in both trials (Table 13). The lowest yield was observed in plots without farmyard manure from 50 to 80 DAP while the highest fresh yield was observed from plants subjected to increased levels of farmyard manure in both trials. Manure effect was not observed in the fresh yield at 90 DAP in trial 1 and 80 DAP and after in the second trial (Table 13).

Nitrogen fertilizer had the same effect as manure on the yield of African nightshade. An increase in nitrogen levels, led to an increase in fresh yield of African nightshade. The highest yield of 45 g/plant (3.2 t ha^{-1}) was realized at 200 kg Nha^{-1} at 90 DAP in trial 1 and 38 g/plant (2.7 t ha^{-1}) in trial 2. There was no significant differences between the effect of treatment level on fresh yield at 90 and 100 DAP in the second trial (Table 13). There was also a general increase in fresh yield with time.

Table 13. Effects of Farmyard Manure and Nitrogen Levels on African Nightshade Fresh Leaf Yield (g/plant) at Different Harvesting Duration

	Fresh Leaf Yield (g/plant)											
	Trial 1[z]						Trial 2					
	Days after Planting (DAP)											
	50	60	70	80	90	100	50	60	70	80	90	100
FYM Levels												
0 t ha^{-1}	8.7b*	11.8b	16.5b	30.7b	37.1	18.4	11.2b	9.4b	14.5c	26.4	24.0	23.2
7.5 t ha^{-1}	17.1a	24.1a	31.2a	43.4a	37.4	22.1	23.9a	29.1a	24.4b	33.0	23.6	22.9
11.3 t ha^{-1}	15.4a	19.8ab	25.1ab	36.8ab	42.2	23.3	22.2a	28.4a	25.2b	27.2	27.4	28.3
15.0 t ha^{-1}	16.1a	19.7ab	25.0ab	45.2a	44.1	24.5	18.4a	26.9a	31.5a	32.1	30.6	29.3
N Levels												
0 kg Nha^{-1}	8.7b*	11.4c	16.8b	29.8b	28.1c	18.4c	11.2b	17.7b	15.5b	23.3b	24.6	22.4
100 kg Nha^{-1}	11.3b	15.9bc	22.2b	35.8b	36.6bc	20.1bc	17.3ab	22.6ab	23.2ab	25.2b	24.5	27.5
150 kg Nha^{-1}	18.6a	22.8ab	30.4a	45.7a	51.2ab	24.3ab	20.3a	25.4ab	28.7a	32.4ab	27.9	25.5
200 kg Nha^{-1}	19.4a	25.7a	31.4a	44.8a	45.0a	28.5a	21.6a	28.0a	28.2a	37.8a	28.6	28.3

*Means followed by the same letters or no letters within a column of either farmyard manure or nitrogen levels are not significantly different according to Duncan's Multiple Range Test at $P \leq 0.05$.

FYM - Farmyard Manure and N - Nitrogen.

[z]Trial1. African nightshade planted on 5th April 2009.

Trial 2. African nightshade planted on 20th July 2009.

4.3.2 Interaction Effects of Farmyard Manure and Nitrogen Levels on African Nightshade Fresh Leaf Yield

There were observable differences in the fresh leaf yield of the African nightshade that could be attributed to the application of different combinations of farmyard manure and nitrogen (Table 14). Leaf yield of the plants that received the highest combination of the treatment were higher by 53% compared to the control in at 80 DAP. However, farmyard manure and nitrogen levels combination had influence in the mean fresh yield only at 80 DAP in trial 1 whereas in trial 2 there were no influence after 70 DAP (Table 14). The average fresh yield from plants that received the highest combination of 15 t ha^{-1} farmyard manure and 200 kg Nha^{-1} were higher by 76% compared to the control in the second trial. Increase in the levels of treatment combinations, generally increased the mean fresh yield at every harvesting interval affected (Table 14).

Table 14. Interaction Effects of Farmyard Manure and Nitrogen Levels on African Nightshade Fresh Leaf Yield (g/plant) at Different Harvesting Duration

		Fresh Leaf Yield (g/ plant)											
		Trial 1[z]						Trial 2					
		Days after Planting (DAP)											
FYM Levels	N Levels	50	60	70	80	90	100	50	60	70	80	90	100
0 t ha^{-1}	0 kg Nha^{-1}	3.0*	4.8	10.2	23.9c	22.6	17.1	5.1b	6.2b	10.7bc	17.0	22.2	20.4
	100 kg Nha^{-1}	7.1	10.9	15.8	31.8bc	42.2	20.2	4.1b	5.3b	7.1c	15.0	19.4	24.3
	150 kg Nha^{-1}	10.2	14.4	26.2	35.6abc	46.0	22.0	8.4ab	9.3ab	20.6abc	41.5	25.8	19.1
	200 kg Nha^{-1}	14.3	17.0	21.9	31.6abc	37.5	26.1	11.2ab	16.7ab	19.6abc	31.8	28.2	28.9
7.5 t ha^{-1}	0 kg Nha^{-1}	8.1	13.1	19.3	31.9bc	19.9	17.3	24.4ab	31.0ab	16.4abc	24.1	20.7	16.4
	100 kg Nha^{-1}	19.3	28.8	35.3	44.8abc	31.9	18.8	26.6ab	33.7ab	22.2abc	33.5	24.9	28.7
	150 kg Nha^{-1}	24.4	29.7	36.1	51.4ab	52.6	22.2	24.6ab	28.2ab	37.6ab	29.2	24.4	25.8
	200 kg Nha^{-1}	16.7	24.8	34.0	45.7abc	45.5	30.8	20.0ab	23.5ab	21.3abc	45.0	24.4	20.9
11.3 t ha^{-1}	0 kg Nha^{-1}	11.3	14.1	18.9	28.4bc	34.5	18.9	10.7ab	11.7ab	12.5abc	25.1	24.2	23.0
	100 kg Nha^{-1}	6.6	8.8	18.2	31.3bc	35.6	19.6	17.9ab	24.2ab	27.7abc	26.9	23.6	24.3
	150 kg Nha^{-1}	20.0	25.6	30.7	36.5abc	57.4	30.6	27.0ab	33.9ab	29.0abc	28.3	31.5	29.8
	200 kg Nha^{-1}	23.8	30.8	32.6	50.8ab	41.3	24.4	33.3a	43.8a	31.6abc	28.5	30.3	36.3
15.0 t ha^{-1}	0 kg Nha^{-1}	9.5	13.5	14.8	35.0abc	35.4	20.2	9.8ab	22.2ab	22.6abc	26.9	31.0	30.0
	100 kg Nha^{-1}	12.1	15.2	19.3	35.3abc	36.3	21.8	20.7ab	27.2ab	35.9ab	25.1	29.9	32.8
	150 kg Nha^{-1}	19.7	21.7	28.7	59.2a	48.7	22.5	21.1ab	30.2ab	27.4ab	30.5	29.9	27.3
	200 kg Nha^{-1}	23.0	28.3	37.2	51.2ab	55.9	33.5	22.0ab	28.1ab	40.2a	46.0	31.5	27.2

*Means followed by the same letters or no letters within columns are not significantly different according to Duncan's Multiple Range Test at $P \leq 0.05$.

FYM - Farmyard Manure and N - Nitrogen.

[z]Trial1. African nightshade planted on 5th April 2009.

Trial 2. African nightshade planted on 20th July 2009.

4.3.3 Effects of Farmyard Manure and Nitrogen Levels on African Nightshade Dry Leaf Yield

The effect of farmyard manure levels on leaf dry yield varied in both trials (Table 15). After 70 DAP farmyard manure had no effect on the leaf dry yield of the edible parts in both trials. The results in trial 2 showed a general increase in the leaf dry yield with increasing amounts of farmyard manure levels (Table 15). The same results were also observed in trial 1 except that there were no significant effect among farmyard manure levels on leaf dry yield at 50 DAP. The dry yield of the plants subjected to the highest manure level increased by 45% compared to the control at 70 DAP in trial 2. The highest dry yield of 2.2 - 3.5 g/plant (0.1 - 0.2 t ha^{-1}) and 3.2 - 3.5 g/plant (0.22 - 0.24 t ha^{-1}) was recorded at 60 and 70 DAP in trial 1 and 2 respectively (Table 15).

Nitrogen fertilizer had inconsistent effects on the dry yield on African nightshade in both trials. For instance in trial 1 at 50 DAP, there was a significant 52% increase in dry yield compared to the control while in trial 2 this effect was not observed (Table 15).

4.3.4 Interaction Effects of Farmyard Manure and Nitrogen Levels on African Nightshade Dry Leaf Yield (g/plant)

There were no interactive effects between farmyard manure and nitrogen fertilizer on the average dry yield at each harvesting intervals in trial 1(Table 16). However, the average dry yield in the second trial was similar to that observed from the fresh yield i.e after the 70 DAP there were no influence of the treatment combination on dry yield of African nightshade. Dry yield from the plants that were subjected to 15 t ha^{-1} of farmyard manure and 200 kg Nha^{-1} were higher by between 61% - 79% at 50 - 70 DAP compared to the control in the second trial (Table 16).

Table 16. Interaction Effects of Farmyard Manure and Nitrogen Levels on African Nightshade Dry Leaf Yield (g/plant) at Different Harvesting Duration

		Leaf Dry Yield (g/plant											
		Trial 1[z]						Trial 2					
		Days after Planting (DAP)											
FYM Levels	N Levels	50	60	70	80	90	100	50	60	70	80	90	100
0 t ha^{-1}	0 kg Nha^{-1}	0.5*	0.5	1.2	2.1	2.2	1.9	0.8b	0.9c	1.3b	1.9	1.8	1.7
	100 kg Nha^{-1}	1.1	1.2	1.7	2.2	3.5	2.5	0.8b	0.9c	1.7b	2.1	1.5	1.8
	150 kg Nha^{-1}	1.6	1.6	2.9	2.7	4.4	1.8	1.0ab	1.4bc	2.5ab	3.6	2.1	2.1
	200 kg Nha^{-1}	1.7	2.0	3.0	2.3	3.5	3.1	1.7ab	2.7abc	2.1ab	3.6	2.3	3.1
7.5 t ha^{-1}	0 kg Nha^{-1}	1.4	3.5	1.9	2.9	2.2	2	1.9ab	3.1abc	2.2ab	3.0	1.5	2.2
	100 kg Nha^{-1}	2.6	3.4	3.4	2.8	3.8	2.2	2.1ab	3.9abc	3.0ab	3.8	1.9	2.5
	150 kg Nha^{-1}	2,7	3.7	3.4	3.5	4.1	2.5	2.0ab	3.3abc	3.8ab	4.0	1.9	2.6
	200 kg Nha^{-1}	2.5	2.6	3.2	3.3	3.4	3.1	2.4ab	3.6abc	2.6ab	5.7	2.1	2.5
11.3 t ha^{-1}	0 kg Nha^{-1}	1.4	1.7	2.0	5.0	3.5	2.9	1.3ab	1.6b	1.6a	2.8	2.1	2.9
	100 kg Nha^{-1}	1.8	0.9	2.0	2.3	2.9	2.4	2.4ab	3.3abc	2.5ab	3.2	1.8	2.4
	150 kg Nha^{-1}	2.2	2.7	3.0	2.8	4.1	3.7	2.7a	4.1abc	3.6ab	4.2	2.6	3.0
	200 kg Nha^{-1}	2.8	3.3	3.4	3.6	3.7	2.6	2.3ab	5.0a	3.9ab	4.4	2.5	3.7
15.0 t ha^{-1}	0 kg Nha^{-1}	1.5	1.6	1.7	2.9	3.3	2.4	1.3ab	2.2abc	2.4ab	3.0	2.3	2.7
	100 kg Nha^{-1}	1.7	1.9	1.9	3.0	3.2	2.5	1.7ab	2.6abc	3.9ab	2.8	2.2	2.9
	150 kg Nha^{-1}	2.2	2.5	3.0	4.1	4.3	2.7	2.7ab	3.6abc	3.3ab	3.8	2.5	2.9
	200 kg Nha^{-1}	3.2	3.1	3.3	4.1	4.4	3.4	2.1ab	4.4ab	4.5a	5.2	2.5	2.8

*Means followed by the same letters or no letters within columns are not significantly different according to Duncan's Multiple Range Test at $P \leq 0.05$.

FYM - Farmyard Manure and N - Nitrogen.

[z]Trial1. African nightshade planted on 5th April 2009.

Trial 2. African nightshade planted on 20th July 2009.

4.3.5 Effects of Farmyard Manure and Nitrogen Levels on African Nightshade Total Fresh Leaf Yield

Farmyard manure levels differed in their influence of total fresh leaf yield in both trials (Table 17 and 18). Farmyard manures at all levels increased total fresh leaf yield over the control. Plants that were treated with the highest (15 t ha^{-1} of farmyard manure) increased total fresh yield by between 26% and 34% in both trials compared to the control. The highest yield of 174 g/plant (12.3 t ha^{-1}) and 169 g/plant (12 t ha^{-1}) g/plant in the 1st and 2nd trial respectively was recorded. Total fresh leaf yield as affected by increasing farmyard manure levels in general were slightly higher in the first than in the second trial (Table 17 and 18).

Among the inorganic nitrogen levels, the higher rates of between 150 - 200 kg Nha^{-1} produced significantly more total fresh leaf by between 33% - 42% in both trials compared to the control at $P \leq 0.05$. There were no noticeable interaction of farmyard manure level and nitrogen level influencing total African nightshade dry leaf yield (Table 17 and 18).

Table 17. Effects of Farmyard Manure and Nitrogen Levels on African Nightshade Fresh Leaf Yield (g/plant)

	Fresh Leaf Yield (g/plant)									
	Trial 1[z]					Trial 2				
	N Levels					N Levels				
	0 kg Nha^{-1}	100 kg Nha^{-1}	150 kg Nha^{-1}	200 kg Nha^{-1}	**FYM Levels**	0 kg Nha^{-1}	100 kg Nha^{-1}	150 kg Nha^{-1}	200 kg Nha^{-1}	**FYM Levels**
FYM Levels										
0 t ha^{-1}	81.8	128.4	154.6	148.6	**128.4b***	81.9	75.7	125.0	136.6	**104.8b**
7.5 t ha^{-1}	109.8	179.1	216.6	196.8	**175.6a**	133.2	169.9	170.1	155.3	**157.1a**
11.3 t ha^{-1}	126.3	120.4	200.9	203.8	**162.9ab**	107.4	114.7	179.7	204.0	**151.5a**
15.0 t ha^{-1}	128.7	140.3	200.7	229.3	**174.8a**	142.7	171.9	166.6	195.2	**169.1a**
N means	**111.7c***	**142.1b**	**193.2a**	**194.7a**		**116.3c**	**140.6bc**	**160.3ab**	**172.8a**	

Table 18. Effects of Farmyard Manure and Nitrogen Levels on African Nightshade Fresh Leaf Yield (t ha^{-1})

	Fresh Leaf Yield (tha^{-1})									
	Trial 1[z]					Trial 2				
	N Levels					N Levels				
	0 kg Nha^{-1}	100 kg Nha^{-1}	150 kg Nha^{-1}	200 kg Nha^{-1}	**FYM Levels**	0 kg Nha^{-1}	100 kg Nha^{-1}	150 kg Nha^{-1}	200 kg Nha^{-1}	**FYM Levels**
FYM Levels										
0 t ha^{-1}	5.8	9.1	11.0	10.5	**9.1b***	5.8	5.3	8.8	9.7	**7.4b**
7.5 t ha^{-1}	7.8	12.7	15.4	14.0	**12.2a**	9.4	12.0	12.0	11.0	**11.1a**
11.3 t ha^{-1}	8.9	8.5	14.2	14.5	**11.5ab**	7.6	10.2	12.7	14.5	**11.3a**
15.0 t ha^{-1}	9.1	9.9	14.2	16.3	**12.4a**	10.1	12.2	11.8	13.8	**12.0a**
N means	**7.9c***	**10.1b**	**13.7a**	**13.8a**		**8.2c**	**9.9bc**	**11.3ab**	**12.3a**	

*Means followed by the same letters or no letters within column or row are not significantly different according to Duncan's Multiple Range Test at $P \leq 0.05$.

FYM - Farmyard Manure and N - Nitrogen.

[z]Trial1. African nightshade planted on 5th April 2009.

Trial 2. African nightshade planted on 20th July 2009.

4.3.6 Effects of Farmyard Manure and Nitrogen Levels on African Nightshade Total Dry Leaf Yield

The average dry yield of African nightshade was dependent on the levels of farmyard manure applied. There was a percentage increase of between 23% and 35% of leaf dry yield from plants treated with the highest level of manure in the two phases of the trial compared to the control (Table 19 and 20). The largest dry yield of 17.8 g/plant (1.3 t ha^{-1}) was observed from plants subjected to 7.5 t ha^{-1} in trial 1 and the highest (15 t ha^{-1}) level in the second trial (Table 19 and 20).

However, there was general increase of dry yield with increasing levels of nitrogen fertilizer in both trials (Table 19 and 20). The maximum level of nitrogen fertilizer gave 18.9 g/plant (1.3 t ha^{-1}) and 19.6 g/plant (1.4 t ha^{-1}) which was significantly higher by 29% and 37% compared to the control in first and second trial respectively. There were no interactive effects between farmyard manure and N fertilizer on leaf yield in all levels of combination. However, when averaged across N fertilizer, farmyard manure significantly increased the leaf yield of the African nightshade (Table 19 and 20).

Table 19. Effects of Farmyard Manure and Nitrogen Levels on African Nightshade Dry Leaf Yield (g/plant)

	Dry Leaf Yield (g/plant)									
	Trial 1[z]					Trial 2				
	N Levels					N Levels				
	0 kg Nha^{-1}	100 kg Nha^{-1}	150 kg Nha^{-1}	200 kg Nha^{-1}	**FYM Levels**	0 kg Nha^{-1}	100 kg Nha^{-1}	150 kg Nha^{-1}	200 kg Nha^{-1}	**FYM Levels**
FYM Levels										
0 t ha^{-1}	8.6	12.6	15.3	15.7	**13.1b***	8.6	8.9	12.9	15.7	**11.5b**
7.5 t ha^{-1}	14.1	18.4	20.2	18.4	**17.8a**	14.2	17.3	17.7	19.1	**17.1a**
11.3 t ha^{-1}	16.7	12.6	18.8	19.8	**17.0ab**	12.4	15.9	20.5	22.1	**17.7a**
15.0 t ha^{-1}	13.6	14.5	19.0	21.7	**17.2ab**	14.1	16.4	19.0	21.7	**17.8a**
N means	**13.3b***	**14.5b**	**18.3a**	**18.9a**		**12.3c**	**14.6b**	**17.5a**	**19.6a**	

Table 20. Effects of Farmyard Manure and Nitrogen Levels on African Nightshade Dry Leaf Yield (t ha^{-1})

	Dry Leaf Yield (tha^{-1})									
	Trial 1[z]					Trial 2				
	N Levels					N Levels				
	0 kg Nha^{-1}	100 kg Nha^{-1}	150 kg Nha^{-1}	200 kg Nha^{-1}	**FYM Levels**	0 kg Nha^{-1}	100 kg Nha^{-1}	150 kg Nha^{-1}	200 kg Nha^{-1}	**FYM Levels**
FYM Levels										
0 t ha^{-1}	0.6	0.9	1.0	1.1	**0.9b***	0.6	0.6	0.9	1.1	**0.8b**
7.5 t ha^{-1}	1.0	1.3	1.4	1.3	**1.3a**	1.0	1.2	1.2	1.3	**1.2a**
11.3 t ha^{-1}	1.1	0.8	1.3	1.4	**1.2ab**	0.8	1.1	1.4	1.5	**1.3a**
15.0 t ha^{-1}	0.9	1.0	1.3	1.5	**1.2ab**	1.0	1.1	1.3	1.5	**1.3a**
N means	**0.9b***	**1.0b**	**1.3a**	**1.3a**		**0.9c**	**1.0b**	**1.2a**	**1.4a**	

*Means followed by the same letters or no letters within column or row are not significantly different according to Duncan's Multiple Range Test at $P \leq 0.05$.

FYM - Farmyard Manure and N - Nitrogen.

[z]Trial1. African nightshade planted on 5th April 2009.

Trial 2. African nightshade planted on 20th July 2009.

4.3.7 Effects of Farmyard Manure and Nitrogen Levels on African Nightshade above Ground Biomass

The average fresh biomass of African nightshade was dependent on the levels of farmyard manure applied in both trials (Figure 4). The addition of manure levels increased biomass yield by 24 and 33% and by 23 and 31% compared to the control in both trial 1 and 2 respectively (Figure 4). The same trends were observed in plots treated with nitrogen levels. Plants subjected to maximum nitrogen level increased fresh and dry biomass yield significantly by between 30% - 42% in both trials compared to the control (Figure 4).

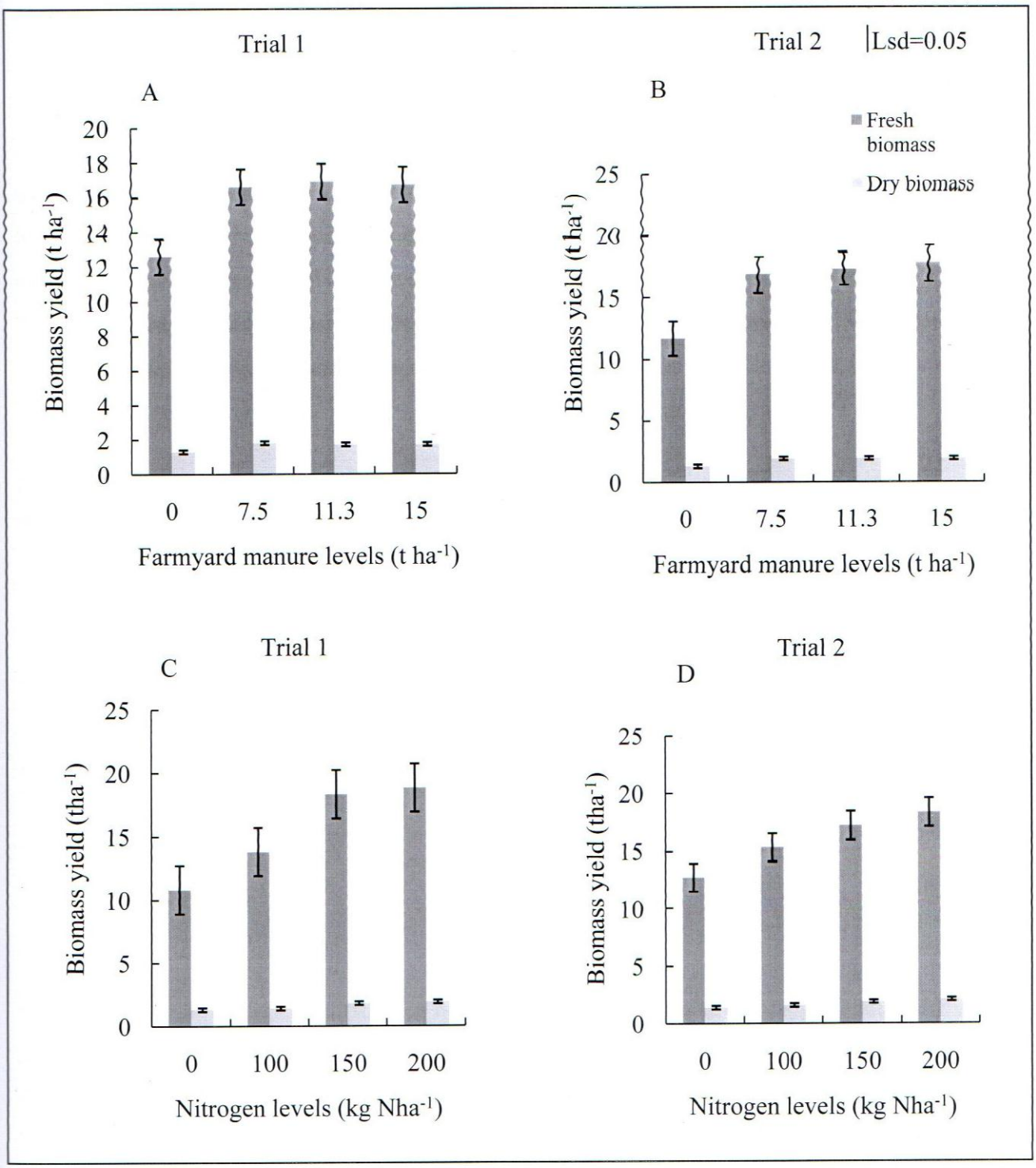


Figure 4. Effects of Farmyard Manure (A and B) and Nitrogen (C and D) Levels on African Nightshade Fresh and Dry above Ground Biomass (tha^{-1})

4.3.8 Interaction Effects of Farmyard Manure and Nitrogen Levels on Fresh and Dry Biomass of African Nightshade

The amount of fresh and dry above ground biomass from African nightshade were significantly influenced by the combined application of farmyard manure and nitrogen in both trials except dry biomass in the first trial. Over the study period, the highest fresh above ground biomass of 21.7 t ha^{-1} obtained from plots that were treated with the highest combination (15 t ha^{-1} of FYM and 200 kg Nha^{-1}) (Table 21).

Table 21. Interaction Effects of Farmyard Manure and Nitrogen Levels on Fresh and Dry African Nightshade Biomass (tha^{-1})

		Biomass Yield (tha^{-1})			
		Trial 1[z]		Trial 2	
FYM Levels	N Levels	FB	DB	FB	DB
0 t ha^{-1}	0 kg Nha^{-1}	8.1b*	0.9	9.7bc	1.1e
	100 kg Nha^{-1}	12.4ab	1.3	9.1c	1.1e
	150 kg Nha^{-1}	14.5ab	1.5	13.2abc	1.5cde
	200 kg Nha^{-1}	15.2ab	1.6	14.7abc	1.7abcde
7.5 t ha^{-1}	0 kg Nha^{-1}	10.4ab	1.3	14.9abc	1.5bcde
	100 kg Nha^{-1}	17.2ab	1.8	18.2abc	1.9abcd
	150 kg Nha^{-1}	20.1ab	2.0	17.9abc	2.0abcd
	200 kg Nha^{-1}	18.7ab	1.9	16.4abc	2.2abc
11.3 t ha^{-1}	0 kg Nha^{-1}	12.2ab	1.6	11.9abc	1.3de
	100 kg Nha^{-1}	11.4ab	1.3	16.8abc	1.7abcde
	150 kg Nha^{-1}	19.9ab	1.9	19.7abc	2.2abc
	200 kg Nha^{-1}	19.6ab	2.0	20.8a	2.3a
15.0 t ha^{-1}	0 kg Nha^{-1}	12.3ab	1.4	14.5abc	1.5cde
	100 kg Nha^{-1}	13.9ab	1.4	17.1abc	1.7abcde
	150 kg Nha^{-1}	18.8ab	1.9	18.1abc	2.0abcd
	200 kg Nha^{-1}	21.7a	2.1	21.1a	2.3a

*Means followed by the same letters or no letters within columns are not significantly different according to Duncan's Multiple Range Test at $P \leq 0.05$.

FYM - Farmyard Manure, N - Nitrogen, FB - Fresh Biomass and DB - Dry Biomass.

[z]Trial1. African nightshade planted on 5th April 2009.

Trial 2. African nightshade planted on 20th July 2009.

4.4 Effect of Farmyard Manure and Nitrogen Levels on African Nightshade Leaf Chlorophyll Content

a) Effects of Farmyard Manure and Nitrogen Levels on African Nightshade Leaf Chlorophyll Content

Farmyard manure affected the leaf chlorophyll content inconsistently in both trials. For instance, there were no effect of farmyard manure at 50, 60 and 90 DAP on the leaf chlorophyll content in the first trial while in the second trial, a general increase in leaf chlorophyll content with the increase in manure levels was observed. The mean chlorophyll content was maximum at 70 and 80 DAP after which it declined by 5% when compared to chlorophyll content at 90 DAP for plants subjected to the maximum rate of manure. Plants that were subjected to 11.3 t ha^{-1} accumulated the most of leaf chlorophyll content by 22% at 70 DAP compared to the control treatment. Generally plants that did not receive manure had significantly lower leaf chlorophyll content at $P \leq 0.05$ than the ones that were supplied with increasing amounts of manure (Table 22).

Application of inorganic nitrogen at different levels affected leaf chlorophyll content in both trials. For instance, high chlorophyll content were observed from plants treated with 150 and 200 kg Nha^{-1}in all the session of data collection except at 90 DAP which had significant ($P \leq 0.05$) difference in all the levels of nitrogen application (Table 22). Similarly, plants that were subjected to higher levels of CAN above 150 kg Nha^{-1} had high leaf chlorophyll content (Table 22).

Table 22. Effects of Farmyard Manure and Nitrogen Levels on African Nightshade Leaf Chlorophyll Content

	Chlorophyll Content (SPAD Readings)									
	Trial 1[z]					Trial 2				
	Days after Planting (DAP)									
	50	60	70	80	90	50	60	70	80	90
FYM Levels										
0 t ha^{-1}	27.9*	32.3	33.4c	32.7b	30.9	31.9b	36.9b	40.5c	39.4b	36.1b
7.5 t ha^{-1}	31.3	35.4	37.6ab	35.3ab	33.3	34.9a	43.1a	49.5ab	49.6a	47.7a
11.3 t ha^{-1}	30.7	32.0	36.6bc	35.8ab	33.4	35.8a	43.7a	52.3a	50.0a	46.4a
15.0 t ha^{-1}	32.4	34.8	40.5a	39.8a	36.8	31.7b	38.9ab	48.7b	48.8a	46.0a
N Levels										
0 kg Nha^{-1}	27.7c*	26.7c	27.8c	25.4c	24.0d	24.4c	29.7c	36.6c	34.7c	33.1c
100 kg Nha^{-1}	29.2bc	31.9b	35.6b	33.0b	31.1c	28.6b	34.4b	42.0b	41.8b	38.2b
150 kg Nha^{-1}	33.3a	38.3a	42.3a	44.1a	41.9a	40.6a	48.8a	55.9a	56.2a	52.2a
200 kg Nha^{-1}	32.1ab	37.7a	42.1a	41.1a	37.5b	40.6a	49.8a	56.4a	55.0a	52.7a

*Means followed by the same letters or no letters within a column of either farmyard manure or nitrogen levels are not significantly different according to Duncan's Multiple Range Test at $P \leq 0.05$.

FYM - Farmyard Manure and N - Nitrogen.

[z]Trial1. African nightshade planted on 5th April 2009.

Trial 2. African nightshade planted on 20th July 2009.

b) Interaction Effects of Farmyard Manure and Nitrogen Levels on African Nightshade Leaf Chlorophyll Content

There were significant interaction between the farmyard manure and inorganic nitrogen levels in influencing leaf chlorophyll content in both trials (Table 23). African nightshade subjected to higher levels of treatment combination of 15 t ha^{-1} and 200 kg Nha^{-1} had significantly higher leaf chlorophyll content by between 47% and 53% compared to the control treatment. Lower chlorophyll content was observed on plants subjected to lower combination of farmyard manure and nitrogenous fertilizer levels (Table 23). Although there were a general increase in leaf chlorophyll content with increase in nutrient combination levels, these increase were not significant at 50 to 70 DAP in trial 1, while in trial 2 leaf chlorophyll content from all intervals of data collection sessions were significantly influenced by interaction effects of the treatments combination (Table 23).

Table 23. Interaction Effects of Farmyard Manure and Nitrogen Levels on African Nightshade Leaf Chlorophyll Content

		Chlorophyll Content (SPAD Readings)									
		Trial 1[z]					Trial 2				
		Days after Planting (DAP)									
FYM Levels	N Levels	50	60	70	80	90	50	60	70	80	90
0 t ha^{-1}	0 kg Nha^{-1}	25.6*	25.9	25.3	20.0d	18.3d	19.4f	24.0f	30.6g	29.0e	25.9e
	100 kg Nha^{-1}	23.7	29.7	32.2	29.9cd	28.2bc	35.0cd	38.2d	41.0efg	38.7cde	34.8cde
	150 kg Nha^{-1}	31.4	35.8	37.3	38.1bc	36.2ab	32.3de	38.2d	38.7efg	39.5cde	32.3e
	200 kg Nha^{-1}	30.8	38.1	37.6	42.7ab	41.2ab	40.8f	47.4b	51.5bcd	50.6abc	51.4abc
7.5 t ha^{-1}	0 kg Nha^{-1}	28.4	28.8	26.3	22.0d	23.1d	22.5f	27.8f	34.5fg	33.5de	33.9abcd
	100 kg Nha^{-1}	33.5	33.3	35.9	28.7d	29.3bc	32.0 de	40.7bc	46.8cde	48.4abcd	45.3de
	150 kg Nha^{-1}	30.8	40.8	45.2	45.1ab	42.1ab	49.6a	55.4a	59.5abc	60.9a	61.0a
	200 kg Nha^{-1}	32.6	38.8	42.2	45.6ab	38.7ab	35.5cd	48.7a	57.1abc	55.3ab	50.7abc
11.3 t ha^{-1}	0 kg Nha^{-1}	26.5	25.1	28.1	28.8d	25.6ab	34.3cd	38.5cd	45.4de	38.2cde	35.8cde
	100 kg Nha^{-1}	28.6	29.7	34.6	36.6bc	34.2bc	24.5ef	29.9ef	42.8efg	40.7bcde	37.8bcde
	150 kg Nha^{-1}	38.1	38.3	41.7	44.8ab	40.6ab	38.8bcd	51.0ab	60.4ab	63.1a	58.0a
	200 kg Nha^{-1}	29.5	34.8	42.2	33.1cd	32.9bc	45.4ab	55.3a	60.4ab	58.2a	53.8ab
15.0 t ha^{-1}	0 kg Nha^{-1}	30.1	27.2	31.6	31.0cd	29.1bc	21.5f	28.5ef	35.9fg	38.1cde	36.7cde
	100 kg Nha^{-1}	30.9	34.9	39.6	36.9bc	32.4bc	23.0f	28.6ef	37.3fg	39.5cde	35.0cde
	150 kg Nha^{-1}	33.0	38.1	45.0	48.6a	48.7a	41.7bc	50.7 b	65.1a	61.5a	57.4a
	200 kg Nha^{-1}	35.6	39.0	45.6	42.8ab	37.1ab	40.7bc	47.8bc	56.5abc	56.1ab	55.0ab

*Means followed by the same letters or no letters within columns are not significantly different according to Duncan's Multiple Range Test at $P \leq 0.05$.

FYM - Farmyard Manure and N - Nitrogen.

[z]Trial1. African nightshade planted on 5th April 2009.

Trial 2. African nightshade planted on 20th July 2009.

4.5 Effects of Farmyard Manure and Nitrogen Levels on African Nightshade Leaf Stomatal Conductance

a) Effects of Farmyard Manure and Nitrogen Levels on African Nightshade Leaf Stomatal Conductance

Farmyard manure levels significantly ($P \leq 0.05$) affected the stomatal conductance of African nightshade leaves in both trial of experiment apart from at 50 and 80 DAP in the second trial. The application of farmyard manure levels generally increased stomatal conductance compared to the control (Figure 5). In the trial 1, plants that were subjected to maximum (15 t ha^{-1}) manure levels significantly increased their stomatal conductance by 65% and 28% at 60 and 70 DAP respectively compared to the control. Inorganic nitrogen levels differently influenced the stomatal conductance in both trials. Increase of nitrogen fertilizer levels, led to a general rise in leaf stomatal conductance in both trials except at 60 and 70 DAP in the second trial (Figure 5).

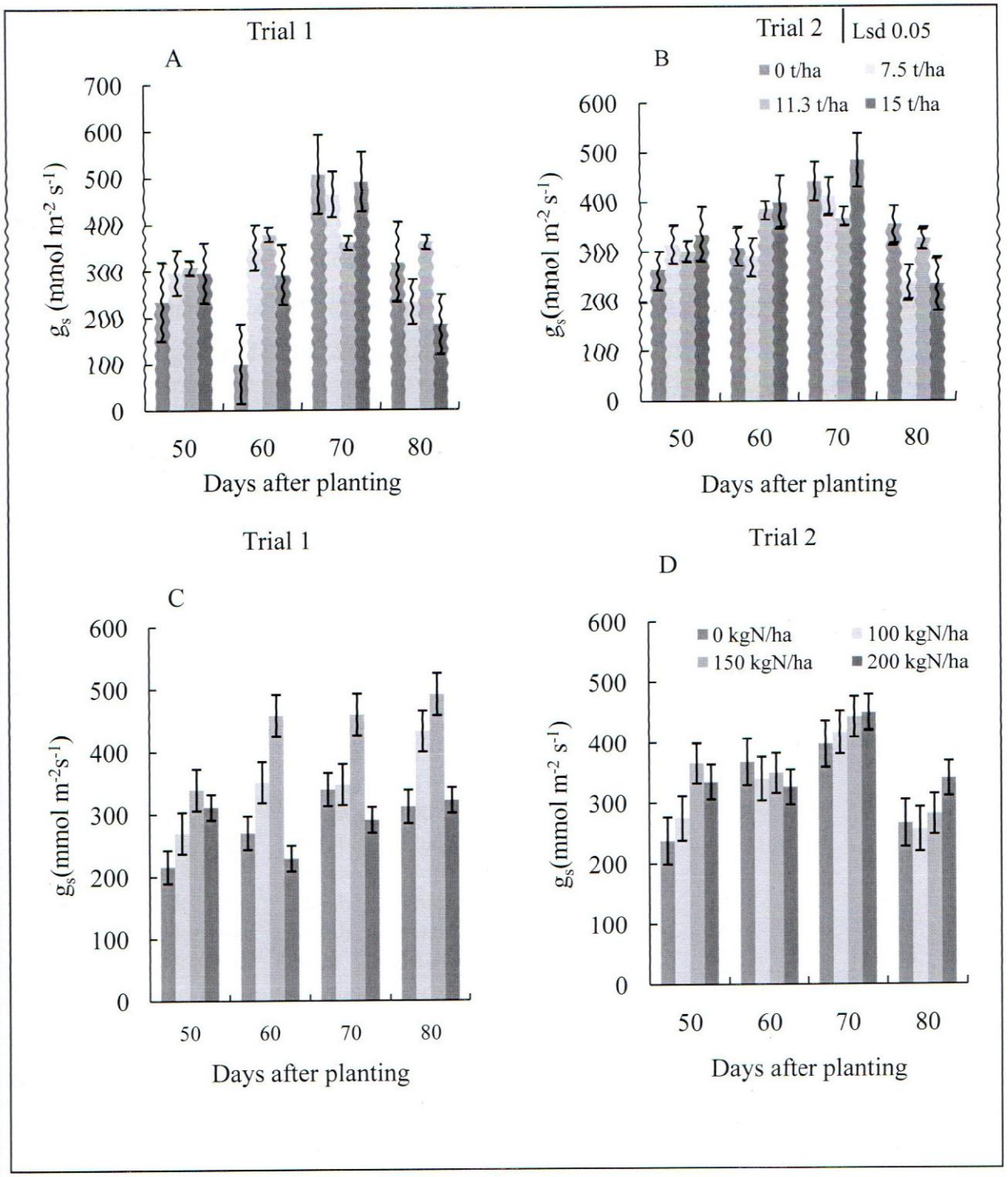


Figure 5. Effects of Farmyard Manure (A and B) and Nitrogen (C and D) Levels on African Nightshade Leaf Stomatal Conductance (mmol $m^{-2}s^{-1}$)

b) Interaction Effect of Farmyard Manure and Nitrogen levels on African Nightshade Leaf Stomatal Conductance

Significant interactions were observed between farmyard manure and nitrogenous fertilizer levels on leaf stomatal conductance in the first trial while there were no interactions in the second trial. However, the interactions were inconsistent and could not be directly attributed to the effect of combined application of the treatments (Table 24).

Table 24. Interaction Effect of Farmyard Manure and Nitrogen Levels on African Nightshade Leaf Stomatal Conductance (mmol $m^{-2}s^{-1}$)

		Stomatal Conductance (mmol $m^{-2}s^{-1}$)							
		Trial 1[z]				Trial 2			
		Days after Planting (DAP)							
FYM Levels	N Levels	50	60	70	80	50	60	70	80
0 t ha^{-1}	0 kg Nha^{-1}	181c*	366 b	525abc	332abc	201	344	430	335
	100 kg Nha^{-1}	201abc	350b	498abc	209de	212	351	424	326
	150 kg Nha^{-1}	231abc	212f	468abc	347a	293	258	451	346
	200 kg Nha^{-1}	317abc	242e	538ab	384a	340	290	465	399
7.5 t ha^{-1}	0 kg Nha^{-1}	176bc	439ab	391d	156e	202	316	417	199
	100 kg Nha^{-1}	327abc	385b	402d	214cd	325	296	346	206
	150 kg Nha^{-1}	326abc	333bcd	508abc	276abc	392	270	430	263
	200 kg Nha^{-1}	309abc	245e	556a	287abc	342	278	458	281
11.3 t ha^{-1}	0 kg Nha^{-1}	315abc	396 b	283ef	382a	267	365	286	325
	100 kg Nha^{-1}	249abc	398 b	408d	328abc	256	400	445	289
	150 kg Nha^{-1}	374ab	399b	324e	345ab	377	409	329	317
	200 kg Nha^{-1}	295abc	322cd	427bcd	389a	304	364	412	369
15.0 t ha^{-1}	0 kg Nha^{-1}	195abc	530a	457abc	143e	278	450	461	208
	100 kg Nha^{-1}	305abc	273de	524abc	169de	308	315	451	205
	150 kg Nha^{-1}	374ab	444ab	540ab	194d	380	461	561	200
	200 kg Nha^{-1}	375a	356 b	446bcd	227bcd	356	377	464	312

*Means followed by the same letters or no letters within columns are not significantly different according to Duncan's Multiple Range Test at $P \leq 0.05$.

FYM - Farmyard Manure and N - Nitrogen.

[z]Trial1. African nightshade planted on 5th April 2009.

Trial 2. African nightshade planted on 20th July 2009.

4.6 Spider Plant

4.6.1 Effects of Farmyard Manure and Nitrogen Levels on Growth Parameters of Spider Plant

There effect of farmyard manure on spider plant was observed in both trials of the experiments (Table 25). It was observed that by increasing levels of manure led to significant general increase of all growth parameters (plant height, number of leaves, number of branches, internodes length, leaf area and leaf area index) in both trials apart from leaf are (LA) and leaf area index which were not affected in trial 1. Plants from plots treated with the highest level of manure increased in leaf area index and plant height by 86% and 65% in 1st and 2nd trial respectively compared to the control (Table 25).

The effect of nitrogen fertilizer on all growth parameters was similar to that of manure in both trials apart from plant height and number of leaves in trial 1. The plant height, number of leaves and leaf area index was higher by 47%, 50% and 67% respectively on plants subjected maximum rate of nitrogen fertilizer when evaluated against the control (Table 25).

Table 25. Effects of Farmyard Manure and Nitrogen Levels on Growth Parameters of Spider plant

	Growth Parameters											
	Trial 1[z]						Trial 2					
	PH(cm)	NL	NB	IL(cm)	LA(cm^2)	LAI	PH(cm)	NL	NB	IL(cm)	LA(cm^2)	LAI
FYM Levels												
0 t ha^{-1}	12.4b*	30.3b	6.5b	0.9b	57.0	0.3	17.4c	27.3c	6.7b	0.9b	48.1b	0.9c
7.5 t ha^{-1}	16.7ab	28.0b	9.0a	1.6b	73.6	1.4	30.7b	40.8b	8.4ab	1.1b	63.7a	1.8b
11.3 t ha^{-1}	20.5a	34.9a	8.9a	1.4a	72.1	1.8	43.6a	59.8a	9.4a	1.8a	74.7a	3.3a
15.0 t ha^{-1}	22.3a	42.5a	9.5a	1.6a	74.5	2.2	41.0ab	54.4a	10.5a	1.7a	71.7a	2.9a
N Levels												
0 kg Nha^{-1}	16.5*	28.0	7.5b	1.0b	59.1b	1.2c	21.2c	29.9b	6.7c	0.8d	49.8b	1.0c
100 kg Nha^{-1}	18.0	32.9	8.0b	1.5a	62.1b	1.4ab	30.9b	39.8b	8.4b	1.2c	57.5b	1.6b
150 kg Nha^{-1}	18.6	37.9	9.5a	1.5a	75.1ab	2.0ab	39.2ab	54.1a	9.4ab	1.9a	5.3a	3.1a
200 kg Nha^{-1}	18.8	37.0	9.0a	1.5a	81.0a	2.2a	40.0a	59.8a	10.5a	1.7b	75.5a	3.3a

*Means followed by the same letters or no letters within a column of either farmyard manure or nitrogen levels are not significantly different according to Duncan's Multiple Range Test at $P \leq 0.05$.

N- Nitrogen, FYM - Farmyard Manure, PH - Plant Height, NL - Number of Leaves, NB - Number of Branches, IL - Internode Length, LA - Leaf Area, LAI - Leaf Area Index.

[z]Trial1. African nightshade planted on 5th April 2009.

Trial 2. African nightshade planted on 20th July 2009.

4.6.2 Interaction Effects of Farmyard Manure and Nitrogen Levels on Growth Parameters of Spider Plant

The interaction of manure and nitrogen fertilizer influenced growth parameters of spider plant (number of leaves, number of branches, internodes length and leaf area index) (Table 26 and 27). However, with the increase of treatment combination, there were a significant increase on the number of leaves and branches. Plants subjected to 15 t ha^{-1} of farmyard manure and 150 kg Nha^{-1} from CAN had the same internodes length with those subjected to the highest levels of treatments while plant height and leaf area were not affected (Table 26). However, leaf area index was influenced significantly by 82% and 85% on plants subjected to the highest combination (15 t ha^{-1} of farmyard manure and 200 kg Nha^{-1}) of the treatments in trial1 and 2 respectively compared to the control (Table 27).

Table 26. Interaction Effects of Farmyard Manure and Nitrogen Levels on Growth Parameters of Spider Plant

		Growth Parameters							
		Trial 1[z]				Trial 2			
FYM Levels	N Levels	PH(cm)	NL	NB	IL(cm)	PH(cm)	NL	NB	IL(cm)
0 t ha^{-1}	0 kg Nha^{-1}	14.0*	16.3b	7.6b	0.94	12.1	17.6	4.3b	0.63d
	100 kg Nha^{-1}	10.2	32.0ab	6.0b	0.96	19.8	26.0	7.6ab	0.77cd
	150 kg Nha^{-1}	13.5	45.0ab	6.0ab	0.98	17.2	26.0	8.0ab	1.46abc
	200 kg Nha^{-1}	11.9	28.0ab	8.0b	1.05	20.5	39.6	7.0ab	1.05cd
7.5 t ha^{-1}	0 kg Nha^{-1}	14.3	27.0ab	8.3ab	1.51	17.5	26.0	8.3ab	0.89cd
	100 kg Nha^{-1}	15.3	24.0ab	9.0ab	1.51	30.7	33.3	6.3ab	0.99cd
	150 kg Nha^{-1}	24.0	38.0ab	11.3ab	1.07	38.5	44.6	8.3ab	1.66abc
	200 kg Nha^{-1}	13.4	23.3ab	7.6b	1.38	36.1	59.3	10.6ab	1.23cd
11.3 t ha^{-1}	0 kg Nha^{-1}	22.2	20.3ab	7.0b	0.95	25.5	35.3	6.6ab	1.04cd
	100 kg Nha^{-1}	20.8	38.3ab	8.6ab	1.53	33.8	50.6	8.6ab	1.63abc
	150 kg Nha^{-1}	15.9	31.6ab	9.0ab	1.59	51.7	76.3	11.0ab	2.04a
	200 kg Nha^{-1}	22.9	49.3ab	10.6ab	1.79	63.5	77.0	11.3ab	2.49a
15.0 t ha^{-1}	0 kg Nha^{-1}	15.8	32.3ab	7.0b	0.83	29.8	40.6	7.6ab	0.87cd
	100 kg Nha^{-1}	20.7	53.3a	10.3ab	1.16	39.2	49.3	11.0ab	1.72abc
	150 kg Nha^{-1}	20.9	37.0ab	9.0ab	1.20	49.5	69.6	10.3ab	2.43a
	200 kg Nha^{-1}	26.9	47.6ab	11.6a	1.83	40.0	63.3	13.3a	2.10a

*Means followed by the same letters or no letters within columns are not significantly different according to Duncan's Multiple Range Test at $P \leq 0.05$. FYM - Farmyard Manure, N- Nitrogen, PH - Plant Height, NL - Number of Leaves, NB - Number of Branches and IL - Internode Length.

[z]Trial1. African nightshade planted on 5th April 2009.

Trial 2. African nightshade planted on 20th July 2009.

Table 27. Interaction Effects of Farmyard Manure and Nitrogen Levels on Growth Parameters of Spider Plant

		Growth Parameters			
		Trial 1[z]		Trial 2	
FYM Levels	N Levels	LA(cm^2)	LAI	LA(cm^2)	LAI
0 t ha^{-1}	0 kg Nha^{-1}	55.1*	0.5b	52.3	0.6c
	100 kg Nha^{-1}	46.9	1.3ab	42.4	0.7c
	150 kg Nha^{-1}	57.3	2.0ab	49.9	0.8c
	200 kg Nha^{-1}	68.7	1.4ab	49.7	1.4c
7.5 t ha^{-1}	0 kg Nha^{-1}	58.4	1.1ab	55.6	1.0c
	100 kg Nha^{-1}	80.5	1.3ab	60.1	1.3c
	150 kg Nha^{-1}	74.8	1.9ab	72.6	2.2bc
	200 kg Nha^{-1}	80.6	1.2ab	66.3	2.7bc
11.3 t ha^{-1}	0 kg Nha^{-1}	52.5	0.7ab	44.0	1.1c
	100 kg Nha^{-1}	56.9	1.5ab	62.1	2.1bc
	150 kg Nha^{-1}	89.4	1.9a	99.9	5.1a
	200 kg Nha^{-1}	89.7	3.2a	92.7	5.1a
15.0 t ha^{-1}	0 kg Nha^{-1}	70.3	1.8ab	47.3	1.4c
	100 kg Nha^{-1}	63.9	2.3ab	65.5	2.3bc
	150 kg Nha^{-1}	79.1	2.1ab	81.0	4.0ab
	200 kg Nha^{-1}	84.9	2.8ab	93.1	4.0ab

*Means followed by the same letters or no letters within columns are not significantly different according to Duncan's Multiple Range Test at $P \leq 0.05$.

FYM - Farmyard Manure, N - Nitrogen, LA - Leaf Area and LAI - Leaf Area Index.

[z]Trial1. African nightshade planted on 5th April 2009.

Trial 2. African nightshade planted on 20th July 2009.

4.7 Effects Farmyard Manure and Nitrogen Levels on Spider Plant Fresh and Dry Yield

4.7.1 Effects of Farmyard Manure and Nitrogen Levels on Spider Plant Fresh Leaf Yield

Results on the effect of farmyard manure levels on spider plant fresh yield varied in trial 1 while in trial 2, consistent effects were observed (Table 28). For instance, manure effect was observed only on 70 and 80 DAP in the first trial. However, in the second trial, a general increase of between 20% and 69% was observed with increase in manure levels when evaluated against the control. In addition, highest yield of 44.5 g/plant (3.2 t ha^{-1}) were noted at 80 DAP in the second trial. When fresh yield were compared to individual manure levels, only the control in all harvesting intervals was significantly lower than the rest of the treatments at $P \leq 0.05$ (Table 28).

Nitrogen fertilizer levels showed similar response as that of manure in their influence on fresh yield at harvesting intervals in days after planting except at 50 and 90 DAP in trial 1 and 2 respectively. Generally, fresh yield from plants that received 100 kg Nha^{-1} was not significantly different from the higher rates. It was noted that at 80 DAP, 45 g/plant (3.2 t ha^{-1}) of fresh yield was realized from plants treated with 200 kg Nha^{-1} which also was higher by 33% when evaluated against the control (Table 28).

Table 28. Effects of Farmyard Manure and Nitrogen Levels on Spider Plant Fresh Leaf Yield (g/plant) at Different Harvesting Duration

	Fresh Leaf Yield (g/plant)											
	Trial 1[z]						Trial 2					
	Days after Planting (DAP)											
	50	60	70	80	90	100	50	60	70	80	90	100
FYM Levels												
0 t ha^{-1}	8.6*	11.2	12.0b	13.3c	26.2	17.4	8.6b	8.8b	11.9b	24.8b	20.8b	16.37b
7.5 t ha^{-1}	10.6	13.8	16.1ab	19.3b	36.2	19.2	14.4ab	13.0ab	29.5a	36.8a	31.4ab	20.4ab
11.3 t ha^{-1}	11.7	13.8	17.3ab	15.2c	28.9	18.4	27.6ab	18.6ab	35.2a	40.4a	31.1ab	20.7ab
15.0 t ha^{-1}	11.1	18.1	19.5a	22.7a	33.6	22.4	28.6a	20.5a	34.7a	44.5a	36.7a	25.5a
N Levels												
0 kg Nha^{-1}	8.7*	9.9b	12.5b	14.5c	25.4b	12.9b	12.6b	9.3b	24.2	30.9b	26.1	16.4b
100 kg Nha^{-1}	10.5	14.1ab	14.1b	16.2bc	27.2b	17.6b	19.1ab	15.2a	29.4	36.3b	29.2	19.4ab
150 kg Nha^{-1}	13.8	17.0a	19.3a	19.5ab	36.6a	22.7a	19.1a	18.8a	26.9	34.3b	33.8	23.7a
200 kg Nha^{-1}	12.0	15.9a	19.0a	20.4a	35.7a	24.1a	28.4a	17.7a	30.9	45.0a	30.9	23.4a

*Means followed by the same letters or no letters within a column of either farmyard manure or nitrogen levels are not significantly different according to Duncan's Multiple Range Test at $P \leq 0.05$.

FYM - Farmyard Manure and N - Nitrogen.

[z]Trial1. African nightshade planted on 5th April 2009.

Trial 2. African nightshade planted on 20th July 2009.

4.7.2 Interaction Effects of Farmyard Manure and Nitrogen Levels on Spider Plant Dry Leaf Yield

The effect of interaction between nitrogenous fertilizer and farmyard manure inconsistently influenced leaf fresh yield of spider plant in both trials while every combination of the treatment had no effect on yield up to 70 DAP (Table 29). Leaf yield of plants subjected to highest combination was increased by more than 50% at 80 DAP compared to the control. However, the same effect of the treatment combination except at 70 DAP influenced leaf fresh yield in the second trial with the highest yield of 47 g/plant (3.3 t ha^{-1}) realized at 80 DAP.

Table 29. Interaction Effects of Farmyard Manure and Nitrogen Levels on Spider Plant Dry Leaf Yield (g/plant) at Different Harvesting Duration

		Fresh Leaf Yield (g/ plant)											
		Trial 1[z]						Trial 2					
		Days after Planting (DAP)											
FYM Levels	N Levels	50	60	70	80	90	100	50	60	70	80	90	100
0 t ha^{-1}	0 kg Nha^{-1}	4.4*	9.1	11.3	12.3bc	25.1	10.8b	6.0	6.7	8.2c	21.6cd	17.1	12.3b
	100 kg Nha^{-1}	4.2	6.1	8.1	10.6c	20.1	13.8ab	9.0	10.0	12.6abc	30.0cd	20.8	15.5ab
	150 kg Nha^{-1}	14.9	16.9	16.3	14.3bc	26.5	20.2ab	8.3	10.0	9.8c	21.4cd	21.8	19.1ab
	200 kg Nha^{-1}	10.9	12.7	12.3	16.1abc	33.1	24.7ab	11.3	7.7	17.1ab	26.1bcd	23.5	18.5ab
7.5 t ha^{-1}	0 kg Nha^{-1}	6.1	8.6	12.7	17.4abc	32.6	11.4ab	5.2	6.3	23.5abc	17.4d	23.6	16.3ab
	100 kg Nha^{-1}	14.9	12.4	9.3	15.7abc	26.6	16.6ab	8.1	10.2	32.6abc	38.7abcd	30.1	16.5ab
	150 kg Nha^{-1}	14.2	21.3	23.1	20.6abc	47.3	25.2ab	13.4	17.0	26.2abc	33.7bcd	38.8	26.1ab
	200 kg Nha^{-1}	7.3	12.7	19.5	23.5ab	39.0	23.5ab	30.9	18.6	35.9a	57.6a	33.2	22.6ab
11.3 t ha^{-1}	0 kg Nha^{-1}	9.1	8.6	12.2	12.6bc	18.2	12.9ab	12.2	11.5	29.6bc	40.4abcd	30.1	16.5ab
	100 kg Nha^{-1}	11.1	19.2	19.4	12.7bc	25.7	17.0ab	24.2	17.2	35.4abc	33.4bcd	30.9	20.2ab
	150 kg Nha^{-1}	11.5	11.8	18.1	19.7abc	38.9	22.5ab	33.0	22.4	37.4a	38.9abcd	35.2	22.2ab
	200 kg Nha^{-1}	15.0	15.7	19.5	16.0abc	32.7	21.3ab	40.8	23.3	38.5a	48.9ab	28.2	24.1ab
15.0 t ha^{-1}	0 kg Nha^{-1}	3.4	13.4	13.7	15.6abc	25.8	16.7ab	26.9	12.6	35.4ab	44.4abc	33.7	20.7ab
	100 kg Nha^{-1}	11.7	18.7	19.7	25.9a	36.9	23.1ab	35.1	23.3	37.1ab	43.1abc	35.1	25.3ab
	150 kg Nha^{-1}	14.6	17.7	19.6	23.4ab	33.5	22.8ab	21.6	24.9	34.1a	43.3abc	39.2	27.5ab
	200 kg Nha^{-1}	14.7	22.5	24.8	26.0a	38.0	27.1a	30.7	21.1	36.0a	47.3ab	38.8	28.6a

*Means followed by the same letters or no letters within columns are not significantly different according to Duncan's Multiple Range Test at $P \leq 0.05$.

FYM - Farmyard Manure and N- Nitrogen,

[z]Trial1. African nightshade planted on 5th April 2009.

Trial 2. African nightshade planted on 20th July 2009.

4.7.3 Effects of Farmyard Manure and Nitrogen Levels on Spider Plant Dry Leaf Yield

There was a general increase of the dry leaf yield of the edible parts with increase of manure levels (Table 30). However, dry leaf yield was higher at 5.7 g/plant (0.4 t ha^{-1}) at 80 DAP for plants treated with 15.0 t ha^{-1} compared to the control. When the dry yield of individual manure levels was compared, it showed that 7.5 t ha^{-1} was not statistically different from the higher levels (Table 30).

Nitrogenous fertilizer levels influenced dry leaf yield similarly as those observed from manure levels in both trials. Plants that were subjected to 100 kg Nha^{-1} generally performed better compared to those from the higher levels. Dry leaf yield of 5.7 g/plant (0.4 t ha^{-1}) and 4.0 g/plant (0.2 t ha^{-1}) was realized from plots treated with 200 kg Nha^{-1} and was greater by 33% and 42% compared to the control (Table 30).

Table 30. Effects of Farmyard Manure and Nitrogen Levels on Spider Plant Dry Leaf Yield (g/plant) at Different Harvesting Duration

	Dry Yield (g/plant)											
	Trial 1[z]						Trial 2					
	Days after Planting (DAP)											
	50	60	70	80	90	100	50	60	70	80	90	100
FYM Levels												
0 t ha^{-1}	1.4b*	1.5b	1.6b	1.9c	3.1	2.5	1.2b	1.8b	2.2b	3.7b	2.0	1.5b
7.5 t ha^{-1}	1.6b	1.9ab	2.2ab	2.5ab	4.5	3.5	1.6ab	2.0b	4.1a	5.1a	2.4	1.7b
11.3 t ha^{-1}	1.9a	1.8ab	2.2ab	2.2bc	4.1	3.0	2.7ab	3.0a	5.3a	5.3a	2.7	2.0ab
15.0 t ha^{-1}	2.0a	2.5a	2.6a	3.1a	4.5	3.1	3.1a	2.9a	4.9a	5.7a	3.1	2.4a
N Levels												
0 kg Nha^{-1}	1.2d*	1.3b	1.6b	2.0b	2.9b	2.4	1.2b	1.5b	3.4b	3.8b	2.3b	1.2b
100 kg Nha^{-1}	1.5c	1.9ab	1.9ab	2.2b	3.5ab	2.9	1.9b	2.1a	4.2ab	5.1ab	2.9b	1.2b
150 kg Nha^{-1}	2.9a	2.3a	2.6a	2.9ab	4.8a	3.4	2.2b	2.9a	4.3ab	4.8ab	3.8ab	1.3ab
200 kg Nha^{-1}	2.3b	2.2a	2.5a	2.5a	4.8a	3.4	3.2a	3.1a	4.7a	5.7a	4.0a	1.5a

*Means followed by the same letters or no letters within a column of either farmyard manure or nitrogen levels are not significantly different according to Duncan's Multiple Range Test at $P \leq 0.05$.

FYM - Farmyard Manure and N- Nitrogen.

[z]Trial1. African nightshade planted on 5th April 2009.

Trial 2. African nightshade planted on 20th July 2009.

4.7.4 Interaction Effects between Farmyard Manure and Nitrogen Levels on Spider Plant Dry Leaf Yield

There was no interaction effect on the mean leaf dry yield of spider plant between farmyard manure and nitrogen fertilizers in the entire harvesting intervals except at 70 DAP in the second trial (Table 31). However, the highest leaf dry yield of 6.0 g/plant was recorded at 80 DAP. Plants that were subjected to the highest combination of the treatments at 70 DAP increased the mean leaf dry yields by 67% compared to the control. Although there were general increase in spider plants leaf dry yields with the increase in treatment combination levels, these increase were not significant at 90 DAP in both trials (Table 31).

Table 31. Interaction Effects of Farmyard Manure and Nitrogen Levels on Spider Plant Dry Leaf Yield (g/plant) at Different Harvesting Duration

		Leaf Dry Yield (g/plant)											
		Trial 1[z]						Trial 2					
		Days after Planting (DAP)											
FYM Levels	N Levels	50	60	70	80	90	100	50	60	70	80	90	100
0 t ha^{-1}	0 kg Nha^{-1}	0.8*	1.3	1.2	1.7	2.5	1.9	0.9	1.3	1.5d	3.2	1.8	1.1
	100 kg Nha^{-1}	1.0	0.9	1.0	1.4	2.8	2.2	1.0	1.5	1.9cd	4.4	2.1	1.3
	150 kg Nha^{-1}	2.8	2.2	2.1	2.5	3.2	2.9	1.5	2.5	2.8bcd	3.4	2.2	1.7
	200 kg Nha^{-1}	2.1	1.7	2.1	1.8	4.0	3.1	1.4	1.8	2.7bcd	3.8	1.8	1.6
7.5 t ha^{-1}	0 kg Nha^{-1}	0.9	1.2	1.7	2.3	3.2	2.9	0.4	1.0	3.3abcd	3.7	3.9	1.2
	100 kg Nha^{-1}	1.4	1.8	1.5	2.3	3.3	2.9	1.4	1.5	4.4abcd	5.4	2.6	1.6
	150 kg Nha^{-1}	2.5	2.9	3.1	2.6	5.9	4.4	1.3	2.4	3.7abcd	5.2	2.6	1.7
	200 kg Nha^{-1}	1.6	1.7	2.7	2.8	5.3	3.8	3.4	3.1	5.0abcd	6.2	2.8	2.1
11.3 t ha^{-1}	0 kg Nha^{-1}	0.7	1.2	1.6	1.7	2.5	2.3	1.5	1.6	4.0abcd	5.0	11.2	1.6
	100 kg Nha^{-1}	1.5	2.3	2.7	1.9	3.3	2.8	2.1	2.9	5.2bcd	4.8	2.9	1.8
	150 kg Nha^{-1}	2.8	1.5	2.3	3.1	5.5	3.2	3.0	3.1	5.7ab	4.8	3.8	2.4
	200 kg Nha^{-1}	2.0	2.2	2.1	2.0	4.8	3.7	4.2	4.3	6.4a	6.8	3.5	2.2
15.0 t ha^{-1}	0 kg Nha^{-1}	1.4	1.7	1.9	2.2	3.5	2.7	2.1	2.3	4.6abcd	5.3	2.9	2.2
	100 kg Nha^{-1}	2.1	2.7	2.5	3.3	4.7	3.6	3.2	2.5	5.3abc	5.9	3.0	1.9
	150 kg Nha^{-1}	3.7	2.7	2.9	3.5	4.4	3.1	3.0	3.4	5.0abcd	5.8	3.7	2.7
	200 kg Nha^{-1}	3.5	3.1	3.2	3.3	5.1	2.8	4.0	3.4	4.6abcd	6.0	3.0	2.8

*Means followed by the same letters or no letters within columns are not significantly different according to Duncan's Multiple Range Test at $P \leq 0.05$.

FYM - Farmyard Manure and N- Nitrogen.

[z]Trial1. African nightshade planted on 5th April 2009.

Trial 2. African nightshade planted on 20th July 2009.

4.7.5 Effect of Farmyard Manure and Nitrogen Levels on Spider Plants Total Fresh Leaf Yield

Farmyard manure had significant ($P \leq 0.05$) effect on total mean fresh yield of spider plant in both trials (Table 32 and 33). The control was significantly ($P \leq 0.05$) lower in the mean total leaf fresh yield than the rest of the treatment levels. Nevertheless, plants subjected to 15tha^{-1} yielded more in fresh yield by 30% and 52% in trial 1 and 2 respectively compared to the control. Although the increase in farmyard manure generally increased total fresh yield of spider plant, plants that were treated with 7.5, 11.3 and 15 t ha^{-1} were not significantly different. The yield from trial 2 was generally more than from trial 1 (Table 32 and 33).

Nitrogenous fertilizer had similar results as that from manure in both trials. Plants that were subjected to highest level of nitrogen fertilizer increased total fresh yield by 37% and 56% in trial 1 and 2 respectively in contrast to the control treatment. The highest, fresh yield of 129 g/plant (9 t ha^{-1}) and 176 g/plant (12 t ha^{-1}) were recorded on the highest level of nitrogen fertilizer. There were no interactive effects between farmyard manure and nitrogen fertilizer on total leaf yield in all levels of combination. However, when averaged across nitrogen fertilizer and farmyard manure significantly increased the leaf yield of the African nightshade (Table 32 and 33).

Table 32. Effects of Farmyard Manure Levels and Nitrogen on Spider Plant Total Fresh Leaf Yield (g/plant)

	Leaf Fresh Yield (g/ plant)									
	Trial 1[z]					Trial 2				
	N Levels					N Levels				
FYM Levels	0 kg Nha^{-1}	100 kg Nha^{-1}	150 kg Nha^{-1}	200 kg Nha^{-1}	**FYM Levels**	0 kg Nha^{-1}	100 kg Nha^{-1}	150 kg Nha^{-1}	200 kg Nha^{-1}	**FYM Levels**
0 t ha^{-1}	73.2	63.2	109.4	110.2	**89.0b***	72.1	98.0	91.6	104.3	**91.5c**
7.5 t ha^{-1}	89.0	95.3	152.1	125.7	**105.6ab**	92.6	136.4	155.5	198.9	**145.8b**
11.3 t ha^{-1}	73.9	105.4	122.9	120.5	**115.5ab**	140.6	161.6	189.4	204	**173.9ab**
15.0 t ha^{-1}	88.9	136.4	131.9	153.4	**127.6a**	174.0	199.0	190.9	198.6	**190.7a**
N means	**81.26b***	**100.7b**	**127.46a**	**129.1a**		**119.85c**	**148.87bc**	**156.89ab**	**176.52a**	

Table 33. Effects of Farmyard Manure and Nitrogen Levels on Spider Plant Total Fresh Leaf Yield (t ha^{-1})

	Leaf Fresh Yield (tha^{-1})									
	Trial 1[z]					Trial 2				
	N Levels					N Levels				
FYM Levels	0 kg Nha^{-1}	100 kg Nha^{-1}	150 kg Nha^{-1}	200 kg Nha^{-1}	**FYM Levels**	0 kg Nha^{-1}	100 kg Nha^{-1}	150 kg Nha^{-1}	200 kg Nha^{-1}	**FYM Levels**
0 t ha^{-1}	5.2	4.5	7.7	7.8	**6.3b***	5.1	6.9	6.5	7.4	**6.5c**
7.5 t ha^{-1}	6.3	6.7	10.8	8.9	**8.2ab**	6.5	9.7	11.0	14.1	**10.3b**
11.3 t ha^{-1}	5.2	7.4	8.7	8.5	**7.5ab**	9.9	11.4	13.4	14.5	**12.3ab**
15.0 t ha^{-1}	6.3	9.6	9.3	10.9	**9.0a**	12.4	14.2	13.5	14.1	**13.5a**
N means	**5.78b***	**7.11b**	**9.06a**	**9.18a**		**8.52c**	**10.58b**	**11.15ab**	**12.55a**	

*Means followed by the same letters or no letters within columns or rows are not significantly different according to Duncan's Multiple Range Test at $P \leq 0.05$.

FYM - Farmyard Manure and N- Nitrogen.

[z]Trial1. African nightshade planted on 5th April 2009.

Trial 2. African nightshade planted on 20th July 2009.

4.7.6 Effects of Farmyard Manure and Nitrogen Levels on Spider Plant Total Fresh and Dry Yield

Total dry yield of the edible portion was statistically affected by manure levels in both trials. The highest (15 t ha^{-1}) level of farmyard manure produced significantly higher dry leaf yield of 15g/plant (1.0 t ha^{-1}) and 24 g/plant (1.5 t ha^{-1}) (Table 34 and 35). The average dry leaf yield of spider plant increased with an increase in the amount of nitrogen fertilizer applied. An increase in dry yield of 35% (0.8 t ha^{-1} vs 1.4 t ha^{-1}) in trial 1 and 21% (1.2 t ha^{-1} vs 1.6 t ha^{-1}) in trial 2 were observed on the effect of the highest level of nitrogen fertilizer compared to the control. Although there was a general increase in dry leaf yield of spider plant when subjected to different nitrogen levels, the higher (150 kg Nha^{-1} and 200 kg Nha^{-1}) and lower (100 kg Nha^{-1} and control) levels were not significantly different (Table 34 and 35). There was no interaction effect between farmyard manure and nitrogen levels in influencing spider plant total dry yield in both trials (Table 34 and 35).

Table 34. Effects of Farmyard Manure Levels and Nitrogen on Spider Plant Total Dry Leaf Yield (g/plant)

	Leaf Dry Yield (g/ plant)									
	Trial 1[z]					Trial 2				
	N Levels					N Levels				
FYM Levels	0 kg Nha^{-1}	100 kg Nha^{-1}	150 kg Nha^{-1}	200 kg Nha^{-1}	**FYM Levels**	0 kg Nha^{-1}	100 kg Nha^{-1}	150 kg Nha^{-1}	200 kg Nha^{-1}	**FYM Levels**
0 t ha^{-1}	9.6	9.5	15.9	15	**12.5c***	10.1	12.4	14.4	13.3	**12.6c**
7.5 t ha^{-1}	12.4	13.4	21.6	18.1	**16.4b**	13.9	17.1	17.2	22.7	**17.7b**
11.3 t ha^{-1}	10.3	14.8	18.6	17	**15.2b**	25.3	19.9	23.0	27.5	**22.4ab**
15.0 t ha^{-1}	13.5	19.2	20.5	21.3	**18.6a**	19.5	22.0	23.9	24.1	**23.9a**
N means	**11.48b***	**14.27b**	**19.19a**	**17.87a**		**17.25b**	**17.90b**	**19.66a**	**21.93a**	

Table 35. Effects of Farmyard Manure and Nitrogen Levels on Spider Plant Total Dry Leaf Yield (t ha^{-1})

	Leaf Dry Yield (tha^{-1})									
	Trial 1[z]					Trial 2				
	N Levels					N Levels				
FYM Levels	0 kg Nha^{-1}	100 kg Nha^{-1}	150 kg Nha^{-1}	200 kg Nha^{-1}	**FYM Levels**	0 kg Nha^{-1}	100 kg Nha^{-1}	150 kg Nha^{-1}	200 kg Nha^{-1}	**FYM Levels**
0 t ha^{-1}	0.6	0.6	1.1	1.0	**0.8c***	0.7	0.8	1.0	0.9	**0.8c**
7.5 t ha^{-1}	0.8	0.9	1.5	1.2	**1.1b**	0.9	1.2	1.2	1.6	**1.2b**
11.3 t ha^{-1}	0.7	1.0	1.3	1.2	**1.0b**	1.8	1.4	1.6	1.9	**1.5a**
15.0 t ha^{-1}	0.9	1.3	1.4	1.5	**1.3a**	1.3	1.5	1.7	1.7	**1.7ab**
N means	**0.82b***	**1.02b**	**1.27a**	**1.36a**		**1.22b**	**1.27b**	**1.39ab**	**1.55a**	

*Means followed by the same letters or no letters within columns or rows are not significantly different according to Duncan's Multiple Range Test at $P \leq 0.05$.

FYM - Farmyard Manure and N- Nitrogen.

[z]Trial1. African nightshade planted on 5th April 2009.

Trial 2. African nightshade planted on 20th July 2009.

4.7.7 Effects of Farmyard Manure and Nitrogen Levels on Spider Plant above Ground Biomass

The mean fresh biomass yield of spider plant was dependent on the farmyard manure applied in both trials (Figure 6). In the 1st trial, plants treated with 15 t ha^{-1} accumulated more fresh and dry above ground biomass over the rest of the treatment. An increase in fresh and dry biomass by 30% over the control in trial 1 was observed. Similarly, in the second trial, plants subjected to the highest level of manure yielded an increase of 54% (18.6 t ha^{-1} vs 40.7 t ha^{-1}) fresh biomass and 43% (1.7 t ha^{-1} vs 3.0 t ha^{-1}) dry biomass compared to the plots with no farmyard manure (Figure 6).

The effect of nitrogen fertilizer on both fresh and dry biomass was similar to that observed from the effect of manure in both trials. Increasing the levels of nitrogen fertilizer led to a general increase of spider plant biomass. Plants subjected to 200 kg Nha^{-1} enhanced production of fresh biomass by 42% and 23% in trial 1 and 2 compared to the control (Figure 6).

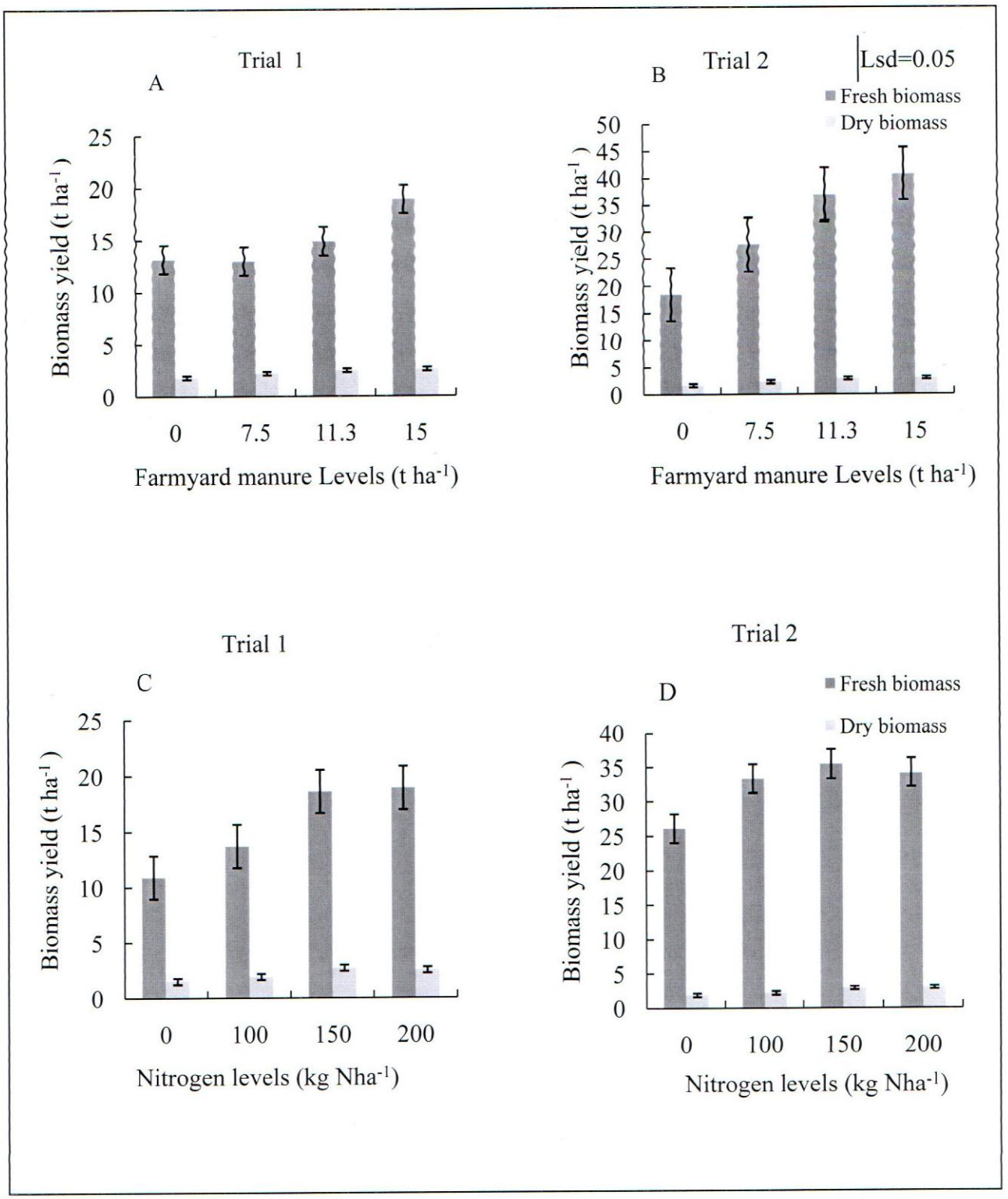


Figure 6. Effects of Farmyard Manure (A and B) and Nitrogen (C and D) Levels on Spider Plant Fresh and Dry above Ground Biomass (tha^{-1}).

4.7.8 Interaction Effects of Farmyard Manure and Nitrogen Levels on Spider Plants Fresh and Dry above Ground Biomass

There was noticeable interaction between farmyard manure and nitrogenous fertilizer on mean fresh and dry above ground biomass of spider plant in trial 2 of the experiment (Table 36). Plots that received combine application of 15 t ha^{-1} of farmyard manure and 200 kg Nha^{-1} of CAN fertilizer produced 62% increase in both fresh and dry biomass compared to the control in trial 2. Whereas in trial 1, the mean fresh and dry above ground biomass of all the treatments combination levels were not significantly influenced (Table 36).

Table 36. Effects of Interaction between Farmyard Manure and Nitrogen Levels on Spider Plant Fresh and Dry above Ground Biomass (tha^{-1})

		Biomass Yield (tha^{-1})			
		Trial 1[z]		Trial 2	
FYM Levels	N Levels	FB	DB	FB	DB
0 t ha^{-1}	0 kg Nha^{-1}	11.4*	1.4	13.4c	1.2d
	100 kg Nha^{-1}	10.6	1.3	24.5abc	1.7cd
	150 kg Nha^{-1}	16.0	2.6	16.7c	2.1bcd
	200 kg Nha^{-1}	14.7	2.1	20.2bc	1.9bcd
7.5 t ha^{-1}	0 kg Nha^{-1}	10.4	1.7	20.5bc	1.8bcd
	100 kg Nha^{-1}	11.8	1.6	33.4abc	1.9bcd
	150 kg Nha^{-1}	22.4	2.9	23.6abc	2.5abcd
	200 kg Nha^{-1}	20.5	2.4	32.8abc	3.0abc
11.3 t ha^{-1}	0 kg Nha^{-1}	10.1	1.3	32.8abc	2.4abcd
	100 kg Nha^{-1}	12.4	2.1	29.7abc	2.4abcd
	150 kg Nha^{-1}	16.0	2.4	37.7abc	3.1ab
	200 kg Nha^{-1}	17.2	2.5	48.0a	3.7a
15.0 t ha^{-1}	0 kg Nha^{-1}	11.5	1.6	37.7abc	2.0bcd
	100 kg Nha^{-1}	20.1	2.6	45.8ab	2.6abcd
	150 kg Nha^{-1}	19.9	3.0	43.7ab	3.7a
	200 kg Nha^{-1}	23.1	3.0	35.5abc	3.5a

*Means followed by the same letters or no letters within columns are not significantly different according to Duncan's Multiple Range Test at $P \leq 0.05$.

FYM - Farmyard Manure, N- Nitrogen, FB- Fresh Biomass and DB- Dry Biomass.

[z]Trial1. African nightshade planted on 5th April 2009.

Trial 2. African nightshade planted on 20th July 2009.

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4.8 Effects of Farmyard Manure and Nitrogen Levels on Spider Plant Leaf Chlorophyll Content

a) Effects of Farmyard Manure and Nitrogen Levels on Spider Plant Leaf Chlorophyll Content

Manure levels affected leaf chlorophyll content of spider plant differently in both trials (Table 37). For instance, between 70 and 90 DAP in both trials, farmyard manure levels influenced leaf chlorophyll content apart from 50 to 60 DAP which was not affected by varying rates of manure. Increase in chlorophyll content by between 16 - 35% compared to the control was observed on plants that were subjected to 15 t ha^{-1} of farmyard manure in all significant sessions of data collection. The nitrogen fertilizer behaved similarly as manure in both trials in influencing leaf chlorophyll content. When compared against individual level of nitrogen fertilizer, the chlorophyll content from plants subjected to 150 and 200 kg Nha^{-1} levels were not statistically different compared to 100 kg Nha^{-1} and the control (Table 37).

Table 37. Effects of Farmyard Manure and Nitrogen Levels on Spider Plant Leaf Chlorophyll Content

	Chlorophyll Content (SPAD Readings)									
	Trial 1[z]					Trial 2				
	Days after Planting (DAP)									
	50	60	70	80	90	50	60	70	80	90
FYM Levels										
0 t ha^{-1}	30.4*	38.2	31.5b	28.0c	29.9b	26.3	39.6	33.0c	30.3b	25.2c
7.5 t ha^{-1}	34.9	45.8	39.2ab	37.5b	30.8b	32.5	41.0	42.3b	33.3ab	29.7b
11.3 t ha^{-1}	31.8	39.2	45.4a	39.3ab	37.2ab	31.6	43.8	45.8ab	36.4ab	32.9ab
15.0 t ha^{-1}	37.2	48.0	46.3a	43.5a	39.0a	33.9	46.1	48.7a	40.1a	36.0a
N Levels										
0 kg Nha^{-1}	28.1b*	33.2b	29.6c	31.6b	28.2c	26.0b	33.5b	34.1c	27.6c	22.3c
100 kg Nha^{-1}	28.8b	37.8b	39.6b	37.3a	33.0b	27.4b	37.0b	40.7b	33.6b	28.9b
150 kg Nha^{-1}	39.4a	48.5a	45.0ab	39.4a	37.0ab	34.8a	48.3a	48.9a	38.2ab	35.3a
200 kg Nha^{-1}	40.0a	49.7a	48.2a	40.0a	38.8a	36.1a	47.6a	46.5a	40.7a	37.4a

*Means followed by the same letters or no letters within a column of either farmyard manure or nitrogen levels are not significantly different according to Duncan's Multiple Range Test at $P \leq 0.05$.

FYM - Farmyard Manure and N- Nitrogen.

[z]Trial1. African nightshade planted on 5th April 2009.

Trial 2. African nightshade planted on 20th July 2009.

b) Interaction Effects of Farmyard Manure and Nitrogen Levels on Spider Plant Leaf Chlorophyll Content

A combined application of farmyard manure and nitrogen fertilizer levels inconsistently influenced the leaf chlorophyll content of spider plant (Table 38). For instance, the treatments combination levels at 50 and 90 DAP significantly influenced spider plants leaf chlorophyll content in trial 1 while in trial 2, significant interaction were observed only at 90 DAP. Plants that were subjected to higher combination 15 t ha^{-1} of farmyard manure and 200 kg Nha^{-1} from CAN fertilizer had leaf chlorophyll content higher by between 25% to 56% compared to the control treatment. At 70 to 80 DAP there were no interaction effect on leaf chlorophyll content in trial1 (Table 38).

Table 38. Interaction Effects of Farmyard Manure and Nitrogen Levels on Spider Plant Leaf Chlorophyll Content

		Chlorophyll Content (SPAD Readings)									
		Trial 1[z]					Trial 2				
		Days after Planting (DAP)									
FYM Levels	N Levels	50	60	70	80	90	50	60	70	80	90
0 t ha^{-1}	0 kg Nha^{-1}	31.9abc*	32.1	23.4	24.1	24.4c	22.6	28.3	24.7	23.8	18.0f
	100 kg Nha^{-1}	31.5c	28.1	34.5	31.6	30.0abc	21.5	28.4	33.9	31.8	25.1d
	150 kg Nha^{-1}	41.0a	42.0	36.8	32.2	31.2abc	31.7	43.9	36.4	27.4	23.6d
	200 kg Nha^{-1}	33.4abc	42.7	37.5	24.0	34.1abc	28.9	42.1	37.2	38.3	33.9abc
7.5 t ha^{-1}	0 kg Nha^{-1}	27.9abc	35.2	37.5	34.4	30.3abc	27.6	36.9	37.6	26.3	22.3ef
	100 kg Nha^{-1}	34.0abc	41.4	35.4	39.8	33.0abc	32.5	41.4	39.4	34.5	30.8bcd
	150 kg Nha^{-1}	38.4abc	54.6	44.6	37.1	31.7abc	35.8	50.9	46.4	37.0	33.9abc
	200 kg Nha^{-1}	39.2abc	52.0	45.2	38.8	28.1c	34.0	46.2	46.0	35.5	31.9abc
11.3 t ha^{-1}	0 kg Nha^{-1}	23.2abc	29.1	35.6	33.1	29.1bc	25.6	33.6	33.3	28.3	21.8ef
	100 kg Nha^{-1}	35.3c	38.6	45.7	36.7	33.9abc	25.6	32.5	43.9	33.1	30.0bcd
	150 kg Nha^{-1}	40.0abc	47.6	54.3	40.8	39.2abc	35.4	47.0	58.1	41.3	37.4abc
	200 kg Nha^{-1}	42.2a	51.5	51.0	46.6	46.6abc	39.9	50.7	48.1	43.1	42.6ab
15.0 t ha^{-1}	0 kg Nha^{-1}	27.4abc	36.4	32.8	34.8	29.1bc	28.1	35.5	40.9	32.3	27.3cd
	100 kg Nha^{-1}	37.7abc	53.3	42.8	41.0	34.9abc	30.1	46.2	44.5	35.1	29.5bcd
	150 kg Nha^{-1}	40.7abc	49.8	57.2	50.0	46.0ab	36.1	51.5	54.9	47.2	46.3a
	200 kg Nha^{-1}	42.8a	52.6	52.2	48.2	46.2ab	41.4	51.3	54.7	45.9	41.1abc

*Means followed by the same letters or no letters within columns are not significantly different according to Duncan's Multiple Range Test at $P \leq 0.05$.

FYM - Farmyard Manure and N- Nitrogen.

[z]Trial1. African nightshade planted on 5th April 2009.

Trial 2. African nightshade planted on 20th July 2009.

4.9 Effects of Farmyard Manure and Nitrogen Levels on Spider Plant Leaf Stomatal Conductance

a) Effects of Farmyard Manure and Nitrogen Levels on Spider plant Leaf Stomatal Conductance

The influence of farmyard manure on stomatal conductance varied in both trials except at 50 DAP. Plants that were treated with 15 t ha^{-1} of farmyard manure performed similar to the control in influencing leaf stomatal conductance while plants that were subjected to 7.5 t ha^{-1} increased leaf stomatal conductance by between 6% - 24% compare to the control treatment (Figure 7).

There was no influence of nitrogen levels on spider plant average leaf stomatal conductance at only 50 and 70 DAP in the first and second trial respectively. However, with the increase of nitrogen level, it generally led to increase in the leaf stomatal conductance in all intervals of data collection. Greater leaves stomatal conductance of 498 mmol/m^{-2}s was realized at 70 DAP in trial 1 which was higher by 7% when evaluated against the control (Figure 7).

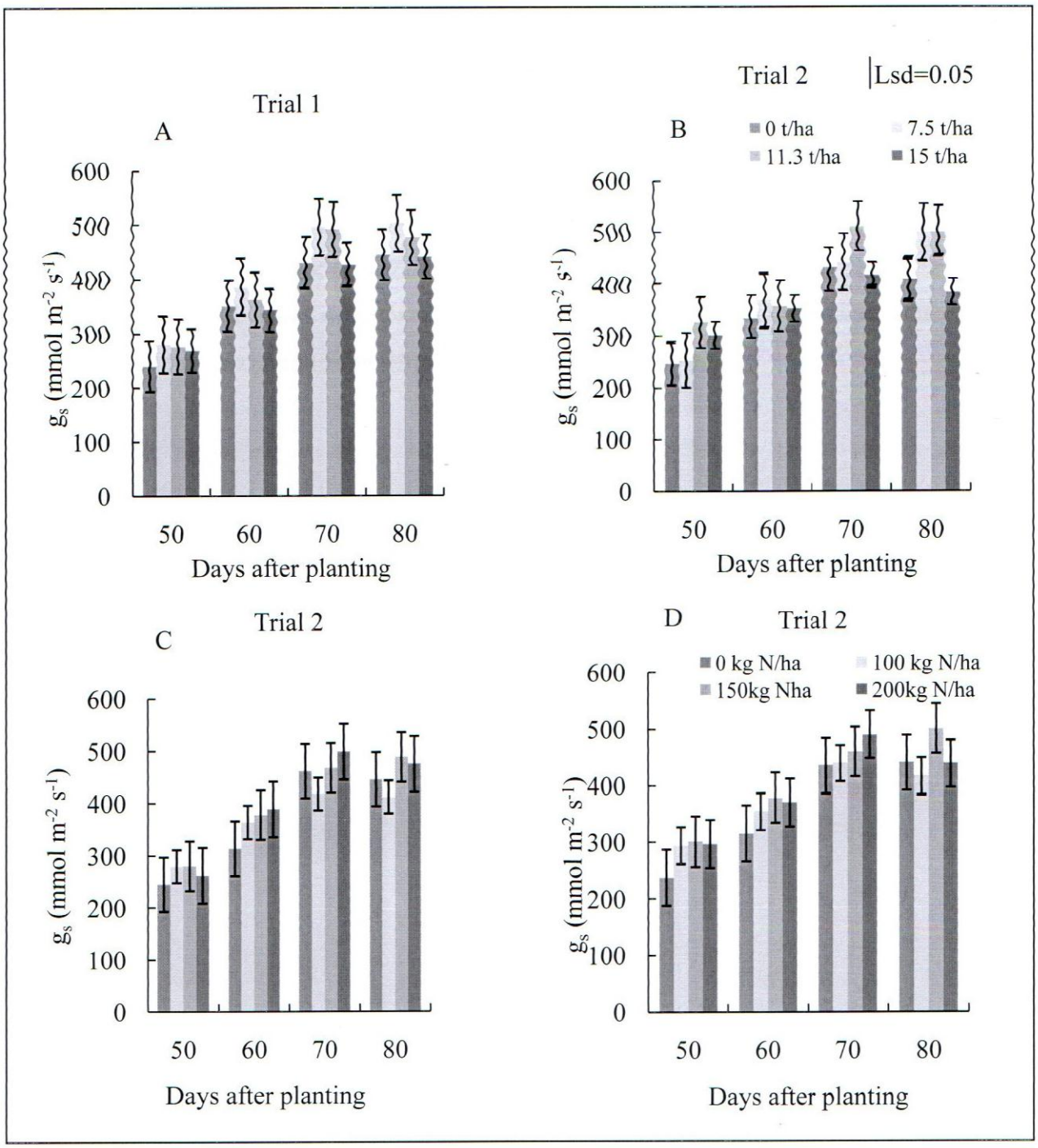


Figure 7. Effects of Farmyard Manure (A and B) and Nitrogen (C and D) Levels on Spider Plant Leaf Stomatal Conductance (mmol $m^{-2}s^{-1}$).

b) Interaction Effects of Farmyard Manure and Nitrogen Levels on Spider Plant Leaf Stomatal Conductance

There were no observable stomatal conductance changes that could be attributed to interactions between farmyard manure and nitrogen fertilizer levels (Table 39). However, plants that were subjected to the highest levels of the combinations (15 t ha^{-1} of farmyard manure and 200 kg Nha^{-1}) increased leaf stomatal conductance by 27% compared to the control treatment. With the increase in time of growth, there was a general increase in mean leaf stomatal conductance of spider plant (Table 39).

Table 39. Interaction Effects of Farmyard Manure and Nitrogen Levels on Spider Plant Leaf Stomatal Conductance (mmol $m^{-2}s^{-1}$)

		Stomatal Conductance (mmol $m^{-2}s^{-1}$)							
		Trial 1[z]				Trial 2			
		Days after Planting (DAP)							
FYM Levels	N Levels	50	60	70	80	50	60	70	80
0 t ha^{-1}	0 kg Nha^{-1}	218.6*	327.1	433.2bcd	443.1	191.2	286.2ab	410.7	401.3
	100 kg Nha^{-1}	235.8	403.1	387.1d	374.8	282.6	410.1ab	434.2	390.3
	150 kg Nha^{-1}	293.1	331.9	384.6d	433.5	258.7	330.8b	389.3	408.7
	200 kg Nha^{-1}	214.2	343.0	520.1ab	527.2	255.2	317.8ab	565.7	435.2
7.5 t ha^{-1}	0 kg Nha^{-1}	254.1	377.1	514.6abc	527.6	216.6	377.5ab	443.4	508.7
	100 kg Nha^{-1}	260.5	344.0	439.3bcd	447.0	203.8	338.8ab	463.7	454.7
	150 kg Nha^{-1}	321.6	422.1	496.9abc	517.9	316.4	431.6ab	444.0	544.3
	200 kg Nha^{-1}	285.9	402.9	532.1abc	517.2	280.5	326.9ab	422.0	492.0
11.3 t ha^{-1}	0 kg Nha^{-1}	233.6	261.5	459.1abc	464.7	261.3	254.5ab	478.9	465.8
	100 kg Nha^{-1}	310.2	337.9	443.7bcd	431.8	360.7	335.0a	462.7	432.8
	150 kg Nha^{-1}	255.1	414.3	567.2a	531.8	354.6	406.0ab	578.8	610.3
	200 kg Nha^{-1}	308.2	435.6	496.1abc	476.4	327.3	437.1ab	523.7	495.7
15.0 t ha^{-1}	0 kg Nha^{-1}	273.3	288.2	439.3bcd	345.6	281.6	339.7ab	406.7	385.8
	100 kg Nha^{-1}	312.3	369.1	399.3cd	391.5	328.7	330.4ab	396.5	387.8
	150 kg Nha^{-1}	250.9	343.4	422.8bcd	470.2	273.1	343.4a	426.2	440.8
	200 kg Nha^{-1}	239.4	372.5	447.1bcd	378.6	323.4	395.0ab	448.7	331.3

*Means followed by the same letters or no letters within columns are not significantly different according to Duncan's Multiple Range Test at $P \leq 0.05$.

FYM - Farmyard Manure and N- Nitrogen.

[z]Trial1. African nightshade planted on 5th April 2009.

Trial 2. African nightshade planted on 20th July 2009.

CHAPTER FIVE

DISCUSSION

5.1 Selected Nutrients Properties of Soil and Plant Tissues

5.1.1 Effects of Farmyard manure and Nitrogen Levels on Selected Nutrients in the Soils Grown with African Nightshade

In this research, the effect of farmyard manure affected the retention of nitrogen and potassium in the soil. This is shown by the fact that the control had the lowest content of total nitrogen and potassium by 60% and 12% respectively compared to the highest level 15 t ha^{-1} of farmyard manure. The initial soil nitrogen (0.21%) and potassium (0.12%) was generally higher by between 23%-52% and 35%-42% respectively compared to their concentration at end of the experiments in all plots. This is could be attributed to the efficient absorption of nutrients by African nightshade as well as extensive leaching process due to continuous irrigation during the period of plant growth. Nitrogenous fertilizer had the same effect as manure in influencing the retention of nitrogen and potassium in the soil. However, plots that received higher levels of treatments retained more of these major elements than the control. This could be possible that manure might have aided moisture retention leading the eventual retention of more nutrients than the lower levels. Similar results were reported by Abou *et al.* 2006 who noted that organic fertilizers help in retaining plant mineral nutrients in the soil throughout its active groups (flavonic and humic acids) which have the ability to retain the metals in complex and chelate forms.

5.1.2 Effects of Farmyard Manure and Nitrogen Levels on Selected Leaf Chemical Nutrients of African Nightshade

Farmyard manure fertilizer application increased accumulation of mineral elements in African nightshade plant leaves. Plants that were subjected to higher levels of farmyard manure levels had more quantities of nitrogen (18%), phosphorus (9%), potassium (21%), calcium (24%) and magnesium (9%) compared to the control. Plants subjected to maximum nitrogen fertilizer level influenced the concentrations of nitrogen (13%), phosphorus (20%), potassium (15%), calcium (8%) and magnesium (6%) compared to the control. This signifies that enhancement of soil nutrition by increasing levels of manure increases the absorption and accumulation of mineral elements by the plant. These could be attributed to farmyard manure superiority in elemental values with the high availability of macro (high content of N, P and K) and micro

elements needed for good plant growth, higher yield and consequently better quality (Nevens and Reheul, 2003). However, the reduced effect of inorganic nitrogen than farmyard manure in influencing the concentration of selected chemical elements in the African nightshade leaf tissues may be attributed to their loss through the processes leaching, denitrification as well as volatilization.

There was significant interaction between farmyard manure and nitrogen in influencing nitrogen, phosphorus and magnesium. Plants that received higher combination of the nitrogen sources were superior in accumulating mineral (N, P and Mg) elements than the control. This is attributed to efficient absorption of nutrients by the plant due to improved root systems enabled by farmyard manure with the presence of readily available inorganic nitrogen. However, the applied farmyard manure along with nitrogenous fertilizers slowly releases nutrients and also prevents the losses of inorganic fertilizers through denitrification, volatilization and leaching by binding the nutrients and releasing with the passage of time. Enriched compost + 50% recommended nitrogen phosphorus and potassium fertilizer in radish crop also significantly increased the nitrogen concentrations as compared with untreated control (Asghar *et al.,* 2006).

The use of nitrogenous fertilizers in production of leafy vegetables leads to accumulation of nitrates beyond safe limits which have been shown to be detrimental to human health (Anjana *et al.,* 2007). The toxic effects of nitrate are due to its endogenous conversion to nitrite, which is implicated in the occurrence of methaemoglobinaemia, gastric cancer and many other diseases (Prakasa and Puttanna 2000). Incidence of methaemoglobinaemia, earlier believed to have been confined to infants only, has been reported in all age groups with high nitrate ingestion, with infants and above 45 years age groups being most susceptible to nitrate toxicity (Gupta *et al.*, 2000). The acceptable daily intake of nitrate of 3.7 mg/kg has been reported by FAO (2003).

5.1.3 Effects of Farmyard manure and Nitrogen Levels on Selected Nutrients in the Soils Grown with Spider Plant

Residual nitrogen, phosphorus and potassium were affected by farmyard manure and nitrogen application. Plots that were treated with increased levels of fertilizers had high nutrient retention than for lower rates. The quantities of the retained nutrients were less than that of initial soil analysis before the start of the experiment. This shows that more nutrients were absorbed by the plant apart from what leached as a result of continuous irrigation during the period of experiment. There were no interaction effects in the retention of macro-elements (NPK).

5.1.4 Effects of Farmyard manure and Nitrogen Levels on Selected Leaf Nutrients of Spider Plant

Increase in the level of either farmyard manure or inorganic nitrogen increased nitrogen, potassium and magnesium uptake to the leaf tissues. These results are in agreement with Olaniyi, (2008) who reported an increase in the chemical composition of lettuce (*Lactuca sativa*) plants due affected organic manure. In general, each increase in organic manure and inorganic fertilizers dosages resulted in an increase in leaf mineral elements contents, but the differences in some cases (P, Ca and Mg) were found to be non-significant. Plants subjected to 15 t ha^{-1} of farmyard manure accumulated higher nutrients (N - 1.8%, K - 807.2 mg /100g dry sample, Mg - 304.9 mg/100g dry sample) than the control (N -2.6%, K - 405.6 mg /100g dry sample, Mg - 283.1 mg/100g dry sample). However, plants subjected to higher nitrogen fertilizer (200 kg N ha^{-1}) accumulated 1.7% N, 738 mg/100g K and 325 mg/100g Mg in their leaf tissues than the control (N - 1.3%, K- 602 mg/100g dry sample, Mg - 296 mg/100g dry sample) all of which were within daily recommended dietary allowance (RDA) for minerals FAO (1988). These could be attributed to the ability of organic manure to supply nutrients throughout mineralization and improvement the physical (soil structure, aeration and water retention capacity) and chemical properties of the soil and the ability of organic fertilizer to release nutrients gradually throughout the growing season (Ouda and Mahadeen, 2008). In addition, Tisdale *et al.* 1985 reported that when plants are nourished with high levels of nitrates (NO_3^-), there is an increase in organic anions synthesis within the plant coupled with corresponding increase in the accumulation of inorganic cations (Ca, Mg and K).

The combination of higher levels of nitrogen with either of farmyard manure level led to increase in accumulation of leaf total nitrogen. This shows that increase in the application of inorganic nitrogen together with farmyard manure enhances spider plants absorption of greater amounts of nutrient elements (N, K and Mg). Leaf nitrogen content was increased by the application of manure and inorganic fertilizer by 38% compared to the control. A higher value of leaf N content could be attributed to the ability of organic manure to supply nutrients throughout mineralization and improvement of the physical and chemical properties of the soil. This is consistent with the report by Ouda and Mahadeen (2008) that interaction between different inorganic and organic manure on broccoli varieties had a significant effect on N and K% leaf contents.

5.2 African Nightshade

5.2.1 Effects of Farmyard Manure and Nitrogen Levels on Growth of African Nightshade

Nitrogen is the most important constituent of plant proteins and is required throughout crop growth cycle (Madan and Munjal, 2009). Organic manures are known to have the ability of supplying both the required macro and micro plant nutrients but in low quantities and usually not early enough for quick utilization. Enriching highly decomposed farmyard manure combats the deficiency of early to late and low supply of nutrients (Ayoola and Makinde, 2007). In this study, increase of farmyard manure levels resulted in significant increase on plant height, number of leaves, and number of branches, internodes length, leaf area leaf area index and total above ground biomass. This is attributed to the advantage of organic manure being able to improve the soil structure, water holding capacity, aeration and slow nutrient release which might have influenced root development and nutrient absorption leading to higher growth rate of *Solanum scabrum* (Abou *et al.*, 2005). Similarly, the growth attributes (plant height, number of leaves, number of branches, internodes length, leaf area and leaf area index) of African nightshade that was observed in the second trial is an indication that the added farmyard manure, which had been applied to the field 2 weeks before planting, was available to the plants. The present results are in agreement with those recorded of Merinyo, (1996) who showed that the rate of nitrogen application of both farmyard manure and nitrogen (CAN) influenced shoot production of *Solanum nigrum* L. In addition, Abou *et al.* (2006) reported greatest plant height and number of leaves on broccoli when they were treated with organic manure in form of 100% cattle manure. Kipkosgei *et al.* (2003) reported an increased vegetative attributes of *Solanum villosum* L. with increasing levels of farmyard manure and inorganic nitrogen (CAN). However, he noted that farmyard manure was generally more effective than nitrogenous fertilizer in influencing the growth of *Solanum villosum*.

Generally, the results indicated that plants that received no fertilizer had inferior growth characteristics compared to those treated with nitrogen from either manure or fertilizers. The results are in agreement with those reported by Kipkosgei *et al.* (2003) and Abukutsa and Karimi (2007). Ondieki, (2009) found out that African nightshades plants subjected to low levels or no fortified manure exhibited poor growth rate associated with nitrogen deficiency.

Previous studies have proved that treating crops like eggplant, tomato and potato with animals manure exhibits high vegetative growth characteristics than without. For instance, Abd El-Rahman and Hosny (2001) pointed out that application of chicken and cattle manures significantly increased vegetative growth characters of eggplant, i.e., plant height, number of leaves and leaf area over control. On tomato and potato crops, vegetative growth characteristics like plant height, number of stems, number of tubers, fresh and dry yield of whole plants were increased as a result of applying chicken manure, compost and chicken manure combined with bio-fertilizer (El-Banna *et al.*, 2001; El-Tantawy , 2009). This was attributed to organic manure ability to enhance physical, chemical and biological properties of the soil as well as through its effect as a source of essential nutrients (El-Nagar, 1996).

In this research, the application of organic and inorganic nitrogen from either single or combined source led to improvement of growth parameters (plant height, number of leaves, number of branches, internodes length, and leaf area index) parameter of *Solanum scabrum*. The results are in agreement with those of Kipkosgei *et al.* (2003) who reported an increased growth attributes of *Solanum villosum* upon application of various concentrations of farmyard manure and inorganic N fertilizer (C.A.N). The increased growth were attributed to the presence of readily available inorganic nitrogen inform of Nitrates (NO_3^-) together with the merits associated with organic fertilizers (improvement of the soil structure, water holding capacity, aeration and slow nutrient release) resulting in improved plant growth vigor.

5.2.2 Effects of Farmyard Manure and Nitrogen Levels on African Nightshade Fresh Leaf and Dry Yield

African nightshade leaf yield was influenced by farmyard manure levels applied in both trials of the experiments. Leaf fresh and dry yields obtained from farmyard manure levels (7.5 to 15 t ha^{-1}) were not statistically different and hence can be stated that farmyard manure above 7.5 t ha^{-1} may not increase African nightshade fresh yield to reach a significant level. The same trends were observed on the above ground biomass. The observation could be attributed to possible significant improvement of African nightshades rooting system and hence higher rate of nutrient absorption. This is consistent with previous reports on strawberry, where Mohamed and Gabr (2002) found that application of chicken manure significantly increased most growth parameters including number of leaves, shoot, fresh and dry yields of plant.

The total fresh yields of 13.7 and 13.8 t ha^{-1} were obtained from plants subjected to 150 and 200 kg Nha^{-1} respectively. However these yields were not significantly different hence showing a declining production trend. It is possible that application of excess N resulted in osmotic imbalances due to luxury nitrogen uptake (nitrogen accumulation) in plant tissues leading to toxic effects of nitrates on the plant (Abukutsa and Karimi, 2007). The decline could also be attributed to the process of leaching of inorganic nitrogen from the soil as a result of continued irrigation and hence plants could not utilize them to the mark expected. Similar findings were observed by Van Averbeke *et al.* 2007 who reported an increased total fresh and oven dry above-ground biomass of *Solanum retroflexum* with increased nitrogen application levels of up to until the rate of 150 kg Nha^{-1}. At an application level of 200 kg Nha^{-1}, both fresh and oven-dry biomasses were practically identical to those at 150 kg Nha^{-1}. These proved that with increase in nitrogen fertilizer, there is an increase in fresh and dry leaf yield up to a point of stagnation (Abukutsa and Karimi, 2007).

The optimum application level of nitrogen fertilizer identified for *Solanum scabrum* in this research is 150 kg Nha^{-1} from CAN which is equal to the optimum rate reported by Merinyo (1996) and lower by 25% compared to 200 kg Nha^{-1} as reported by Chweya (1997) on *Solanum nigrum* L. In addition, 7.5 tha^{-1} of farmyard manure was optimal which is less by 25% to that recommended by Merinyo (1996). The results of this study suggest that optimizing soil nitrogen availability is the most critical nutrient management tool in the production of leafy vegetables. Nevertheless, lower yields were recorded on control plants at 7.9 t ha^{-1} and 8.2 t ha^{-1} in the first and second trials respectively. These results are in line with those of Masinde *et al.* (2009) who reported that African nightshade (*Solanum Villosum*) plants respond to nitrogen deficiency by reduction of leaf area and consequently fresh and dry matter production.

In this research, the effect of combined application of inorganic nitrogen and farmyard manure fertilizer levels did not influence fresh and dry yields after 80 DAP in the second trial. The significant interactions were observed at 80 DAP in trial 1 and from 50 to 70 DAP in the second trial. It is possible that significantly higher interaction which leads to higher yield occurs between manure and nitrogen fertilizer applied at higher levels. However, the interaction effect is only observed at early stages of growth (50-80 DAP) which could be attributed to the presence of sufficient nutrients early in the season which could be used by the plant before they are leached or absorbed by the plant due to luxury absorption of nitrogen. The nitrogenous fertilizer

simply provides a starter boost of nitrogen inform of nitrates to the plants while farmyard manure provides not only organic N but also improves the physical condition of the soil, provides energy for microorganisms activity, increases nutrient supply and efficiency of macro-elements as well as its ability to meet some micro-nutrient requirements (Kolbe *et al.*, 1995).

In this research, there was a general increase in successive harvests from 50 to 80 DAP, and then it started to decline. These results are not true for Kipkosgei *et al.*, (2003) who reported high leaf yields in the first harvest followed by a decline in consecutive harvests. The steady decline in fresh leaf harvests after 80 DAP could be due a decline in photosynthetic leaf area caused by defoliation, plant aging and reduction of nitrogen fertilizer in the soil caused by leaching as a result of irrigation. This indicates that *Solanum scabrum* could be one of the most promising high yielding vegetable if continued nutrients application is administered.

Plants grown during the second trial were generally better than those of first trial in terms of growth and ultimate yield. This could be attributed low temperatures (Figure 1) in the first trial when the crop was tending towards optimum growth which reduced not only root growth rate but also nutrient and water absorption due to higher viscosity and lower metabolic activity of the root tissue (Abdelhafeez *et al.*, 1991). It follows that plants were not be able to meet their fast increasing transpiration demands and a temporarily physiological water deficit occurred. This led to both a reduction in the transpiring surface (leaf area) and stomatal conductance and hence decline in photosynthesis (Chu and Toop, 1995). In the second trial, temperatures ascended and remained higher hence encouraging increase in transpiration, nutrient uptake, stomatal conductance and chlorophyll leading to increased photosynthetic rate (Abdel-Mawgoud, 2002) which led to increase in all growth parameters (plant height, number of leaves, number of branches, internodes length and leaf area leaf area index) and yield than in the first trial. This is in agreement findings reported by Abdelhafeez *et al.* (1991) who concluded that water uptake increases very rapidly with increase in temperatures.

5.2.3 Effects of Farmyard Manure and Nitrogen Levels on African Nightshade Leaf Chlorophyll Content

Generally farmyard manure levels except the control had influence on African nightshade leaf chlorophyll content as determined by use of SPAD (Chlorophyll Meter). It was observed that at 7.5 t ha^{-1} of farmyard manure had high chlorophyll content recorded, although they were virtually identical with those of 11.3 and 15 t ha^{-1}. This could be attributed to availability and

efficient nitrogen uptake by the plants which were released into the soil through the process of mineralization.

However, chlorophyll concentration of leaves is affected by nitrogen status of the plant which is predetermined by its availability in the soil (Alena *et al.*, 2005; Amujoyegbe *et al.*, 2007). In this study, leaf chlorophyll content of African nightshade in all the succeeding measurements were influenced by nitrogen application levels. Leaf chlorophyll readings increased with increasing nitrogen rate applied as well as time of growth till there was a reduction. The decline can be attributed to diminishing levels of nitrogen in the soil due continuous utilization and subsequent senescence of the plant. These result are consistent with those of Semiha (2009) who reported a significant linear relationship between leaf chlorophyll and nitrogen fertilizer applied (R^2=0.91) on potato (*Solanum tuberosum* L.).

Leaf chlorophyll content for plants that were subjected to 150 kg Nha^{-1} and 200 kg Nha^{-1} were highest though not distinctively different. It is possible that sufficient nitrogen was available to develop the site of photosynthesis thereby increasing growth and yield of *Solanum scabrum* more than control. In addition, a nitrogen level of 150 kg Nha^{-1} was optimum and hence addition of 200 kg Nha^{-1} did not lead to further uptake by plant to bring any significance on leaf chlorophyll content. Semiha (2009) and Gholizasedeh *et al.* (2009) reported linear relationship between leaf chlorophyll and nitrogen applied and subsequent increase in yield and yield related parameters of potato cultivars (*Solanum tuberosum* L).

The effect of interaction between farmyard manure and nitrogen were observed from 80 and 90th DAP in the 1st trial while in the 2nd trial, interaction effects was observed between 50-90 DAP. The results show that increase in farmyard manure level with either level of nitrogenous fertilizer, leads to an increase in leaf chlorophyll content. These results might be due to enhanced nutrient uptake by plants as a result of complementary nutrient application. This is consistent with the previous reports on combined use of rye straw and nitrogen which resulted in higher yields of tomato, eggplant and pepper than either nitrogen fertilizer or farmyard manure used alone (Jablonska,1990). Hosmani (1993) also reported higher yields of chili with integrated use of chemical and organic fertilizers than with the use of either of these separately. Lower levels of the two sources of nutrient resulted in less chlorophyll content.

5.2.4 Effects of Farmyard Manure and Nitrogen Levels on African Nightshade Leaf Stomatal Conductance

The two sources of nitrogen levels varied in influencing leaf stomata stomatal conductance across the two experimental trials. The highest and lowest combination of treatments levels showed a decrease in stomatal conductance while the combination of 7.5 and 11.3 $t\ ha^{-1}$ of farmyard manure gave greater stomatal conductance. This signifies that deficiency and excess nitrogen in the soil reduce the leaf gaseous exchange and hence curtailing the process of photosynthesis (Karanatsidis and Berova, 2009). The increase in stomatal conductance in the other treatments may be attributed to proper root development which enhances water and nitrogen use efficiency by the plant. This leads to increase in the rate of gaseous exchange and photosynthesis and hence an eventual increase of growth and yield of the plants (Suhash *et al.*, 2000).

5.3 Spider Plant

5.3.1 Effects of Farmyard Manure and Nitrogen Levels on Growth of Spider Plant

Response of various growths attributes (plant height, number of leaves, number of branches, internodes length and leaf area leaf area index) measured depended on farmyard manure and inorganic nitrogen fertilizer levels applied. Plants that received low levels of treatments exhibited reduced growth and early flowering hence limiting the production of more leaves. This could be attributed to depletion of soil nutrients. Plants that received little or no nutrients were stunted in growth and pale in colour compared to healthy plants from higher levels of nitrogen fertilizers (Mauyo *et al.*, 2008).

Plants with increased nitrogen fertilizer showed an increase of plant height, leaf numbers, shoot number, internodes length, leaf area and leaf area index compared to the control. Significant increases in leaf area index of 86% and 60% from plants that received higher levels of farmyard manure and inorganic nitrogen in trial 1 and 2 compared to the control was plausible. The same results were observed by Oliniyi (2008) who reported an increased plant height, number of leaves and internodes length of amaranth varieties when applied with increasing nitrogen rates from 0 - 60 kg Nha^{-1}. Similar findings were reported by Mauyo *et al.* (2008) when he subjected spider plant to nitrogen levels without farmyard manure. In addition, nitrogen deficiency limits the production of protein and chlorophyll molecules which are essential for production of new cells, thus reducing their growth (Abukutsa and Karimi, 2007).

The results from this study revealed that interaction between farmyard manure and inorganic nitrogen significantly affected number of leaves, number of branches, internodes length and leave area index. The growth attributes were higher for plants which received higher amount of combined farmyard manure and nitrogen fertilizer. The results are in conformity with those of Kipkosgei *et al.*, (2003) who reported that increase of farmyard manure and inorganic fertilizer incorporation into the soil boosts the general growth characteristics of *Solanum villosum*. The increase in growth resulting from organic fertilizer may be attributed to possible enhanced soil aggregation, soil aeration and increasing water holding capacity and offers good root growth environmental conditions and efficient absorption while inorganic nitrogen supplied starter boost of nitrogen to the spider plants (Hosmani, 1993). In addition, farmyard manure being rich in macro and micro nutrients enhanced vegetative growth. The results are in line with those of Abou *et al.* (2006) who noted an increase in growth parameters of broccoli under complementary application of poultry manure and nitrogenous fertilizer. Makinde, 2007 reported enhanced growth in height and leaf area of maize under integrated nutrients application than insole application.

5.3.2 Effects Farmyard Manure and Nitrogen Levels on Spider Plant Fresh Leaf and Dry Yield

The effect of farmyard manure and nitrogen levels on spider plant signify that there was an increase in fresh and dry leaf yield with increasing fertilizer levels from 50-100 DAP. In addition, above ground biomass was observed to increase with increasing levels of both farmyard manure and nitrogenous fertilizer. This is attributed to increased plant nutrient uptake with increasing level of fertilization. The control had lowest yield due to a possible depletion of nutrients levels in the soil. Yield from trial 1 was more superior than trial 2 because of cold weather experienced later in the 1st trial. Farmyard manure applied at 15 t ha^{-1} resulted in fresh yield of 9.0 and 13.5 t ha^{-1} in the 1st and 2nd trial while inorganic nitrogen applied at 200 kg Nha^{-1} resulted in 9.8 and 12.5 tha^{-1} respectively. These results show that farmyard manure is generally more effective than inorganic nitrogen in influencing yield of spider plant, and they are consistent with those of Kipkosgei *et al.* (2003) who reported that farmyard manure on *Solanum villosum* is superior to nitrogenous fertilizer.

Frequent leaf harvesting also could have led to increased partitioning of photosynthates to formation of young shoots and subsequent production of leaves. Frequent leaf harvesting has

been shown to affect photosynthates distribution with more partitioned to growing shoots than the main stem and primary branches (Frankow-Lindberg, 1997). In this crop, plant height is curtailed and shoot numbers is increased with harvesting.

In this study, integrated use of farmyard manure and inorganic fertilizers improved growth and ultimate yield of spider plant. These can be an approach for sustainable production of crops. Plants that were subjected to a higher combination of farmyard manure and inorganic nitrogen yielded between 47% to 60% fresh yield at different harvesting intervals compared to the control. However there was no significant interaction on total fresh leaf and dry yield. The increase in yield could be attributed to improvement of soil pH, organic carbon, N, P, K and micro-elements together with readily available inorganic nitrogen. These results are in agreement with those of Palm *et al.* (1997) who reported that application of compost along with chemical fertilizers has been found to give highest yield and maximum return in many vegetables including radish. From the results, there were no significant interaction effects on total fresh and dry biomass but a general increase in yield with combined application of farmyard manure and nitrogenous fertilizer was observed.

5.3.3 Effects of Farmyard Manure and Nitrogen Levels on Spider Plant Leaf Chlorophyll Content

The rate of plant growth depends on the rate of photosynthesis. Photosynthesis depends on the proper functions of enzymes. Enzymes require mineral elements to function effectively (Sumeet *et al.,* 2009). Thus photosynthesis and other metabolic processes depend on an adequate supply of mineral nutrients. Nitrogen governs plant growth by virtue of being a major constituent of chlorophyll, protein, amino acids and photosynthetic activity (Sumeet *et al.,* 2009).

In this study, increasing farmyard manure levels enhanced the leaf chlorophyll content at the later stages of spider plants growth in both trials. This was observed at 70 to 90 DAP where the higher levels of farmyard manure led to increase of leaf chlorophyll intensity than lower levels. These results are consistent with those of Karanatsidis and Berova (2009) who reported an increased amount chlorophyll 'a' and 'b' on higher levels of organic manure over the control. In addition, Ondieki (2009) reported an increase in Chlorophyll 'a' and 'b' with increase in the levels of fortified compost manure on African nightshade species. As with farmyard manure, inorganic nitrogen influenced leaf chlorophyll content of the leaves. Increase of nitrogen application led to subsequent increase in leaf chlorophyll content of spider plant. This might be

due to efficient absorption and assimilation of nitrogen and by the plant which serves as a constituent of chlorophyll in the plant tissue.

The results are in agreement with those of Blackmer and Schepers (1995), who reported that chlorophyll is strongly related to nitrogen concentration in the soil. Similarly, plant photosynthetic potential is directly proportional to leaf chlorophyll intensity which is predetermined by nitrogen availability in the soil (Biljana and Aca, 2009;Schlemmer *et al.*, 2005). This explains the high fresh leaf yield of spider plant under high nitrogen levels.

The data obtained in this study reveals that interaction of farmyard manure and inorganic nitrogen significantly increased leaf chlorophyll content of African nightshade. Application of the highest dosages of combined farmyard manure (15 t ha^{-1}) with highest dose of inorganic fertilizer (200 kg Nha^{-1}) induced the highest leaf chlorophyll content, while the lowest chlorophyll content was obtained from the control treatment at 50 and 90 DAP. These results are in agreement with the previous findings obtained on brocolli (*Brassica oleracea* L. var. *Italica*) where a combined application of organic (poultry manure) manure and inorganic increased leaf chlorophyll content (Abou *et al.*, 2006). A promotion effect of organic and inorganic fertilizers on chlorophyll contents might be attributed to the fact that nitrogen is a constituent of chlorophyll molecule. Moreover, nitrogen is the main constituent of all amino acids in proteins and lipids that act as a structural compound of the chloroplast which determines the rate of photosynthates manufactured through the process of photosynthesis (Badr and Fekry, 1998)

5.3.4 Effects of Farmyard Manure and Nitrogen Levels on Spider Plant Leaf Stomatal Conductance

The effect of farmyard manure on stomatal conductance varied throughout the growth of spider plant in both trials. Plants that received 11.3 and 15 t ha^{-1} exhibited higher levels of stomatal conductance in both trials while lower levels of nitrogen from calcium ammonium nitrate exhibited reduction in leaf stomatal conductance. In this study, increase in levels of inorganic nitrogen did not led to an increase in leaf stomatal conductance but increased with time. This shows that along with the stomatal conductance, the increased leaf chlorophyll content is one of the reasons for the higher photosynthetic rate in plants treated with optimum levels of fertilizers. The control of leaf stomatal conductance is a crucial mechanism for plants, since it is essential for both carbon dioxide acquisition and utilization in the process of photosynthesis. The end product being an increase in plant biomass and subsequent increase in yield (Dodd, 2003).

Integrated application of farmyard manure and inorganic nitrogen fertilizer influenced leaf stomatal conductance upon interaction at 60 and 70 DAP. Plants treated with combined application of the fertilizer were significantly higher in leaf stomatal conductance compared to the control plants. This shows that the interaction improves the leaf gas exchange due increased chlorophyll pigment content that led to higher stomatal conductance in plants.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusion

Generally, this study demonstrated the importance of farmyard manure and inorganic nitrogen applied complementarily in production of African nightshade (*Solanum scabrum*) and spider plant (*Cleome gynandra* L.). Based on the findings, the following conclusions can be made on each of the two crops:

6.1.1 African Nightshade

1. Both farmyard manure and inorganic nitrogen applied complementarily or singly influences growth and above ground biomass production of African nightshade. Increasing levels of farmyard manure and nitrogen fertilizers, leads to subsequent increase in all growth parameters, fresh edible yield and eventual above ground biomass production.
2. When farmyard manure is applied solely at 7.5 t ha^{-1}, it gives higher edible leaf yield of up to 12.2 t ha^{-1} while when 150 kg Nha^{-1} is applied solely it gives higher yields of up to 13.7 t ha^{-1}.
3. There were no interactive effects between farmyard manure and nitrogen fertilizer in influencing total leaf yield of African nightshade.
4. Increase in the application of farmyard manure and inorganic nitrogen levels beyond 7.5 t ha^{-1} and 150 kg Nha^{-1} respectively do not further enhance growth and productivity of African nightshade.
5. Both farmyard manure and inorganic nitrogen levels influenced physiological measurements. Leaf chlorophyll content increase with increase in levels of farmyard manure and inorganic nitrogen levels. However, with increase in time of plant growth from 50 to 80 DAP it led to subsequent increase in leaf chlorophyll content. Although the degree of response of African nightshade varied with respect to leaf stomatal conductance, the least conductance was generally recorded from the control plots.
6. Based on the results, sole or combined application of either farmyard manure or nitrogen fertilizers improves nutrient composition of African nightshade leaves.

6.1.2 Spider Plant

1. Farmyard manure and inorganic nitrogen fertilizers levels applied solely or combined enhances growth and above ground biomass. Increase in of farmyard manure and nitrogen fertilizers levels, leads to successive increase in spider plant's growth, fresh edible yield and above ground biomass.
2. When farmyard manure applied solely at 11.3 t ha^{-1}, it gives higher edible leaf yields of up to 12.3 t ha^{-1} while when 150 kg Nha^{-1} is applied solely it gives higher yields of up to 11.2 t ha^{-1}.
3. There were no interaction effects between farmyard manure and nitrogenous fertilizer in influencing spider plant's total yield.
4. The application of 15 tha^{-1} of farmyard manure and 200 kg Nha^{-1} of inorganic nitrogen could not further increase the growth and eventual productivity of spider plant.
5. Both farmyard manure and inorganic nitrogen levels influenced spider plants physiological measurements. Leaf chlorophyll content was increased with rising levels of farmyard manure and inorganic nitrogen. Stomatal conductance behaved the same way as chlorophyll content when afore-mentioned treatments levels were applied.
6. Based on the results, sole or combined application of either farmyard manure or nitrogen fertilizers improves nutrient composition of spider plant leaves.

6.2 Recommendations

From the preceding conclusions, the following recommendations can be made:

6.2.1 African Nightshade

1. The growers are advised to use 7.5 t ha^{-1} of farmyard manure or 150 kg Nha^{-1} of inorganic nitrogen fertilizer in production of African nightshade (*Solanum scabrum*).
2. Further studies is needed to establish whether reducing farmyard manure levels from 7.5 t ha^{-1} could still maintain the productivity of African nightshade (*Solanum scabrum*) at 12.2 t ha^{-1}.
3. Other fertility management research required for *Solanum scabrum* production is further splitting of nitrogen applications on the optimum application level of this nutrient.
4. Further studies is needed to be done on effect of farmyard manure and inorganic nitrogen levels under varied rainfall conditions so as to establish the optimum levels before comprehensive conclusions are drawn for all seasons.

5. Further studies on the effect of farmyard manure and nitrogenous fertilizers on nitrates, oxalates, phenols and glucosinolates compound in the leaves of African nightshade (*Solanum scabrum*) should be done.

6.2.2 Spider Plant

1. The productivity of spider plant can be maximized by application of 11.3 t ha^{-1} of farmyard manure or 150 kg Nha^{-1}.
2. Further studies should be conducted to establish the best time and number of split application of inorganic nitrogen fertilizer which can further enhance the productivity of spider plant.
3. Further studies should be conducted to establish the best harvesting interval which promotes faster edible shoot-leaf ratio production of spider plant.
4. Further studies should be done on effect of farmyard manure and inorganic nitrogen levels under varied rainfall conditions so as to establish the optimum levels before comprehensive conclusions are drawn for all seasons.
5. Further studies on the effect of farmyard manure and nitrogenous fertilizers on phenolic compounds in the leaves of spider plant should be done.

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