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# The Effect of Integrated Application of Farmyard Manure and Calcium Ammonium Nitrate on Growth and Yield Attributes of African Nightshade (*Solanum Scabrum* Mill.)

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**ABSTRACT—** ***The effect of integrated application of Farmyard Manure (FYM) and Calcium Ammonium Nitrate (CAN-26% N) on growth and yield of Solanum scabrum Mill. was assessed in a field experiment carried out at Horticulture Research and Teaching Field, Egerton University, Kenya from April to July 2009 and August to November 2009. The experiment was split-plot arranged in a randomized complete block design, replicated three times. The main plot treatments were farmyard manure at the rates of 0, 7.5, 11.5 and 15 t ha$^{-1}$ and the sub-plot treatments were CAN at the rates of 0, 100, 150 and 200 kg N ha$^{-1}$. The data collected were pooled before being subjected to analysis of variance (ANOVA). Plants that received the highest combination of 15 tha$^{-1}$ FYM and 200 kg N ha$^{-1}$ of CAN fertilizer were taller by 64% compared to the control. Optimum yield of 16.9 t ha$^{-1}$ was obtained from plants that received a combination of 7.5 t ha$^{-1}$ of farmyard manure and 150 kg N ha$^{-1}$ of CAN.***

**Keywords—** African nightshade, edible yield, Farm yard manure and biomass

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## 1. INTRODUCTION

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. The most important traditional vegetables in Kenya include *Amaranthus* spp, *Solanum nigrum, Cleome gynandra, Crotolaria brevidens* and *Vigna unguiculata* [1]. African nightshade (*Solanum scabrum* Mill.) is one of the most important traditional leafy vegetable consumed by various rural communities. 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.

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. 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 [2]. Increased crop productivity is the aim of every producer and cannot be achieved without effective nutrient management. 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. Continuous use of inorganic fertilizer as the main source of nutrients leads to rapid decline in crop yields because of acidification and soil compaction [3].

There are several options for restoring and maintaining soil fertility for instance by integrating organic and inorganic fertilizers and 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. The use of integrated organic manure and mineral fertilizers is a sound soil fertility management strategy in many countries of the world [4]. This is because it aims at alleviating the limiting nutrients and improves their availability from the soil reserves. The present study was aimed at enhancing the productivity of African nightshade (*Solanum scabrum* Mill.) by integrating farmyard manure and nitrogen fertilizer to optimize on their growth and fresh leaf yield.

## 2. MATERIAL AND METHODS

### 2.1 Study Site

The study was conducted at Horticulture Research and Teaching Field, Egerton University, Njoro, Kenya. The experiment was carried out between April to July 2009 and repeated between August and November 2009. The study site lies on a latitude of 0° 23' south, longitude 35°35' East and an altitude of 2238 m above sea level. The area falls in agro-ecological zone Lower Highland 3. 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. The temperatures in the field lied between 10.2 and 22.0°C (Fig. 1). Soils at the site are vintric mollic andosols [5].

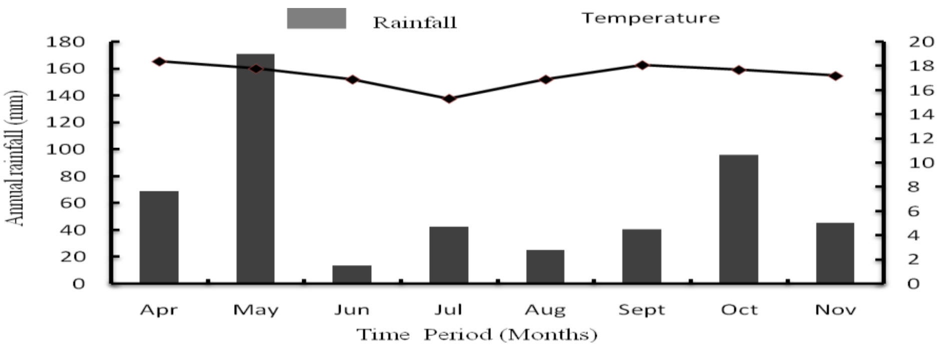


Fig. 1: Rainfall and Temperature Data for Egerton University Tatton Farm uring study period (Source- Engineering Meteorological Station 2009).

### 2.2. Experimental Design and Treatment Applications

The experiment was two-way factorial arranged in randomized complete block with 3 replications. The main plot measured 8.5 m by 1.5 m (12.75 $m^2$) and sub plot 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 giving a plant population of 71,111 plants $ha^{-1}$. Inter-plot was spaced at 0.5 m and 1.0 m path separated individual main blocks. Taking into consideration that farmyard manure and initial soil analysis had 1.33% and 0.21% nitrogen, 11.5 t $ha^{-1}$ of FYM and 150 kg N $ha^{-1}$ of CAN respectively were used as the recommended rates [6]. On the basis of a fore mentioned rates, 0, 7.5, 11.5 and 15 $tha^{-1}$ (0, 1.6, 2.5 and 3.5 kg/plot) of farmyard manure was used as main plot treatments in this study. Farmyard manure treatments were incorporated into the plots two weeks before planting. Similarly, 0 kg N $ha^{-1}$, 100 kg N $ha^{-1}$, 150 kg N $ha^{-1}$and 200 kg N $ha^{-1}$ (0, 86, 129 and 172 g of 26% CAN) of inorganic nitrogen from CAN was also 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.

### 2.3. Soil and Manure Analysis

Soil and manure analysis was performed before the commencement of field experiments and at the end of experiment. The soil pH was measured using pH meter (Fisher Accument ®). Total nitrogen for soils and farmyard manure was determined following Kjeldah method while available potassium, magnesium, calcium and iron were determined by use of Atomic Absorption Spectrophotometer (Model 201 VGP Scientific). Available P was determined calorimetrically using Spectrophotometer (Novaspec® II). All tests were performed at Egerton University Soil Analysis Laboratory. The soil had a pH ($H_2O$) of 5.3, 0.21% Nitrogen; 0.14% Available P, 0.12% K, 0.21% Fe, 62.6 mg/100g dry soil of Ca and 21.18 mg/100g dry soil of Mg. Farmyard manure had a pH ($H_2O$) of 6.7, 1.33 % N, 0.23% P, 2.30% K, 0.78% Ca, 0.38% Mg and 0.14% Fe.

### 2.4. Land Preparation and Planting

Land preparation was done two months before planting. The field was ploughed and then harrowed to create a suitable tilth. Planting beds were then raised 30 cm high ensuring that inter-plot spacing are maintained. Farmyard manure and CAN were incorporated into the respective plots according to field randomization to a depth of 15 cm two weeks before planting. 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 $ha^{-1}$. *Solanum scabrum* Mill. seeds sourced from Kenya Seed Company were sown directly along the furrows. Approximately 160 seeds were sown per plot of 2.25 $m^2$. Thinning out of weak seedlings was done three weeks after germination to leave only healthy vigorous growing plants in all the plots. Each sub-subplot remained with 16 plants to give a population density of 7 plants per $m^2$.

### 2.5. Growth Measurements

Four inner plants out of sixteen plants per plot were used for data collection which started seven weeks after planting. Plant height was measured from the ground level to the tip of the longest stem while the number of leaves and branches were counted before the first harvest. Internode length was measured between the $3^{rd}$ and $4^{th}$ leaves was using a ruler while stem base diameter was measured using vanier caliper. Means of the parameters measured from each treatment were recorded as the score for that treatment. The leaf area was calculated using the following formula as described by [7]. Leaf Area = (L x W) x (0.67); where L-length and W-width of the leaf. Leaf Area Index was computed using the formula; LAI = (Leaf Area/ land surface area occupied by the plants from where the leaf area was obtained).

### 2.6. Yield Measurements

Leaf harvesting began on $50^{th}$ day after planting and continued at an interval of 10 days until the experiment was terminated at 100 days after planting (DAP). Fresh and dry weights leaves were measured using sensitive weighing balance to ensure accuracy. Total leaf yield for each treatment was obtained by summing up the leaf yield from each given treatment at different leaf harvesting intervals. Total yield of harvested leaves from each plot was converted to yield in tons per hectare. Similarly, total fresh and dry above ground biomass were measured and later converted to tones per hectare

### 2.7. Photosynthesis and Stomatal Conductance Measurements

The fourth leaf from each of the four inner plants was used to determine the leaf chlorophyll content and stomatal conductance (mmol/$m^2$s) per plot using the SPAD (Minolta SPAD 502® Meter) and Leaf porometer respectively before each harvesting session ($50^{th}$, $60^{th}$, $70^{th}$, $80^{th}$and $90^{th}$ days after planting).

### 2.8. Statistical Analysis

The data were subjected to analysis of variance using the General Linear Model for split-plot design to obtain the P value of the effect of the model for each treatment using Proc GLM code of SAS-computer software [8].

## 3. RESULTS

### 3.1. Growth Parameter

Parameters that were measured to determine the treatments effects on growth of African nightshade included: Plant height, number of leaves, internode length, number of branches, leaf area and leaf area index. Increased rates of manure increased the magnitude of all the growth parameters measured. Plants that received the highest level of farmyard manure were significantly taller by 50% while the number of leaves was increased by 41% compared to the control. Leaf area index was increased by 48% at 15 $tha^{-1}$ of manure (Table 1). Generally CAN had the same effects as those observed in FYM treatments. However, there was no statistical difference between plants that received 150 kg $Nha^{-1}$ and 200 kg $Nha^{-1}$ in nearly all growth parameters at $P \leq 0.05$ apart from leaf area index. Plants that were subjected to 200 kg $Nha^{-1}$ were taller by 27% while the number of leaves increased by 47% over the control. The highest rate (200 kg $Nha^{-1}$) of nitrogen also increased the leaf area index by 58% compared to the control (Table 1). There were noticeable interactions between manure and CAN fertilizer in influencing some African nightshades growth parameters (Table 2). Among the parameters that were significant at $P \leq 0.05$, leaf area index had the highest effect of interaction by 88% compared the control. Plants that received the highest combination 15 $tha^{-1}$ FYM and 200 Kg $Nha^{-1}$) of fertilizers were taller by 64% and had largest leaf area (134 $cm^2$) compared to the control.

Table 1: Effects of farmyard manure and calcium ammonium nitrate on vegetative growth of African nightshade

| Nitrogen Source | | Plant height (cm) | Leaf Number | No. of Branches | Internode Length (cm) | Leaf Area($cm^2$) | Leaf Area Index |
|---|---|---|---|---|---|---|---|
| FYM (t/ha) | 0 | 15.3c | 26.2c | 9.5c | 2.1b | 98.4c | 1.9c |
| | 7.5 | 23.2b | 33.2b | 11.3bc | 2.5a | 139.5a | 3.3b |
| | 11.5 | 29.0a | 42.6a | 13.1ab | 2.4a | 139.7a | 4.2a |
| | 15.0 | 30.1a | 44.5a | 15.5a | 2.4a | 118.6b | 3.7ab |
| CAN (kg N t/ha) | 0 | 19.6b | 24.5c | 8.7b | 2.0b | 104.2b | 1.9c |
| | 100 | 22.6b | 33.0b | 12.8a | 2.1b | 133.0ab | 3.1b |
| | 150 | 28.6a | 42.3a | 13.2a | 2.5a | 122.5a | 3.6b |
| | 200 | 27.0a | 46.7a | 14.6a | 2.6a | 136.4a | 4.6a |

*Means followed by the same letters within a column of either farmyard manure or nitrogen levels are not significantly different according to Duncan Multiple Range Test at $P \leq 0.05$.

Table 2: Interactive effects between of farmyard manure and CAN on growth of African nightshade

| FYM (kg N/ha) | CAN (t/ha) | Plant height (cm) | Leaf Number | No. of Branches | Internode Length (cm) | Leaf Area($cm^2$) | Leaf Area Index |
|---|---|---|---|---|---|---|---|
| **0** | 0 | 5.5* | 17.3b | 5.0b | 2.0 | 45.0 | 0.2b |
| | 100 | 6.2 | 18.6b | 6.0ab | 1.5 | 51.8 | 0.7ab |
| | 150 | 7.8 | 22.6ab | 7.0ab | 2.4 | 49.8 | 0.8ab |
| | 200 | 7.2 | 19.6ab | 6.0ab | 2.4 | 47.2 | 0.6ab |
| **7.5** | 0 | 8.4 | 19.0b | 6.0ab | 2.4 | 58.0 | 0.8ab |
| | 100 | 10.0 | 21.6ab | 7.3ab | 2.4 | 76.4 | 1.2ab |
| | 150 | 10.5 | 26.6ab | 8.3ab | 2.9 | 72.2 | 1.3ab |
| | 200 | 8.8 | 25.6ab | 8.6ab | 2.6 | 57.6 | 1.1ab |
| **11.5** | 0 | 9.3 | 19.3b | 6.0ab | 2.0 | 36.9 | 0.5ab |
| | 100 | 6.5 | 19.0b | 6.0ab | 1.8 | 55.1 | 0.7ab |
| | 150 | 11.5 | 27.0ab | 8.0ab | 2.6 | 88.0 | 1.7a |
| | 200 | 9.9 | 28.3ab | 9.0a | 2.9 | 79.7 | 1.6ab |
| **15.0** | 0 | 8.6 | 21.3ab | 7.0ab | 1.9 | 66.5 | 1.0ab |
| | 100 | 10.9 | 21.6ab | 6.6ab | 2.0 | 49.6 | 0.7ab |
| | 150 | 9.6 | 29.0ab | 8.0ab | 1.9 | 52.5 | 1.1ab |
| | 200 | 9.9 | 31.0a | 7.6ab | 2.6 | 76.8 | 1.7a |

*Means not followed by the same letters within a column are not significantly different according to Duncan Multiple Range Test at P≤0.05.

### 3.2. Yield at Subsequent Harvesting Levels

There was a general increase in fresh yield with increase in levels of farmyard (Table 3). The lowest yield was however obtained from plants without farmyard manure and harvested from 50 to 80 days after planting. Nitrogen fertilizer had the same effect as manure on the yield of black nightshade. Increase in nitrogen levels, led to an increase in fresh weight of African nightshade. The highest yield of 45 g/plant was realized at 200 Kg $Nha^{-1}$ at 90 DAP. Generally, with increase in the levels of treatment combinations, there was an increase in the mean fresh yield at every harvesting interval (Table 4).

Table 3: Effects of farmyard manure and CAN on African nightshade leaf fresh yield (g/plant)

| Nitrogen Source | | Days After Planting: 50 | 60 | 70 | 80 | 90 | 100 |
|---|---|---|---|---|---|---|---|
| FYM (t/ha) | 0 | 8.7b | 11.8b | 18.5b | 30.7b | 37.1* | 21.4 |
| | 7.5 | 17.1a | 24.1a | 31.2a | 43.4a | 37.4 | 22.1 |
| | 11.5 | 15.4a | 19.8ab | 25.1ab | 36.8ab | 42.2 | 23.3 |
| | 15.0 | 16.1a | 19.7ab | 25.0ab | 45.2a | 44.1 | 24.5 |
| CAN (kg N/ha) | 0 | 8.0b$^z$ | 11.4c | 15.8b | 29.8b | 28.1c | 18.4c |
| | 100 | 11.3b | 15.9bc | 22.2b | 35.8b | 36.6bc | 20.1bc |
| | 150 | 18.6a | 22.8ab | 30.4a | 45.7a | 51.2ab | 24.3ab |
| | 200 | 19.4a | 25.7a | 31.4a | 44.8a | 45.0a | 28.5a |

*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 Multiple Range Test at P≤0.05.

### 3.3. Leaf Fresh and Dry Weight of African Nightshade

The effect of farmyard manure on dry weight varied with the duration of plant growth (Table 5). After 70 DAP farmyard manure had no effect on the dry weight of the edible parts. The results showed general increase in the yield of dry weight with increasing amounts of farmyard manure except at 50 DAP (Table 5). Calcium ammonium nitrate had inconsistent effects on the dry weight of the plant. At 50 DAP; there was a significant 52% increase in dry weight compared to the control. Increase in the levels of treatments combination, led to subsequent increase in the mean dry weights at each harvesting interval (Table 6).

Table 4: Interaction effects between farmyard manure and CAN on African nightshade fresh leaf yield (g/plant)

| FYM(t/ha) | CAN kg (N/ha) | Days after Planting 50 | 60 | 70 | 80 | 90 | 100 |
|---|---|---|---|---|---|---|---|
| **0** | 0 | 3.0* | 4.8 | 10.2 | 23.9c | 22.6 | 17.1 |
| | 100 | 7.1 | 10.9 | 15.8 | 31.8bc | 42.2 | 20.2 |
| | 150 | 10.2 | 14.4 | 26.2 | 35.6abc | 46.0 | 22.0 |
| | 200 | 14.3 | 17.0 | 21.9 | 31.6abc | 37.5 | 26.1 |
| **7.5** | 0 | 8.1 | 13.1 | 19.3 | 31.9bc | 19.9 | 17.3 |
| | 100 | 19.3 | 28.8 | 35.3 | 44.8abc | 31.9 | 18.8 |
| | 150 | 24.4 | 29.7 | 36.1 | 51.4ab | 52.6 | 22.2 |
| | 200 | 16.7 | 24.8 | 34.0 | 45.7abc | 45.5 | 30.8 |
| **11.5** | 0 | 11.3 | 14.1 | 18.9 | 28.4bc | 34.5 | 18.9 |
| | 100 | 6.6 | 8.8 | 18.2 | 31.3bc | 35.6 | 19.6 |
| | 150 | 20.0 | 25.6 | 30.7 | 36.5abc | 57.4 | 30.6 |
| | 200 | 23.8 | 30.8 | 32.6 | 50.8ab | 41.3 | 24.4 |
| **15.0** | 0 | 9.5 | 13.5 | 14.8 | 35.0abc | 35.4 | 20.2 |
| | 100 | 12.1 | 15.2 | 19.3 | 35.3abc | 36.3 | 21.8 |
| | 150 | 19.7 | 21.7 | 28.7 | 59.2a | 48.7 | 22.5 |
| | 200[1] | 23.0 | 28.3 | 37.2 | 51.2ab | 55.9 | 33.5 |

*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 Multiple Range Test at P≤0.05.

Table 5: Effects of farmyard manure and CAN levels on African nightshade yield dry weight (g/plant)

| **Nitrogen Source** | | **Days After Planting** 50 | 60 | 70 | 80 | 90 | 100 |
|---|---|---|---|---|---|---|---|
| FYM (t/ha) | 0 | 1.2* | 1.3b$^z$ | 2.2b | 2.3 | 3.4 | 2.3 |
| | 7.5 | 2.3 | 3.3a | 3.0a | 3.1 | 3.4 | 2.4 |
| | 11.5 | 2.1 | 2.2ab | 2.6ab | 3.4 | 3.6 | 2.9 |
| | 15.0 | 2.1 | 2.2ab | 2.5ab | 3.5 | 3.8 | 2.8 |
| CAN (kg N t/ha) | 0 | 1.2bz | 1.8* | 1.7b | 3.2 | 2.8b | 2.3b |
| | 100 | 1.8ab | 1.9 | 2.3b | 2.6 | 3.4ab | 2.4b |
| | 150 | 2.2a | 2.6 | 3.1a | 3.3 | 4.2a | 2.7ab |
| | 200 | 2.5a | 2.7 | 3.2a | 3.3 | 3.7ab | 3.0a |

* Means not followed by the same letters within a column are not significantly different according to Duncan Multiple Range Test at P≤0.05.

Table 6: Interaction effects between farmyard manure and CAN levels on African nightshade dry leaf yield (g/plant)

| FYM(t/ha) | CAN kg (N/ha) | Days after Planting 50 | 60 | 70 | 80 | 90 | 100 |
|---|---|---|---|---|---|---|---|
| **0** | 0 | 0.8b | 0.9c | 1.3b | 1.9* | 1.8 | 1.7 |
| | 100 | 0.8b | 0.9c | 1.7b | 2.1 | 1.5 | 1.8 |
| | 150 | 1.0ab | 1.4bc | 2.5ab | 3.6 | 2.1 | 2.1 |
| | 200 | 1.7ab | 2.7abc | 2.1ab | 3.6 | 2.3 | 3.1 |
| **7.5** | 0 | 1.9ab | 3.1abc | 2.2ab | 3.0 | 1.5 | 2.2 |
| | 100 | 2.1ab | 3.9abc | 3.0ab | 3.8 | 1.9 | 2.5 |
| | 150 | 2.0ab | 3.3abc | 3.8ab | 4.0 | 1.9 | 2.6 |
| | 200 | 2.4ab | 3.6abc | 2.6ab | 5.7 | 2.1 | 2.5 |
| **11.5** | 0 | 1.3ab | 1.6b | 1.6a | 2.8 | 2.1 | 2.9 |
| | 100 | 2.4ab | 3.3abc | 2.5ab | 3.2 | 1.8 | 2.4 |
| | 150 | 2.7a | 4.1abc | 3.6ab | 4.2 | 2.6 | 3.0 |
| | 200 | 2.3ab | 5.0a | 3.9ab | 4.4 | 2.5 | 3.7 |
| **15.0** | 0 | 1.3ab | 2.2abc | 2.4ab | 3.0 | 2.3 | 2.7 |
| | 100 | 1.7ab | 2.6abc | 3.9ab | 2.8 | 2.2 | 2.9 |
| | 150 | 2.7ab | 3.6abc | 3.3ab | 3.8 | 2.5 | 2.9 |
| | 200 | 2.1ab | 4.4ab | 4.5a | 5.2 | 2.5 | 2.8 |

* Means not followed by the same letters within a column are not significantly different according to Duncan Multiple Range Test at P≤0.05.

The average total fresh yield of African nightshade was dependent on the levels of farmyard manure applied. However, manure levels between 7.5 and 15 t ha$^{-1}$ were not significantly different (P≤0.05) in influencing fresh. Plants that were treated with the highest (15 t ha$^{-1}$) level of FYM increased total fresh yield by 26% compared to the control. The maximum level of nitrogen fertilizer gave fresh leaf yield of 13.8 t ha$^{-1}$ which was significantly higher by 42% compared to the control (Fig. 2). Total dry yield of African nightshade tended to increase by increasing level of farmyard manure with inorganic nitrogen from CAN, however, this increment was not significant

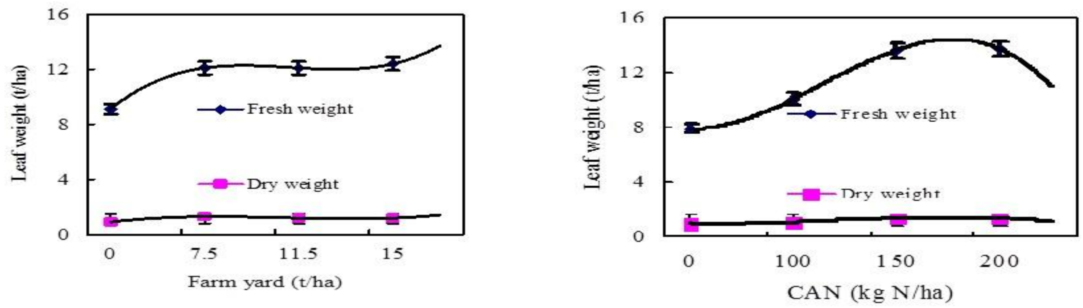


Fig. 2: Effects of farmyard manure and CAN levels on African nightshade fresh and dry yield (tha$^{-1}$).

### *3.4. Leaf Chlorophyll Content*

Chlorophyll content was dependent on farmyard manure at later stages of growth. 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. However, Plants that were subjected to 15 t ha$^{-1}$ accumulated 22% more chlorophyll content at 70 DAP compared to the control treatment. Generally, plants that received neither farmyard manure nor inorganic nitrogen had significantly lower leaf chlorophyll content at P≤0.05 compared to the treated plants (Table 7). The application of farmyard manure levels generally increased stomatal conductance compared to the control in all days of data collection at P≤0.05 (Fig. 3). Plants that were subjected to maximum (15 t ha$^{-1}$) manure levels significantly increased stomatal conductance by 65% at 60 DAP. Inorganic nitrogen application also influenced stomatal conductance, but to a different magnitude (Fig. 3).

Table 7: Effects of farmyard manure and CAN levels on African nightshade leaf chlorophyll content (SPAD readings)

| Nitrogen Source | | Days After Planting | | | | | |
|---|---|---|---|---|---|---|---|
| | | 50 | 60 | 70 | 80 | 90 | 100 |
| FYM (t/ha) | 0 | 27.9* | 32.3 | 33.4c | 32.7b | 30.9b | 27.9* |
| | 7.5 | 31.3 | 35.4 | 37.6ab | 35.3ab | 34.3a | 31.3 |
| | 11.5 | 30.7 | 32.0 | 36.6bc | 35.8ab | 34.4a | 30.7 |
| | 15.0 | 32.4 | 34.8 | 40.5a | 39.8a | 36.8a | 32.4 |
| CAN (kg N t/ha) | 0 | 27.7c* | 26.7c | 27.8c | 25.4c | 24.0d | 27.7c* |
| | 100 | 29.2bc | 31.9b | 35.6b | 33.0b | 31.1c | 29.2bc |
| | 150 | 33.3a | 38.3a | 42.3a | 44.1a | 41.9a | 33.3a |
| | 200 | 32.1ab | 37.7a | 42.1a | 41.1a | 37.5b | 32.1ab |

*Means not followed by the same letters within a column are not significantly different according to Duncan Multiple Range Test at P≤0.05

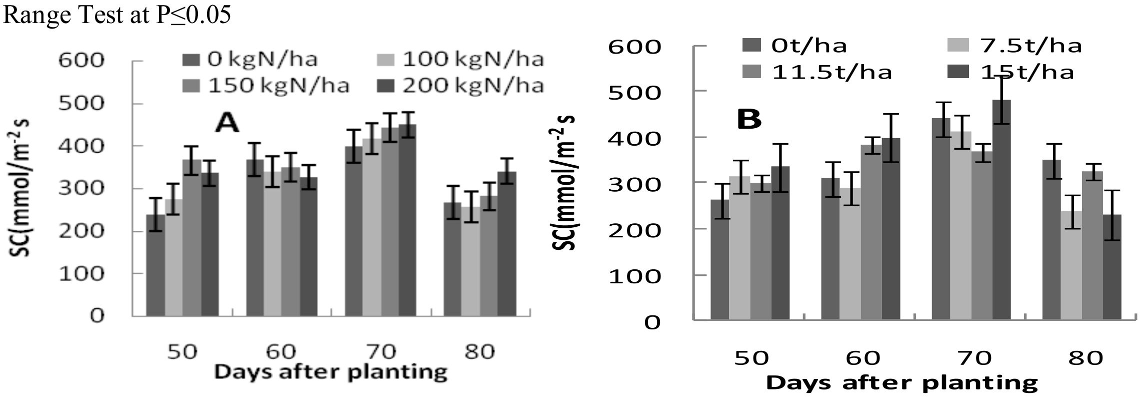


Fig. 3: Effects of CAN (A) levels and farmyard manure (B) on African nightshade's leaf stomatal conductance SC (mmol/m$^{-2}$)

## 4. DISCUSSION

Application of the farmyard manure and calcium ammonium nitrate either singly or in combination affected the growth of African nightshade at varied magnitudes. Plants that received the highest amount of the treatments generally exhibited robust growth when compared to the control. For example, the leaf area index of these plants was 88% higher compared to the plants that received no treatments. The results are in agreement with those of [9] who reported an increased growth attributes of *Solanum villosum* upon application of various rates of farmyard manure and [10] who observed the same trend with application nitrogen fertilizer (C.A.N). The increased growth we observed might be due to the possible presence of readily available inorganic nitrogen together with the merits associated with organic fertilizers (improvement of the soil structure, water holding capacity, aeration and slow nutrient release) resulting to improved plant growth vigor. The enhanced leaf dry weight observed at the highest treatment combination of 15 t $ha^{-1}$ by 200 Kg $Nha^{-1}$ indicates the importance of soil nitrogen in optimizing the production of leafy vegetables.

The total fresh yields of 13.7 t $ha^{-1}$ were obtained from plants subjected to 150 kg N $ha^{-1}$. There was no further increase in the leaf fresh weight with increase in the treatments levels. Observed decline in fresh leaf yield trend with increase in manure and CAN applications could be attributed to the possible increase in osmotic imbalances due to luxury nitrogen uptake (nitrogen accumulation) in plant tissues leading to toxic effects of nitrates on the plant. The decline also could be attributed to the process of leaching of inorganic nitrogen from the soil as a result continued irrigation. Similar findings were observed by [11] who reported an increased total fresh and dry above-ground biomass of *Solanum retroflexum* with increased nitrogen application rates until the rate of 150 kg N·$ha^{-1.}$ Yields of the plants that received the highest combination of the treatment were higher by 53% compared to the control at 80 DAP. It is possible that there was a significant improvement of African nightshade rooting system and hence higher rate of nutrient absorption that lead to the observed increase in the fresh leaf yield. This is consistent with previous reports on *Solanum americana*, where [9] found that application of fortified manure significantly increased most growth parameters including number of leaves, shoot, fresh and dry weights of the plant.

The application of the highest combined level of the treatments produced the highest fresh leaf yield (16 t $ha^{-1}$). 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 $ha^{-1}$. These results are in line with those of [12] who reported that African nightshade (*Solanum villosum*) plants respond to nitrogen deficiency by reduction of leaf area and consequently fresh and dry matter production. Generally, it could be concluded that, the highest total yield of African nightshade was recorded by the combined effect of manure and inorganic nitrogen compared to the control.

Generally, increase in manure levels led to significant ($P \leq 0.05$) increase in leaf chlorophyll content. Chlorophyll concentration of leaves is affected by nitrogen status of the plant which is predetermined by its availability in the soil [13]. Leaf chlorophyll content of black nightshade in all the succeeding measurements were influenced by nitrogen application levels. Leaf chlorophyll content for plants that were subjected to 150 kg N $ha^{-1}$ and 200 kg N $ha^{-1}$ 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 N $ha^{-1}$ was optimum and hence addition of 200 kg N $ha^{-1}$ did not lead to further uptake by plant to bring any significance on leaf chlorophyll content. These result are consistent with those of [14] who reported a significant linear relationship between leaf chlorophyll and nitrogen fertilizer applied ($R^2$=0.91) on potato (*Solanum tuberosum)*. The control of leaf stomatal conductance is a crucial mechanism for plants, since it is essential for both carbon dioxide acquisition and its utilization in the process of photosynthesis. The end product being an increase in plant biomass and subsequent increase yields [15].

## 5. CONCLUSION

African nightshade productivity can be enhanced in soil amended with manure fertilizer but application rate and availability of all minerals should be considered. African nightshade plants grown in soil amended with farmyard manure fertilizer showed a vigorous vegetative growth and, high yield. In general, combined application of 7.5 t $ha^{-1}$ of FYM and 150 kg N $ha^{-1}$ proved to be the best levels for promoting growth and yield of up to 15.4 t $ha^{-1}$. This study showed that to obtain maximum yield per plant, African nightshade grower should apply 7 t $ha^{-1}$ of farmyard manure and 150 kg N $ha^{-1}$ of inorganic nitrogen fertilizer.

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