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EFFECTS OF COMPOSTED FARMYARD MANURE ON GROWTH AND YIELD OF SPIDER PLANT (*Cleome gynandra*)

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ABSTRACT
A field experiment was conducted to evaluate the effect of farmyard manure on the growth and yield of spider plant at Horticulture Research and Teaching Field, Egerton University, Kenya from April to November 2009. Farmyard manure was applied at the rate of 0 kg (0 t ha^{-1}) 1.6 kg (7.5 t ha^{-1}), 2.5 kg (11 t ha^{-1}) and 3.5 kg (3.5 t ha^{-1}). Treatments were laid out in a completely randomized block design and replicated three times. Growth, yield and physiological data were collected and subjected to analysis of variance (ANOVA). Significant treatments means were separated using Turkey's honestly significant difference test (Turkey's HSD) at P≤0.05. The results showed that the applications of farmyard manure significantly ($p<0.05$) influenced all growth, yield and physiological parameters investigated in this research. The highest rates of farmyard manure (11.5 to 15 t ha^{-1}) significantly increased the growth and yield parameters by between 36% and 57% compared to the control. The same treatment increased chlorophyll content by between 16-35% compared to the control in both seasons. The use of farmyard manure as an organic manure soils is therefore essential in increasing spider plant yield. Thus 11.5 t ha^{-1} of farmyard manure should be recommended for farmers growing spider plant.

KEYWORDS: chlorophyll, farmyard manure, Spider plant, stomatal conductance, yield

INTRODUCTYION

The consumption of traditional leafy vegetables in developing countries is on the rise due to their nutritional and medicinal value as well as good adaptability to harsh climatic conditions and tolerance to pests and diseases (Prasad *et al*., 2008). In Kenya, the traditional leafy vegetables commonly utilized include spider plant (*Cleome gynandra* L.), Nightshades (*Solanum scabrum; Solanum scabrum*) and amaranthus (*Amaranthus hibridus)* cowpea (*Vigna unguiculata*), crotalaria (*Crotalaria brevidens*) Jute (*Corchorus olitorius*) (Chweya and Mnzava, 1997).. Spider plant (*Cleome gynandra* L.) belongs to the family *Capparaceae*. It is widely distributed in the drier parts of the tropics and subtropics, but occurs mostly in Africa (Kuhn, 1988). Spider plant is adapted to a wide range of environmental conditions. It grows well from 0-2400 meters above the sea level. It is an erect herbaceous annual herb, which thrives best from 18 to 25°C and grows well on a range of soil from sandy loam to clay loams (Chweya and Mnzava, 1997).

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 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 (Chweya and Mnzava, 1997) Boiling the leaves may reduce vitamin C content by up to 81% and drying can reduce vitamin C content further by 95% (Mathooko and Imungi, 1994). Sap from leaves has been used as an analgesic particularly for head ache, epileptic fits and ear ache while 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 (Malonza *et al*., 1992). 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 (Maundu *et al*., 1999).

Continuous cultivation with little or no fertilizer application has often been associated with a decline in soil fertility with subsequent reduction in crop yields. The degradation is brought about by loss of organic matter which consequently results in soil acidity, nutrient imbalance and finally low crop yields. However, the use of inorganic fertilizers alone may cause problems for human health and environment (Ayoola and Makinde, 2007). In addition, excessive quantities of inorganic fertilizers are applied by farmers to vegetables to achieve a higher growth and yield as they are considered a major source of plant nutrients. The increase of inorganic fertilizers globally calls for a speedy intervention where high and sustainable vegetable yields can be obtained and maintained by promoting the use of organic nitrogen supplying fertilizer.

Organic fertilizers can serve as alternative practice to minimize the use of mineral fertilizers as they aid in improving soil structure, increase soil organic carbon and microbial biomass (Suresh *et al*., 2004). They also provide significant quantities of major and micro nutrients, and have a persistent effect on the soil over years. This study was conducted to assess the growth and yield of spider plant with different levels of farmyard manure.

MATERIALS AND METHODS

Study site

Spider plant was grown at Egerton University, Tatton Farm (Horticulture Research and Teaching Field) Njoro, Kenya. 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 (Jaetzold and Schmidt, 1983). The 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. Soils at the site are vintric mollic andosols (Kinyanjui, 1979).

Experimental Design Treatment applications

The experimental design was randomized complete block design, with 3 replications. Farmyard manure rates were applied randomly at the rate of 0, 7.5, 11.5 and 15 tha^{-1} (0, 1.6, 2.5 and 3.5 kg/plot) and incorporated uniformly within the plots before leveling. These treatments were established on the recommendation of 80 Kg N ha^{-1}. The plot measured 1.5 m by 1.5 m (2.25 m^2).

Soil and manure analysis

Soil and manure analysis was performed before the commencement of field experiments. Total nitrogen was determined following Kjeldah method. Available phosphorus was determined calorimetrically using Spectrophotometer (Novaspec® II). Potassium, magnesium, calcium and magnesium from soil, manure and plant tissues were determined by use of Atomic Absorption Spectrophotometer (AAS). The soil pH was measured using and pH meter (Fisher Accument ®) (Table 1).

TABLE 1. Chemical composition of soil and farmyard manure

Parameters	Soil	Farmyard Manure
pH (H_2O)	5.32	7.16
pH (KCl)	5.82	6.76
Total N (%)	0.21	1.33
Available P (%)	0.14	0.23
Exchangeable K (%)	0.12	2.38
Exchangeable Fe (%)	0.21	0.14
Exchangeable Ca (%)	0.06	0.78
Exchangeable Mg (%)	2.86	0.38

Land preparation and planting

Land preparation was done two months before sowing by performing deep ploughing followed by breaking of clods to attain good tilth. Beds were then raised 30 cm high ensuring that inter-plot spacing of 0.5 m and 1 m path separating blocks were maintained. Drip irrigation system was then laid down running across all the plots. Triple superphosphate (TSP) fertilizer applied at the rate of 200 kg ha^{-1} (Abukutsa, 2007) was thoroughly mixed with the soil along the furrows spaced 30 cm apart. *Cleome gynandra* seeds sourced from Kenya Seed Company, Nakuru was sown directly along the furrows at a rate of approximately 160 seeds per plot and covered with a thin layer of soil to ensure maximum germination. Supplementary watering commenced immediately after sowing while weeding prevailed throughout the experimental period. Spacing was then done at an inter-row of 30 cm and intra-row of 30 cm giving a plant population of 71,111 plants ha^{-1}. Deep ditches between plots were constructed to avoid movement of nitrogen. Thinning out of weak plants was done three weeks after germination to remain with sixteen healthy vigorous growing plants per plots.

Growth measurements

Four inner out of sixteen plants per plot were used for data collection during the 7th week after planting. The growth parameters measured included plant height, number of leaves and branches as well as internode length measured between the 3rd and 4th internodes. Means of a fore mentioned measurements from each experimental plots were recorded as the score for that treatment. The leaf area was calculated using the formula described by Pearcy *et al.*, (1989).

Leaf Area = (L x W) x (0.67); where L-length and W-width of individual leaf. Leaf Area Index (LAI) was computed using the formula given by Pearcy *et al.,* (1989). LAI = (Leaf Area/land surface area occupied by the plant from where the leaf area was obtained).

Yield measurements

Leaf harvesting from the four inner plants began on 50th day after planting and continued at an interval of 10 days until 100 DAP (Days after planting) when the experiment was terminated. Fresh and dry yield at every interval was measured using sensitive weighing balance to maximize on accuracy immediately after removing the plants from the experimental plots and after oven drying. Total leaf yield for each treatment was obtained by summing up the leaf yields from each given treatment at different leaf harvesting intervals. Total yield of harvested leaves from each plot was converted to yield in tones per hectare. Similarly, fresh and dry leaf yields and stump were summed up to arrive at above ground biomass in tones per hectare.

Photosynthesis and stomatal conductance Measurements

The fourth leaf from each of the four inner plants was used to determine the chlorophyll per plot using the SPAD

(Minolta SPAD 502® Meter) and stomatal conductance (mmol $m^{-1}s^{-1}$) using the Decagon SC-1® Leaf Porometer before each harvesting interval (50th, 60th, 70th, 80th and 90th DAP).

Statistical Analysis

Statistical analysis was carried out using design of experiment (DOE) and Fit Model procedure of the JMP IN 5.1 (Sall *et al.*, 2003) statistical package software. The treatment means that were significantly different were separated using Turkey's honestly significant difference test (Turkey's HSD) at P≤0.05.

RESULTS

Effects farmyard manure vegetative growth

Increasing rates of manure led to a general increase in all growth parameters that were recorded. Plants subjected to 7.5 t ha^{-1} in season 1 and at 11.5 t ha^{-1} in the second season were tallest. The highest number of leaves and longest stem intenodes (35% and 50%) respectively over the control were recorded in plants subjected to 11.5 t ha^{-1} in the two seasons of study (Table 2a). Effects on leaf area index was seasonal, with 85% increase in the plants subjected to the highest farmyard manure recorded in season 2 whereas there were no treatment influence observed in the first season (Table 2b).

TABLE 2A. Effects of farmyard manure rates on vegetative growth of spider plant

	Season 1			Season 2		
Manure Rates (t ha^{-1})	Plant height(cm)	Number of leaves	Number of branches	Plant height(cm)	Number of leaves	Number of branches
0	12.4b*	30.3b	6.5b	17.4c	27.3c	6.7b
7.5	16.7ab	28.0b	9.0a	30.7b	40.8b	8.4ab
11.5	20.5a	34.9a	8.9a	43.6a	59.8a	9.4a
15.0	22.3a	42.5a	9.5a	41.0ab	54.4a	10.5a

*Means followed by the same letters within a column are not significantly different according to Turkey's HSD at P≤0.05.

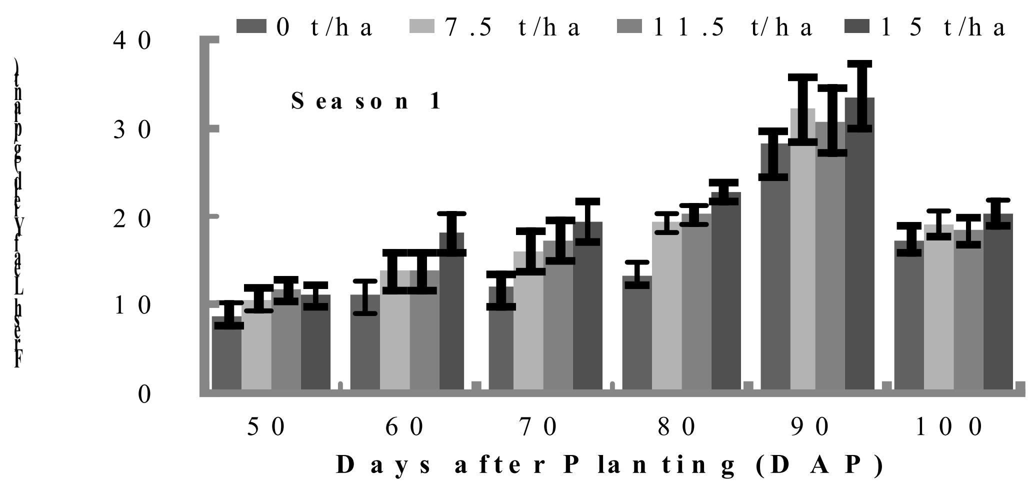
TABLE 2B. Effects of farmyard manure rates on vegetative growth of spider plant

	Season 1			Season 2		
Nitrogen Sources (t ha^{-1})	Internode length(cm)	Leaf area(cm^2)	Leaf area index	Internode length(cm)	Leaf area(cm^2)	Leaf area index
0	0.9b	57.0a	0.3a	0.9b	48.1b	0.9c
7.5	1.6b	73.6a	1.4a	1.1b	63.7a	1.8b
11.5	1.4a	72.1a	1.8a	1.8a	74.7a	3.3a
15.0	1.6a	74.5a	2.2a	1.7a	71.7a	2.9a

*Means followed by the same letters within a column are not significantly different according to Turkey's HSD at P≤0.05.

Effects farmyard manure on yield at harvesting intervals

When fresh yield were compared to individual manure levels, a general increase of between 20% and 69% in fresh yield was observed with increase in manure levels when evaluated against the control. However, as observed in figure (1), there was a gradual increase in fresh yield from 50 to 90 DAP after which there was a decline at 100 DAP in season 1. Whereas in season 2, there was a decline of fresh yield at all the rate of manure at 60 DAP followed by a rapid increase at 70 and 80 DAP. In addition, highest yield of 44.5 g/plant (3.2 tha^{-1}) was noted at 80 DAP in season 2. Results on the effect of farmyard manure levels on spider plant fresh yield had consistent effects in all the harvesting intervals (Figure 1).



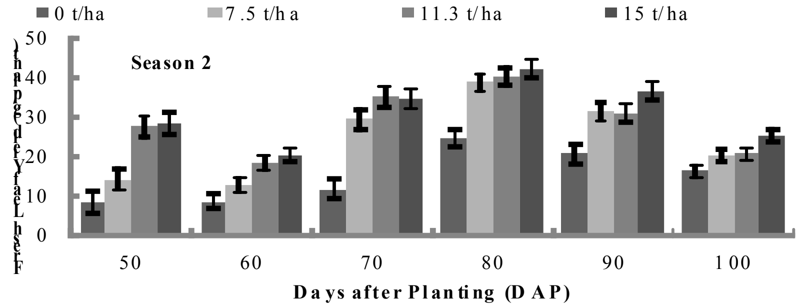


FIGURE 1. Effects of farmyard manure rates on spider plant fresh leaf yield (g/plant) at different harvesting intervals in seasons 1 and 2

Effect of farmyard manure total fresh leaf yield
Results in Figure (2) showed that there were significant differences in the total fresh yield among farmyard manure in the two seasons of study. Plants subjected to 15t ha^{-1} produced more fresh leaves by 52% compared to the control. In season 2, plants which were treated with 11.5 t ha^{-1} and 15 t ha^{-1} produced the highest fresh yield of 12.3 and 13.5 t ha^{-1} respectively

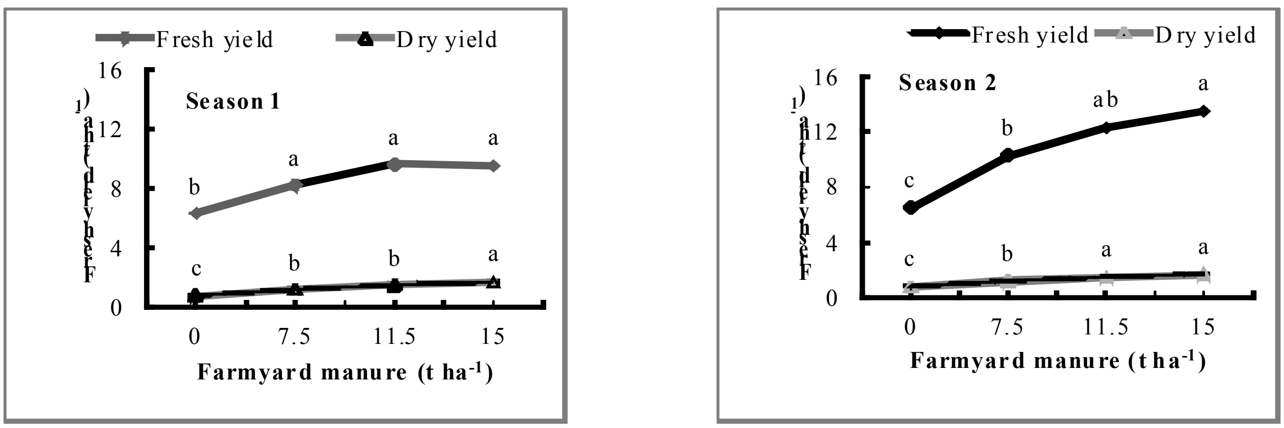


FIGURE 2. Effects of farmyard manure rates on spider plant fresh and dry yield (t ha^{-1}) seasons 1 and 2

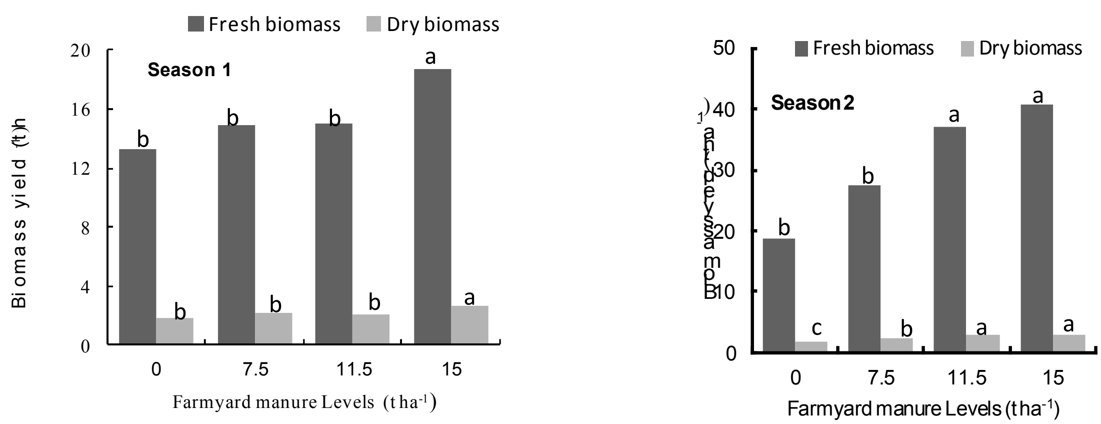


FIGURE 3. Effects of farmyard manure rates on spider plant fresh and dry above ground biomass (tha^{-1}) seasons 1 and 2

Effects of farmyard manure on biomass yield
In season 1, plants treated with 15 t ha^{-1} accumulated more fresh and dry above ground biomass by 30% over the control. Similarly, in the second season, 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 3). However, there was no further significant increase in the biomass yield in plants subjected to farmyard manure above 11.5 t ha^{-1}

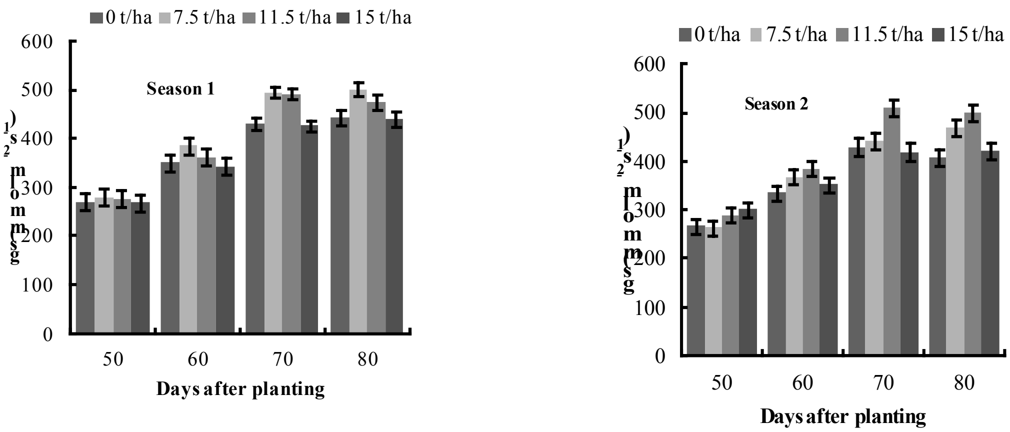


FIGURE 4. Effects of farmyard manure rates on spider plant leaf stomatal conductance (g_s mmol m^{-2} s^{-1}) seasons 1 and 2

Effects of farmyard manure leaf chlorophyll content

Farmyard manure application influenced leaf chlorophyll concentration most of the days that the data were recorded apart from 50 to 60 DAP. Leaves of the plants subjected to the highest (15 t ha^{-1}) of farmyard manure had 16 - 35% more chlorophyll compared to the control.

TABLE 3. Effects of farmyard manure rates on chlorophyll content (SPAD Readings) of spider plant

	Season 1					Season 1				
	Days after Planting (DAP)					Days after Planting (DAP)				
Manure Rates (t ha^{-1})	50	60	70	80	90	50	60	70	80	90
0	30.4a*	38.2a	31.5b	28.0c	29.9b	26.3a	39.6a	33.0c	30.3b	25.2c
7.5	34.9a	45.8a	39.2ab	37.5b	30.8b	32.5a	41.0a	42.3b	33.3ab	29.7b
7.5	31.8a	39.2a	45.4a	39.3ab	37.2ab	31.6a	43.8a	45.8ab	36.4ab	32.9ab
15.0	37.2a	48.0a	46.3a	43.5a	39.0a	33.9a	46.1a	48.7a	40.1a	36.0a

*Means followed by the same letters within a column are not significantly different according to Turkey's HSD at P≤0.05.

Effects of farmyard manure on leaf stomatal conductance

Farmyard manure at 50 DAP in both season, had no influence on stomatal conductance. However, plants that received 7.5 and 11.5 t ha^{-1} exhibited higher stomatal conductance. However, a decline in stomatal conductance was observed in plants subjected to 15 t ha^{-1} in both seasons.

DISCUSSION

Effects farmyard manure vegetative growth

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 levels applied. Chweya and Mnzava (1997) reported that soils with high organic content and adequate mineral nutrients are required to favour the growth and yield of the spider plant. Plants that received low levels of treatments show evidence of reduced growth in all parameters measure and exhibited early flowering hence limiting the further production of marketable leaves. This could be attributed to a possible depletion of soil nutrients in both seasons. In addition, 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. In addition, nitrogen deficiency limits the production of protein and chlorophyll molecules which are essential for production of new cells, thus reducing their growth.

Effects farmyard manure on yield at harvesting intervals

Higher manure rates also resulted into enhanced yield of shoots and leaf numbers per plant. The observation could be attributed to possible significant improvement of spider plant rooting system and hence higher rate of nutrient absorption. This is consistent with previous reports on strawberry Kipkosgei *et al.* (2003) on spider plant and palm *et al.* (1997) on general vegetables including radish and Ondieki *et al.* (2011) on the effect of fortified manure on the yield of African nightshade. The increase in the total yield may due to the effects of organic fertilizers soil aggregation, soil aeration and increasing water holding capacity and offers good environmental conditions for the root system of spider plants. In addition, farmyard manures are slow release nutrients all over the growth seasons. 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). Yield from season 1 was more superior than season 2 because of cold weather experienced later in season 1.

Effects of farmyard manure on biomass yield

The mean fresh and dry biomass yield of spider plant was dependent on the farmyard manure applied in both seasons. The results shows that biomass yield of spider plant increases with increasing rates of farmyard manure and this is attributed to enhanced nutrient uptake with increasing rates of fertilization till a point of stagnation. In addition, farmyard manure fertilizer being an excellent source of macro- and micro-nutrients, could have contributed to enhanced biomass production. 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 rates.

Effects of farmyard manure leaf chlorophyll content

Manure rates affected leaf chlorophyll content of spider plant differently in both seasons. From the results, it evident that increase of farmyard manure rates led to subsequent increase in leaf chlorophyll content of spider plant. This might be due to efficient absorption and assimilation of nitrogen from the manure by the plant which serves as a constituent of chlorophyll which has been reported by to be directly proportional to photosynthetic potential and yield of any given plant (Biljana and Aca, 2009). These results are consistent with those reported by Ondieki *et al.* (2011) who found an increase in Chlorophyll 'a' and 'b' with increase in the levels of fortified compost manure on African nightshade species. 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 also in agreement with those of Sumeet *et al* (2009), who reported that chlorophyll is strongly related to nitrogen concentration in the soil and is constituent of chlorophyll, protein, amino acids and photosynthetic activity.

Effects of farmyard manure on leaf stomatal conductance

The effect of farmyard manure on stomatal conductance varied throughout the growth of spider plant in both seasons. This could be due to ability of farmyard manure to improve structural and hydrological soil properties (Palm *et al*., 1997). This is coupled with improved root development and subsequent increase in potassium absorption which is responsible for regulation of opening and closing of stomata. In addition, the reduction of stomatal conductance at the control treatment and the highest farmyard manure rate could signify that deficiency and excess nitrogen in the soil reduce the leaf gaseous exchange and hence curtailing the process of photosynthesis leading to reduced yield of a given crop. 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).

CONCLUSION

Farmyard manure enhances growth and yield of spider plant. Increase in the application of farmyard manure rates, leads to successive increase in spider plant's growth, fresh edible yield and above ground biomass. In addition, farmyard manure significantly increased stomatal conductance and leaf chlorophyll content of spider plant. The productivity of spider plant can be maximized by application of 11.5 t ha^{-1} of farmyard manure which gives the highest fresh yield of up to 12.3 t ha^{-1}.The dependence on inorganic fertilizers to sustain cropping of spider plant can be limited by the use of farmyard manure. It enhances spider plant growth performance and prolongs harvesting duration.

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