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Full Length Research Paper

Effects of nitrogen levels on growth and yield of spider plant in Kenya

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The supply of spider plant (*Cleome gynandra*) as one of the African leafy vegetables in Kenya is low and this is attributed to poor fertilizer use and limited access by farmers to improved varieties. This study was carried out to evaluate the effect of different N forms on growth and yield of spider plant. Greenhouse and field experiments were conducted in 2011 and 2012 in Ruiru and Juja. Objectives were: to determine the plant growth and yield of spider plant cultivars under different nitrogen levels. 8 lines that were developed at the World Vegetable Centre, Arusha, were evaluated alongside the commercial variety (control). All experiments were undertaken for 2 seasons, where both variety and nitrogen factors were investigated under split plot design. Plants were harvested at 7-10-day intervals. Data was analyzed in SAS 9.1.3 software. Accessions were ranked from 1-9 in terms of performance. Results indicated that application of manure resulted in increased yield and other growth parameters compared to other nitrogen fertilizers ($P \leq 0.05$). Availability of improved and high yielding cultivars coupled with use of manure will increase supply of spider plant.

Keywords: African leafy vegetables, Cleome gynandra, manure, cultivars.

INTRODUCTION

Spider plant (cleome gynandra) is amongst the most preferred African leafy vegetables in the tropics. It contains numerous vitamins, minerals and bioactive phytochemical compounds for nutritional and health benefits. Studies have shown that spider plant *(Cleome gynandra)* is among the African leafy vegetables (ALVs) whose consumption has grown steadily in Kenya. Its health and economic benefits have been explored extensively in the recent past (Ojiewo *et al.*, 2010). However, limited access by farmers to improved spider plant varieties and low fertilizer use are major causes of low fresh leaf yields for this crop. To increase production of traditional leafy vegetables, use of correct fertilizer type and amount is inevitable. Nitrogen is a vital mineral element for plant growth which affects not only the biomass accumulation but also the nutritional quality of higher plants. Nitrogen is an important nutrient that is constituent of amino acids, proteins and DNA that are part of cell division. Additionally, it is a major component of chlorophyll that is the backbone of photosynthesis.

Mineral fertilizer releases nitrogen faster than manure, which is a slow release and thus, takes time to mineralize in the soil. In principle, manure-nitrogen will be available to the plants for a longer period due to lower prevalence to leaching and/or volatilization. Besides nitrogen, manure also has other important plant nutrients that are essential for plant growth. Manure is an important source of essential plant nutrients and organic matter for crop production (Ogendo *et al.* 2008). It leads to improved soil physical properties, water-holding capacity, cation carbon to nitrogen ratio that facilitates speedy nitrification exchange capacity (Brady, 1984).

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Nutrients in manure are released over a long period of time, which can be up to three years (Macer, 1973). Manure also reduces soil (Brady, 1984). Previous research has shown that application of nitrogen increased fresh and dry above-ground biomass in leafy vegetables between levels of 100-250kg N/ha (van Averbeke *et al*., 2007). Yields are also being improved through selection of genotypes of spider plant, which has intensified in the recent past (Onim and Mwaniki, 2008; Masinde, 2011), since commercial varieties have shortfalls such as yield, nutrient, and geographical diversity. Limited access to quality seed and shortage of suitable cultivars has been key cause of low spider plant productivity (Abukutsa-Onyango, 2010b). Commercial farmers apply nitrogen in order to obtain higher yields of spider plant (Agong and Masinde, 2006). Mauyo *et al*. (2008) have shown that applying nitrogen significantly increased plant height, number of leaves and shoots, and fresh yields ($p \leq 0.05$), which is either organic or inorganic. Use of inorganic and organic fertilizers significantly improved yields of *Brassica oleracea* var *oleracea* (Wambani *et al*. 2006). Although it was not a component of this study, literature has shown that crop higher yields were obtained when organic and inorganic sources were combined (Herman, 2011). Mtambanengwe *et al*. (2006) observed that N availability from low quality organic materials can be improved with the application of inorganic fertilizer.

MATERIALS AND METHODS

Field trials were carried out in order to evaluate, select and document spider plant varieties agronomic performance. Field experiments were conducted in Ruiru District situated in Central Province, Kenya, between March-June 2011 and April-July 2012; its geographical coordinates are latitude1° 9' 0" S, and longitude 36° 58' 0" E. The area is classified under sub-tropical highland climate, by Köppen climate classification system, receives average annual rainfall of 1,025 mm. Temperature range is 10-26°C with altitude of 1,795 m above sea level. The soils are typically red on undulating topography. Main human activities include coffee farming, dairy, and horticulture (MoA, 2008). The experimental factors tested consisted of three nitrogen levels. The nitrogen levels were manure, 2.6 g N/plant and 5.2 g N/plant. 1 bucket, each weighing 10kg of fine and well decomposed cattle manure, were put in each sub-plot measuring 1.2 m by 3 m. Both experiments were laid out as a complete randomized design (CRD) with three replications. Analyses of variance (ANOVA) were done using SAS (SAS 9.1.3) for dry weight, leaf area, height and number of leaves. The level of significance was at $p<5\%$ and mean separation was done using LSD.

RESULTS AND DISCUSSION

Effect of Nitrogen levels on plant height of spider plant accessions across harvesting periods in Ruiru season one

Application of manure had significant effect ($P \leq 0.05$) on the plant height of the various accessions of spider plant during the long season in Ruiru Table 4.1). The height of the plant increased with the duration in weeks and at the ninth week, the plant height was at its highest length. However, there was no significant increase in plant height due to application of mineral nitrogen at levels of 2.6 g and 5.2 g/plant. In the second season, manure significantly increased the height of spider plant compared to the other two levels of N application (2.6 g and 5.2 g/plant) across harvesting periods ($P \leq 0.05$). There was no significant increase in plant height as a result of applying nitrogen at the levels of 2.6 g and 5.2 g/plant in the second season (Table 4.2). The average plant height for the second season in Ruiru was higher compared to the first season across different harvesting periods.

Influence of nitrogen levels on the stem size across different harvesting periods in Ruiru season one

Application of nitrogen fertilizer significantly influenced ($P \leq 0.05$) the size of spider plant stem across harvesting periods. Application of 5.2 g of nitrogen fertilizer per plant significantly produced bigger stem sizes in the fifth and sixth week compared to those plants where manure and 2.6 g nitrogen per plant was used (Table 4.3). However, in the eighth and ninth week, there was no significant difference in the stem sizes as a result of application of nitrogen.

In the second season, application of nitrogen fertilizers significantly influenced ($P \leq 0.05$) the size of spider plant stem throughout the harvesting periods (Table 4.4). Application of manure resulted in bigger stem sizes of spider plant compared to the application of 2.6 g and 5.2 g of nitrogen across all the harvesting periods.

Influence of nitrogen levels on the number of leaves of spider plant across various harvesting periods in Ruiru season one

The amount of nitrogen level application on spider plant significantly influenced ($P \leq 0.05$) the number of leaves of the plant in Ruiru long season (Table 4.5). There were more leaves when 5.2 g of nitrogen fertilizer was used compared to manure in the first five weeks of harvesting. There was no significant difference in the number of leaves across the sixth and ninth week of harvesting (Table 4.6).

In the second season, application of manure significantly influenced ($P \leq 0.05$) the number of leaves of spider plant leaf across various harvesting periods. Application of manure resulted into increased leaves compared to other nitrogen levels across all the five harvesting periods (Table 4.7).

Effect of nitrogen levels on yields of spider plant across different harvesting periods in Ruiru season one

Application of different nitrogen levels on spider plant significantly ($P \leq 0.05$) influenced the yields in Ruiru season one across different harvesting periods (Table 4.8).

Table 4.1: Effect of Nitrogen levels on plant height across different harvesting periods at Ruiru season one.

Harvesting period in weeks

N- levels5	**6**	**7**	**8**	**9**	
Manure	16a	24.15a	34.11a	44.3a	55.8a
2.6 g N/plant	14.11b	21.04b	30.19b	40.0b	50.4b
5.2 g N/plant	15.11ab	20.78b	29.85b	39.22b	49b
LSD	**1.75**	**2.069**	**2.921**	**3.797**	**4.92**
CV%	**6.8**	**7.7**	**4.8**	**4.3**	**7.5**

Means in a same column followed by different letter (s) are significantly different at P<0.05 NS = Not significant.

Table 4.2: Effect of Nitrogen levels on plant height across different harvesting periods at Ruiru second season.

Harvesting period in weeks

N- levels5	**6**	**7**	**8**	**9**	
Manure	15.96a	34.52a	60a	75.1a	92.5a
2.6 g N/plant	12.48b	25.11b	42.19b	57b	70.6b
5.2 g N/plant	12.48b	25.74b	43.56b	59.5b	75b
LSD	**0.641**	**1.802**	**4.41**	**7.39**	**9.06**
CV%	**2.3**	**4.8**	**12.6**	**14.3**	**11.8**
**	**	**	**	**	

Means in a same column followed by different letter (s) are significantly different at P<0.05 NS = Not significant. * Significant at $\alpha=0.05$** Significant at $\alpha=0.01$

Table 4.3: Effect of nitrogen levels on stem size across different harvesting periods in Ruiru season one.

Harvesting period in weeks

N- levels 5	**6**	**7**	**8**	**9**	
Manure	0.195b	1.081a	2.03b	4.57a	4.88a
2.6 g N/plant	0.24ab	1.031a	2.83a	4.17a	5.18a
5.2 g N/plant	0.249a	1.181a	2.18b	4.28a	4 .7a
LSD	**0.0527**	**0.549**	**0.63**	**0.897**	**0.584**
CV%	**22.3**	**6**	**0.6**	**1**	**11.5**
p-value	**0.096**	**0.351**	**0.03**	**0.652**	**0.251**

Means in a same column followed by different letter (s) are significantly different at P<0.05 NS = Not significant.

Manure application resulted into more yields in the fifth and sixth week of harvesting compared to application of 2.6 and 5.2 g of nitrogen per plant.

In the second season, application of nitrogen levels influenced yields of spider plant across all the harvesting periods ($P \leq 0.05$). Manure produced the highest yields

Table 4.4: Effect of nitrogen levels on stem size across different harvesting periods in Ruiru season two

Harvesting period in weeks

N- levels5	**6**	**7**	**8**	**9**	
Manure	0.285a	0.943a	2.567a	4.2a	4.88a
2.6 g N/plant	0.199b	0.699b	1.843b	2.59b	3.43b
5.2 g N/plant	0.205b	0.733ab	2.153b	3.1b	3.78b
LSD	**0.0792**	**0.2327**	**0.3778**	**0.536**	**0.594**
CV%	**37.2**	**18.3**	**16.1**	**25.1**	**17.3**
p-value	**0.061**	**0.084**	**0.001**	**0.001**	**0.001**

Means in a same column followed by different letter (s) are significantly different at P<0.05 NS = Not significant.

Table 4.5: Effect of nitrogen levels on the number of leaves across different harvesting periods in Ruiru season one.

Harvesting period in weeks

N- levels 5	**6**	**7**	**8**	**9**	
Manure	0.273b	0.853a	2.16a	3.16a	3.25a
2.6 g N/plant	0.428a	0.926a	2.62a	3.31a	3.78a
5.2 g N/plant	0.433a	0.958a	2.33a	3.26a	3.44a
LSD	**0.0918**	**0.2371**	**0.554**	**0.592**	**0.566**
CV%	**1.4**	**7.2**	**9.1**	**0.7**	**13.1**
p-value0.001	**0.66**	**0.248**	**0.872**	**0.172**	

Means in a same column followed by different letter (s) are significantly different at P<0.05.

Table 4.6: Effect of nitrogen levels on the number of leaves across different harvesting periods in Ruiru season two

Harvesting period in weeks

N- levels 5	**6**	**7**	**8**	**9**	
Manure	0.342a	0.829a	2.313a	4.1a	5.08a
2.6 g N/plant	0.209b	0.625b	1.662b	2.44c	3.35bc
5.2 g N/plant	0.253b	0.613b	1.992b	3.11b	3.94b
LSD	**0.0694**	**0.1898**	**0.554**	**0.572**	**0.635**
CV%	**47.1**	**20.9**	**22.4**	**25.1**	**19.6**
p-value	**0.001**	**0.045**	**0.248**	**0.001**	**0.001**

Means in the same column followed by different letter (s) are significantly different at P<0.05.

across all the harvesting periods compared to all other nitrogen levels. Consequently, there was no significant different in yields of spider plant as a result of application of either 2.6 g or 5.2 g of nitrogen per plant.

Table 4.7: Effect of nitrogen levels on the yields of spider plant across different harvesting periods in Ruiru season one.

Harvesting period in weeks					
N- levels	**5**	**6**	**7**	**8**	**9**
Manure	1012a	758a	419a	380a	664a
2.6 g N/plant	694b	465b	303a	288a	596a
5.2 g N/plant	755ab	506b	296a	280a	610a
LSD	**304.9**	**205.2**	**144.5**	**144**	**173.1**
CV %	**30.9**	**12.6**	**9.7**	**11.5**	**19.4**
p-value	**0.095**	**0.012**	**0.17**	**0.306**	**0.712**

Means in a same column followed by different letter (s) are significantly different at P<0.05.

Table 4.8 Effect of nitrogen levels on the yields of spider plant across different harvesting periods in Ruiru season two

Harvesting period in weeks					
N- levels	**5**	**6**	**7**	**8**	**9**
Manure	1787a	1374a	2163a	1969a	1920a
2.6 g N/plant	930b	683b	1521b	1342b	1394b
5.2 g N/plant	941b	743b	1632b	1473b	1437b
LSD	**382.2**	**332.3**	**187.5**	**253.9**	**208.1**
CV %	**41.8**	**37.8**	**12.8**	**15.2**	**10**
p-value	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**

Means in a same column followed by different letter (s) are significantly different.

DISCUSSION

Manure produces heavier flowers as opposed to fertilizer. This is due to the added benefit of improved soil structure, organic matter and other nutrients. There is higher nutrient use efficiency for manure because there is less leaching, fixation and volatilization compared to mineral fertilizers. Similarly, the leaf area under manure was significantly higher than the mineral fertilizer nitrogen. The number of leaves is significantly influenced by the varieties' characteristics as opposed to application of different nitrogen rates.

There was significant difference between yield from manure and fertilizer. However, there was no significant difference among the 2 levels of nitrogen fertilizers. Therefore, farmers would rather apply the lower rate of fertilizer nitrogen of 2.6 g per plant or less, in order to save cost and also conserve the environment. Excess nitrogen causes non-point source nitrate pollution of groundwater, when it is lost through leaching and/or runoff that cause eutrophication of water bodies (Alva *et al.*, 2008). It also volatizes into the atmosphere as nitrous oxide that accelerates global warming. When applied at high rates as fertilizer, plants continue to uptake (nitrogen) thus, causing phytotoxity. When eaten, such crops can have high level of nitrogen dosage beyond recommended daily intake. Many plants, especially leafy vegetables, accumulate nitrate under low light conditions as uptake of nitrate exceeds reduction. Plants adapted to higher pH and more aerobic soils prefer nitrate uptake as opposed to ammonium or amino acids (Maathius, 2009). Nitrate may harm the health of the consumer as it is converted to nitrite causing methaemoglobinaemia or carcinogenic nitrosamines (Blom-Zandstra, 2008). Acceptable daily intake (ADI) for nitrate of 0–3.7mg nitrate ion/kg body weight (WHO/FAO, 2012).

CONCLUSION AND RECOMMENDATIONS

The above findings indicate that application of manure significantly increases both growth and yield variables in spider plant. The study therefore recommends that spider plant farmers should strive to incorporate manure application during planting. Furthermore, efforts should be geared towards making farm manure so as to achieve sufficient amount that can be incorporated into spider plant production in large scale.

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