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Kenneth Mutoro & Kalio S. Wasike

University of Agriculture and Technology

ABSTRACT

The supply of spider plant (Cleome gynandra L.) as one of the African leafy vegetables in Kenya is low and this is attributed to limited access by farmers to improved varieties. This study was carried out to evaluate the comparative effect of different accessions on growth of spider plant in greenhouse and outdoor systems. Greenhouse and outdoor experiments were conducted in 2011 and 2012 in Juja and Ruiru sub counties of Kiambu county, Kenya. The main objective was: to determine the influence of spider plant genotypes on plant growth variables, and compare the two production systems of outdoor and greenhouse. The 4 lines that were developed at the World Vegetable Centre, Arusha, were evaluated alongside the commercial variety, P6 (control). Plants were harvested at 6 and 9 weeks old, and both plant height and leaf area estimated. Data was analyzed in SAS 9.1.3 software. Accessions were ranked from 1-5 in terms of performance. Results indicated that UGSF14 and MLSF17 produce more leaf area and tall plants compared to all other genotypes under the outdoor system. The study recommended that farmers should grow improved spider plant varieties under outdoor system rather than in the greenhouse in order to realize more yields.

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Author α: Department of Horticulture and Food Security, Jomo Kenyatta University of Agriculture and Technology, P.O. Box 62000-00200, Nairobi, Kenya.
σ: *Kalio S. Wasike (Masinde Muliro University of Science & Technology Kakamega, Kenya).*

I. INTRODUCTION

Spider plant (*Cleome gynandra* L.) is amongst the most preferred African leafy vegetables (ALVs) in the tropics. It contains numerous vitamins, minerals and bioactive phytochemical compounds for nutritional and health benefits. Most of the ALVs can considerably contribute to requirements of vitamin A and iron, both critical nutrients for developing countries (Jaarsfeld *et al.*, 2014). Studies have shown that spider plant is among the African leafy vegetables 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 is a major cause of low fresh leaf yields for this crop. To further improve production, plant nutrition through use of nitrogen rich organic manure is also important. 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 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 more 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

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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 exchange capacity (Ng'etich *et al.,* 2012). Nutrients in manure are released over a long period of time, which can be up to three years (Herman, 2011). Manure also reduces soil carbon to nitrogen ratio that facilitates speedy nitrification (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), considering that commercial varieties have shortfalls with regard to 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 fertlizer in order to obtain higher yields of spider plant (Agong and Masinde, 2006). Mauyo *et al.* (2008) have shown that applying nitrogen fertlizer 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). However, nitrogen phytotoxity can be harmful to human health (Blom-Zandstra, 2008). Although it was not a component of this study, literature has shown that higher crop yields were obtained when organic and inorganic sources were combined (Herman, 2011). Vorster and Rensburg (2005) and Mtambanengwe *et al.* (2006) observed that N availability from low quality organic materials can be improved with the integration of inorganic fertilizer.

II. MATERIALS AND METHODS

Greenhouse and outdoor experiments were carried out in order to evaluate, select and document spider plant varieties' agronomic performance. Experiments were conducted in neighboring Juja and Ruiru sub counties situated in Kiambu county, Kenya, between March-June 2011 and April-July 2012; its geographical coordinates are latitude 1° 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 five spider plant genotypes. The genotypes included: P6; MLSF17; UGSF9; UGSF14 and UGSF36. 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 height and leaf area of spider plant. The level of significance was at $p<5\%$ and mean separation was done using LSD.

III. RESULTS AND DISCUSSION

3.1 Effect of genotypes on plant height across harvesting periods in outdoor and greenhouse.

Genotypes significantly influenced the height of spider plant across different harvesting periods between greenhouse and outdoor experiment (Table3.1). UGSF 14 had the tallest and significance plant under outdoor system in the sixth week of harvesting compared to the other four genotypes. MLSF 17 was the second in plant height after UGSF14. However, in the 9th week of harvesting MLSF 17 had the tallest plant height compared to all other genotypes while UGSF14 and UGSF36 had the second tallest crop among the group. In the greenhouse production system, there was no significance difference in the height of the plant between different genotypes at both the 6th and 9th week of harvesting (Table 3.1). Genotypes produced tall plants when planted in the outdoor than when planted in the greenhouse environment (Table 3.1). The above findings can be attributed to the inability of spider plant being unable to produce better yields due to restrictions in the greenhouse condition such as nutrients, root expansion and micro climate (Jaarsfeld *et al.* 2014). In the outdoor system, plants were not planted in polythene bags and hence root development and absorption of nutrients was not limited. This further indicates that spider plant is not suited for greenhouse production and hence its productivity is compromised when planted in the greenhouse than compared when planted in the outdoor production system.

Table 3.1: Effect of genotypes on plant height across different harvesting periods in outdoor and greenhouse production systems

	OUTDOOR		GREENHOUSE	
Genotypes	**6**	**9**	**6**	**9**
MLSF17	9.22b	81.33a	14.78a	46.78a
UGSF14	11.44a	70.22b	13.67a	42.56a
UGSF36	10.11ab	68.44b	14.67a	45.22a
UGSF9	10.56ab	76.22ab	14.11a	50.33a
P6	9.89ab	74.78ab	14.33a	46.33a
LSD	1.534	6.63	1.559	6.017
CV%	8.4	9.6	4.3	18.9

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

3.2 Effect of genotypes on plant leaf area across different harvesting periods in outdoor and greenhouse systems.

Genotypes significantly influence the leaf area of spider plant across different harvesting periods (Table 3.2). In the 6th week of harvesting, there was no significance difference between the leaf areas of spider plant among the five genotypes evaluated under outdoor production system. There was a significance difference in the leaf area of spider plant between difference genotypes at the 9th week of harvesting under the outdoor system. MLSF17 had the largest leaf area under the outdoor system in the 9th week of harvesting compared to all other genotypes; all other four genotypes had no significance difference in their leaf area. There was no significant difference in the leaf area of various genotypes of spider plant and across harvesting periods under greenhouse production system (Table 3.2).

In the 9th week of harvesting, genotypes produced the largest leaf area under outdoor production system compared to the greenhouse production system at the same time. Similarly, the results indicate that spider plant will produce more leafy material when grown in the outdoor system than when grown in the greenhouse environment. The probable reason for the differences being attributed to imbalance in supply of both nutrients due to micro-climate in the greenhouse where evapotranspiration is limited compared to the outdoor condition (Albright, 2002).

Table 3.2: Effect of genotypes on plant leaf area across harvesting periods in outdoor and greenhouse systems

Genotypes	OUTDOOR 6	OUTDOOR 9	GREENHOUSE 6	GREENHOUSE 9
MLSF17	49.75a	1239.3a	44.74a	185.8a
UGSF14	46.83a	929.4b	39.31a	172.4a
UGSF36	35.22a	895.7b	44.02a	135.5a
UGSF9	38.79a	915.2b	45.26a	157.7a
P6	41.2a	961ab	43.71a	179.3a
LSD	14.51	206.5	10.19	56.02
CV%	22.7	32.9	3.1	56.3

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

IV. CONCLUSION AND RECOMMENDATIONS

There is higher nutrient use efficiency for spider plant when planted in the outdoor system compared to the greenhouse environment. MLSF17 and UGSF14 produce the tallest plants compared to all other genotypes when planted in the outdoor system. Under greenhouse conditions, all genotypes will produce similar heights and leaf area.

The number of leaves and total lea area are significantly influenced by the genotypes' characteristics. MLSF17 and UGSF14 produce the largest amount of leaf surface area compared to all other genotypes when planted in the outdoor system.

The present study thus, recommends that farmers should adopt UGSF14 and MLSF17 in order to realize more yields from spider plant cultivation. Furthermore, emphasis should be in production of spider plant under outdoor system compared to the greenhouse environment. The conclusion agrees with Albright (2002), who reported that greenhouse environment affects wind and humidity that in turn, influence evapotranspiration and pollination.

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