EVALUATION AND SELECTION OF SPIDERPLANT *(CLEOME GYNANDRA* L.*)* VARIETIES SUITED FOR PRODUCTION IN KENYA

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Abstract

Limited access by farmers to improved spider plant *(Cleome gynandra)* varieties and low fertilizer use are major causes of low leaf yields for this crop. Surveys have shown that the crop is among traditional leafy vegetables whose consumption is on the increase in Kenya. Greenhouse and field experiments were conducted in 2011 and 2012 in Ruiru and Juja. Objectives were: to determine the plant growth and yield; to undertake a survey of both farmer and consumer preference; and to establish their comparative nutritional profile under different agronomic conditions. 8 lines that were developed at the World Vegetable Centre, Arusha, were evaluated alongside the commercial variety (control). They included UGSF25, MLSF17, UGSF3, UGSF14, UGSF25, UGSF36, IP3 and UGSF9. All experiments were undertaken for 2 seasons, where both variety and nitrogen factors were investigated under split–plot design. Measurements were done to quantify growth in terms of height, leaf number, yield, leaf area, SPAD and dry weight. Plants were harvested at 7-10 day intervals. Data was analysed in SAS 9.1 and SPSS software. Varieties were ranked from 1-9 in terms of performance. The top 5 varieties - MLSF17, UGSF14, UGSF36, UGSF9 and control were selected for further evaluation. Market survey and participatory evaluation for both sensory tests and on-farm farmer surveys were undertaken for both crop seasons I and II. Results indicated that line MLSF17 had the highest yields followed by UGSF14, Control, UGSF9 and UGSF36 respectively at $p \leq 0.05$. However, there was no significant difference for varietal preference by spider plant growers and consumers. Availability of improved and high yielding spider plant cultivars will leverage farmers to cultivate this crop and explore different agro ecological zones for increased leaf yield.

Key words: African leafy vegetables, *Cleome gynandra*, CAN fertilizer, manure, cultivars, participatory evaluation

1 Introduction

Studies have shown that spider plant *(Cleome gynandra)* is among the African leafy vegetables (ALVs) whose consumption has risen steadily in Kenya. Their status has risen significantly to be ranked among internationally recognized vegetables with high nutritional, medicinal and economic potential. 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. Selection of genotypes of spider plant has intensified in the recent past, (Masinde, 2011), since commercial varieties have shortcomings such as yield, nutrient, and geographical diversity.

As the demand for ALVs increase, their role in food security continue to become recognized by funding agencies, policy makers, educators, health workers and other stakeholders (Abukutsa, 2010a). This increase in demand continue to attract new growers, while current growers raise acreage and adopt intensive monoculture production systems that use fertilizers, manure and irrigation. Commercial farmers apply nitrogen in order to obtain higher yields of spiderplant (Agong and Masinde, 2006, Minja *et al.,* 2008). Application of nitrogen has been shown to increase fresh and dry above-ground biomass in leafy vegetables between levels of 100-250 kg N/ha. Mauyo *et al*. (2008) have shown that applying nitrogen significantly increased plant height, number of leaves and shoots, and fresh yields ($p \leq 0.05$). Chweya (1990) reported availability of 4 spiderplant genotypes currently being grown in Kenya ranging from green to purple pigmentation. Limited access to quality seed and shortage of suitable cultivars is key cause of low spiderplant productivity (Abukutsa-Onyango, 2010b). Research work is being undertaken by relevant institutions in specific agroecological zones (Hutchinson *et al.*, 2006), and there are high yielding lines that have been developed by research institutions, which need to be evaluated.

During this study, field and greenhouse experiments were conducted in 2011 and 2012 in Ruiru and Juja. Objectives were: to determine the plant growth and yield; and to undertake a survey of both farmer and consumer preference conditions. 8 lines of spider plant that were developed at the World Vegetable Centre, Arusha, were evaluated alongside the commercial variety (control). They included UGSF25, MLSF17, MLSF3, UGSF14, UGSF25, UGSF36, IP3 and UGSF9. All experiments were undertaken for 2 seasons, where both variety and nitrogen factors were investigated. Measurements were done to quantify growth in terms of height, leaf number, yield, leaf area, SPAD and dry weight. Plants were harvested at 7-10 day intervals and data was analyzed accordingly. After ranking, the top 5 varieties - MLSF17, UGSF14, UGSF36, UGSF9 and control were selected for further evaluation. Participatory evaluation of both of consumer and grower is an indicator for acceptability. Results indicated that line MLSF17 had the highest yields followed by UGSF14, Control, UGSF9 and UGSF36 respectively at $p \leq 0.05$. However, there was no significant difference for varietal preference by spider plant growers and consumers. Availability of improved and high yielding spider plant cultivars will leverage farmers to cultivate this crop and explore different agro ecological zones for increased leaf yield. The new varieties have potential to yield more than the reported ceiling in addition to better horticultural traits such as stress tolerance (Ojiewo *et al.*, 2010).

2 Materials and Methods

2.1 Experimental Sites

The field experiments were conducted at Ruiru situated in Central Province, Kenya, between March-July 2011 and March-July 2012; its geographical coordinates are 1° 9' 0" S, 36° 58' 0" E. The area is classified under sub-tropical highland climate (Köppen climate classification), 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 consisted of 9 genotypes and 3 nitrogen levels. Another field trail was conducted at the department of Horticulture, Jomo Kenyatta University of Agriculture and Technology (JKUAT) (latitude. 1º 10' 48' S, long. 37º 07' 12' E) greenhouses from JKUAT farm between May and September 2012. The soil classification is montmorillonite clay over petroplinthite. The experimental factors consisted of 5 genotypes and 3 nitrogen levels. Greenhouse experiments were conducted at between March and June, and June and September 2012.

2.2 Greenhouse Experiments

Both greenhouse experiments were laid out as a complete randomized design with three replications. The total number of pots in the greenhouse was 225. The soil used in this study was a mixture of red soil and black cotton soil (ratio 1:1) with composite nitrogen level of .08% N and pH corrected to 6.2. Average diurnal temperatures ranged from 15 to 37ºC. Plastic pots were each filled with 4 kg of air-dried soil each. About 10 seeds of each genotype were then sown in the pots, watered and covered by dry grass. Watering was done by horse pipe daily to keep the soil moist. The nitrogen treatments of 0, 2.6 and 5.2 gN/plant were applied in 4 splits, with first quarter of the nitrogen level at three weeks after planting, and the rest 4 days apart after planting using calcium ammonium nitrate (CAN) (26% N) fertilizer. Aphids were controlled by spraying with pirimor® (2-Dimethylamino-5,6-dimethylpyrimidin-4-yl dimethyl- carbamate), at 2.5 mg/litre of water. During flowering, the flowers were removed daily to encourage vegetative growth.

Destructive and non-destructive samplings were done at 10 days-interval starting from the day the first nitrogen split was applied. Plant height for all the plants was measured weekly by use of a meter rule and the number of leaves of all plants counted. Chlorophyll concentration was measured weekly using SPAD meter, each time measuring the 10th youngest leaf on the main stem. A total of five harvests were done. At each harvest three plants were selected randomly and cut at the soil base for each nitrogen level and genotype. The shoots were then divided into the stem, leaf blades and petioles. The area of the leaf blades was measured by using leaf area meter (model 3100 LICOR Lincoln Nebraska, USA).The plant parts were then dried at 72ºC for 72 hours, weighed to obtain the dry weights. Dry matter was measured to determine chemical profile for selected nutrients.

2.3 Field Experiments

The field experiments were laid out as a split-plot in a randomized block design with three replications and three nitrogen levels. There were nine genotypes in Ruiru and five at JKUAT. The nitrogen treatments in both sites were well decomposed cattle manure, 2.6 and 5.2 gN/plant. The nitrogen levels were the main plots while the genotypes formed the sub plots. Direct sowing was done on finely tilled beds measuring 1.2 m x 10 m. The seeds were placed in furrows made at a spacing of 30 cm between furrows. Three weeks after planting, thinning was done leaving intra-row spacing of 10cm. Plant population per subplot was determined. The nitrogen treatments were applied in two splits, with the first half being applied after thinning and the second half two weeks later. The fertilizer was weighed according to the plant population and fertilizer level and applied along drills on the plots ensuring that each row of plants was in between two drills to avoid plant damage. Farmer, market and consumer preference surveys were conducted for both crop seasons at Ruiru. Spider plant farmers selected with help of local District Agricultural Officer were invited to the experimental site to evaluate the spider plant lines at harvesting stage. The farmers filled in a simple questionnaire requiring them to indicate their overall preference.

In one of the harvests, the shoots were bundled according to the lines. Once on the retails market, observation was made on customer selection and the data filled out in a simple form. The preference of consumers was established in organoleptic evaluation. The shoots of the spider plant lines were boiled and a panel of non-trained consumers will be invited to taste and filled a questionnaire.

2.4 Data Analysis

Analyses of variance (ANOVA) were done using SAS (SAS, 1999) for dry weights, leaf area and N content. The level of significance was at p≤5% and mean separation was done using LSD. The farmer, market and consumer survey results were analyzed using SPSS.

3.0 Results

3.1 Growth and Yield

The average fresh leaf yield per plant per genotype varied from 52 to 76 g for Ruiru season I (Table 1), 64 to 95 g for Ruiru season II (Table 2), and 76 to 84 g for JKUAT crop (Table 3). There was improvement in yield from season II compared to season I. The JKUAT crop yield was not significantly different.

3.1.1 Fresh Leaf Yield

Table 1: Fresh leaf yield (g) for Ruiru season I

Genotype	**Control**	**MLSF17**	**MLSF3**	**UGSF9**	**UGSF12**	**UGSF25**	**UGSF36**	**IP3**	**UGSF14**	**Total**
Plant pop	1283	1462	1314	1413	1229	1617	1468	1265	955	12006
Yield (g)	65354	89672	56040	75180	89064	82424	78734	82758	82736	701962
yield/plant	52	62	44	54	74	52	54	66	76	60

Table 2: Fresh leaf yield (g)for Ruiru season II (Manure plots)

Genotype	**Control**	**MLSF17**	**MLSF3**	**UGSF9**	**UGSF12**	**UGSF25**	**UGSF36**	**IP3**	**UGSF14**	**Total**
Plant pop	433	418	445	434	462	445	387	457	433	3914
Yield (g)	38160	39610	28340	38610	34140	31520	28330	33690	38160	310560
yield/plant	88	95	64	89	74	71	73	74	88	79

Table 3: Fresh leaf yield (g) for JKUAT outdoor

Genotype	**Control**	**MLSF17**	**UGSF14**	**UGSF9**	**UGSF36**	**Total**
Plant pop	712	1096	1036	1072	972	4888
Yield (g)	56248	92064	81844	81472	79704	391332
yield/plant	79	84	79	76	82	80

3.1.2 Fresh leaf area

The highest fresh leaf area observed per plant per genotype varied from 432 to 1104 cm^2 for Ruiru season I with nitrogen treatment 3 having the highest value (table 4). For season II, leaf area ranged from 1353 cm^2 for genotype UGSF25 to 1909 cm^2 for genotype MLSF17 (Table 5). For the JKUAT crop, manure gave the highest fresh leaf area of 1414 cm^2 compared to 589 for treatment 2.6 gN/plant (Table 6) measured across the five genotypes.

Table 4: Leaf area (LA) in cm^2 for Ruiru season I

										Mean	
Genotype	**Control**	**MLSF17**	**MLSF3**	**UGSF9**	**UGSF12**	**UGSF25**	**UGSF36**	**IP3**	**UGSF14**	Manure	2.6g/N	5.2g/N
LA1	119	85	91	56	72	56	73	80	83	89	79	70
LA2	184	172	193	168	174	191	183	169	167	196	166	172
LA3	250	406	387	262	481	420	511	427	430	394	427	370
LA4	545	513	495	527	775	384	526	580	642	495	617	551
LA5	679	679	511	432	778	416	659	989	1104	631	729	765

Table 5: Leaf area (LA) in cm^2 for Ruiru season II

											Mean
Genotype	**Control**	**MLSF17**	**MLSF3**	**UGSF9**	**UGSF12**	**UGSF25**	**UGSF36**	**IP3**	**UGSF14**	Manure	2.6g/N	5.2g/N
LA1	107	98	112	91	94	97	88	94	115	130	85	86
LA2	342	287	362	329	267	284	265	318	316	393	254	277
LA3	555	591	541	562	563	461	518	479	536	668	471	464
LA4	983	1033	1012	964	983	795	888	910	1028	1208	797	860
LA5	1746	1909	1770	1670	1603	1353	1728	1722	1638	2044	1455	1548

Table 6: Leaf area (LA) in cm^2 for JKUAT

						Mean		
	Control	**MLSF17**	**UGSF14**	**UGSF9**	**UGSF36**	Manure	2.6g/N	5.2g/N
LA1	50.3	49	32	37	35	45.7	35	40.8
LA2	308	227	232	218	205	305	181	228
LA3	504	579	628	617	593	662	486	589
LA4	1355	848	981	763	1022	1414	589	1025

3.1.3 Dry Leaf Weight

Genotype UGSF36 recorded the highest leaf dry weight (LDW) of 4.89 and 4.5 g/plant respectively for both seasons in Ruiru (Table 7 and 8). IP3 had the lowest at 1.93 g/plant for Ruiru season I (Table 7) and UGSF12 and UGSF25 had lowest for season II in Ruiru (Table 8). For both seasons, manure had the highest mean LDW compared to 2.6 and 5.2 gN/plant. MLSF17 had the highest seed weight of 471.8 g per 100 seeds while MLSF3 had the lowest 424.8 g (Table 11).

Table 7: Leaf dry weight (DW) in g for Ruiru season I

									Mean		
Genotype	**Control**	**MLSF17**	**MLSF3**	**UGSF9**	**UGSF12**	**UGSF25**	**UGSF36**	**IP3**	**UGSF14**	Manure	2.6g/N	5.2g/N
LDW1	0.57	0.35	0.45	0.28	0.37	0.28	0.36	0.36	0.38	0.38	0.37	0.38
LDW2	0.83	1.04	0.94	0.73	1.01	0.94	1.11	0.72	0.9	0.99	0.87	0.88
LDW3	1.6	3.2	2.17	1.87	2.48	2.32	2.64	2.64	2.4	2.15	2.59	2.37
LDW4	3.06	3.02	2.61	3.38	2.98	2.48	3.38	3.29	4.96	3.27	3.22	3.23
W5	3.17	3.6	3.89	2.45	3.5	3.57	4.89	1.93	4.38	3.6	3	3.9

Table 8: Dry weight (DW) in g for Ruiru season II

										Mean	
Genotype	**Control**	**MLSF17**	**MLSF3**	**UGSF9**	**UGSF12**	**UGSF25**	**UGSF36**	**IP3**	**UGSF14**	**Manure**	**2.6g/N**	**5.2g/N**
LDW1	0.35	0.3	0.29	0.19	0.36	0.22	0.22	0.19	0.29	0.34	0.21	0.25
LDW2	0.78	0.97	0.57	0.58	0.7	0.73	0.75	0.43	0.68	0.83	0.63	0.61
LDW3	1.83	2.02	1.96	2.02	1.91	2.14	2.16	1.74	2.12	2.3	1.66	1.99
LDW4	3.12	3.51	3.23	3.61	3.33	2.93	3	2.88	3.33	4.1	2.43	3.11
LDW5	4.44	4.18	4.1	4.1	3.85	3.85	4.5	4.09	4	5.08	3.35	3.94

3.1.4 SPAD values

The average chlorophyll content per treatment ranged from 20.8 to 50.5 measured across the five genotypes. UGSF9 recorded the highest value of 45.7 while control had the lowest at 39.8 for season I (Table 9). For greenhouse season II, UGSF14 had the highest mean chlorophyll of 39 (Table 10).

Table 9: SPAD reading for greenhouse season I

							Mean	
Genotype	Control	MLSF17	UGSF14	UGSF9	UGSF36	0	2.6g/N	5.2g/N
SPAD1	20.1	16	17.7	19.6	20.2	18.2	18.9	19.1
SPAD2	25	20.3	22.5	24.4	23.4	19.9	24.4	25.1
SPAD3	35.4	36	34	40.3	38.4	18.1	46.8	45
SPAD4	39.8	40.2	35.3	45.7	40.2	20.8	48.3	50.5

Table 10: SPAD reading for greenhouse season II

							Mean	
Genotype	**Control**	**MLSF17**	**UGSF14**	**UGSF9**	**UGSF36**	0	2.6g/N	5.2g/N
SPAD1	20.1	20	19.8	19.7	18.8	19.7	19.1	20.3
SPAD2	30.6	34.2	32.6	34.4	33.5	26	34.8	20.3
SPAD3	35.4	38	39.6	38	38.4	19.2	46.1	48.2
SPAD4	36	37.9	39	37.4	37.7	27	39.6	46.2

Table 11: Weight (mg) per 100 spider plant genotype seeds

Line	Replicate 1	Replicate 2	Replicate 3	Total
UGSF9	157.8	156.6	155.1	469.5
UGSF12	152.2	152.6	150.9	455.7
UGSF14	149.2	146.8	148.7	444.7
UGSF25	148.5	147.5	149.6	445.6
UGSF36	153.5	155.9	155.7	465.1
MLSF3	141.4	142.6	140.8	424.8
MLSF17	158.0	157.2	156.6	471.8
IP3	145.7	146.8	147.4	439.9
N6	162.8	161.2	161.5	457.1

3.2 Consumer and Grower Preference

During the preliminary analysis, there was no significant difference among growers and consumers for genotypes. However, consumers gave varying reasons for their choices ranging from degree of bitterness, aroma, texture, medicinal value, among others. Some panelists did not give any reasons for their preferences of certain genotypes.

4 Discussion and Conclusions

4.1 Effect of Manure and CAN on Yield

Previous research has shown that application of nitrogen has been shown to increase fresh and dry above-ground biomass in leafy vegetables between levels of 100-250 kg N/ha. Yields are also being improved through selection of genotypes of spider plant, which has intensified in the recent past (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*. 2008).

Manure plots yielded significantly high fresh leaf yields and biomass. Manure is an important source of essential plant nutrients and organic matter for crop production. It leads to improved soil physical properties, water holding capacity, cation exchange capacity (Brady, 1984). Nutrients in manure are released over a long period of time which can upto three years (Macer 1973). Manure also reduces soil C:N ratio that facilitates speedy nitrification. (Brady,1984). Genotypes with high leaf dry weight are likely to have high nitrogen assimilation efficiency and are more preferred for adoption by farmers (Masinde, 2011). However, excess nitrogen fertilization suppresses root growth through production of vigorous shoot growth (Faust, 1989). The SPAD values have positive correlation with nitrogen level. Nitrogen plays a major role in chlorophyll synthesis (Salisbury and Ross, 1991). The 10th youngest leaf on the main stem was measured to improve reliability and minimize error due to leaf age.

4.2 Cultural Practices

Management level is central to improved spider plant yields. The improvement in yields fpor Ruiru season II is attributed to better management with lessons from season I. Watering to keep top soil at field capacity is key, since absorbing roots occupy the top 2-3 cm of soil. Spider plant is highly susceptible to water stress (Masinde, 2003). Deflowering is also important in extending harvesting duration, by avoiding early senescence. This involves removal of young flower buds. Genotypes did not show significant variation between the field and greenhouse growing conditions. Lack of significance amongst tasters and growers indicate that the genotypes may have very close relationship both genetically and phytochemically.

5 Conclusion

In conclusion, the study recommends adoption of genotypes MLSF17, UGSF14, Control, UGSF9 and UGSF36 for adoption by farmers considering their outstanding agronomic performance. However, it is recommended to undertake phytochemical analysis for each genotype and effect of high N stress on plant toxin accumulation. Also, trained panelists should be involved in the sensory test to verify whether there could significance difference among consumers.

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