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Research Application Summary

# Evaluation of spider plant (*Cleome gynandra* L) accessions for agronomic traits under greenhouse conditions

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## Abstract

Spider plant *(Cleome gynandra* L) is one of the African leaf vegetables with great potential of enhancing nutritional security and livelihood of many resource-poor communities. Although spider plant has a good potential for improving diets and income, there is limited agronomic information on the existing spider plant genotypes for vegetable use. A greenhouse pot experiment laid as a complete randomized block with three replications was conducted to evaluate agronomic traits of 25 spider plant accessions for vegetable production. The trial was run for two seasons, April -June 2021 and January -March 2022. Data quantified include plant height, number of primary branches per plant, number of leaves, leaf chlorophyll content, leaves fresh and dry mass, and moisture contents of the leaves. Analysis of variance (ANOVA) of the collected data was performed using a statistical analysis at 95% significance confidence level. Results indicated that there is a significant variation in plant height, number of primary branches per plant, number of leaves, leaf chlorophyll content, and leaves fresh weight among 25 tested spider plant accessions. Plant height differed significantly (P 0.05) from 49.83 (accessions ODS15037) to 18.28cm (Accession Rhothwe2). Furthermore, leaf chlorophyll content (SPAD values) for accessions ELG1907A (39.12), TOT3536 (37.51), ODS15045 (37.12), NC05015 (36.9), TOT5799 (36.39), and LAIOgongo has indicated a relatively high significant SPAD readings when compared to others. Genotypes TOT8926 (56.35g), ODS15019 (52.48g), O-S15020 (50.52g), and ELG1907A (49.42g), ODS15075 (47.85g) have indicated highly significant commulative leaf, tender shoots and flowers fresh biomass in g plant-1. On the other hand, BUAN1 (15.70g), Rothwe2 (18.21g), and Rothwe1 (27.46g) indicated the lowest fresh cumurative biomass production (P 0.05). Further research is recommended on these potential genetic resources for improvement of agronomic traits of spider plant.

Keywords: *Cleome gynandra* L , genotypes, leafy vegetable, volunteer crop

## Résumé

La corète potagère (*Cleome gynandra* L) est l'un des légumes à feuilles africains présentant un grand potentiel pour améliorer la sécurité nutritionnelle et les moyens de subsistance de nombreuses communautés défavorisées en ressources. Bien que la corète potagère ait un bon potentiel pour améliorer les régimes alimentaires et les revenus, il existe peu d'informations agronomiques sur les génotypes existants de corète potagère pour une utilisation en tant que légume. Une expérience en pot sous serre, réalisée selon un plan en blocs complets randomisés avec trois répétitions, a été menée pour évaluer les caractéristiques agronomiques de 25 accessions de corète potagère destinées à la production de légumes. L'essai a été réalisé sur deux saisons, d'avril à juin 2021 et de janvier à mars 2022. Les données quantifiées comprenaient la hauteur des plantes, le nombre de branches primaires par plante, le nombre de feuilles, la teneur en chlorophylle des feuilles, la masse fraîche et sèche des feuilles, ainsi que la teneur en humidité des feuilles. Une analyse de variance (ANOVA) des données collectées a été réalisée en utilisant une analyse statistique avec un niveau de confiance de 95 % de signification. Les résultats ont indiqué qu'il existe une variation significative de la hauteur des plantes, du nombre de branches primaires par plante, du nombre de feuilles, de la teneur en chlorophylle des feuilles et de la masse fraîche des feuilles parmi les 25 accessions de corète potagère testées. La hauteur des plantes différait significativement (P 0,05) de 49,83 cm (accession ODS15037) à 18,28 cm (accession Rhothwe2). De plus, la teneur en chlorophylle des feuilles (valeurs SPAD) pour les accessions ELG1907A (39,12), TOT3536 (37,51), ODS15045 (37,12), NC05015 (36,9), TOT5799 (36,39) et LAIOgongo ont indiqué des lectures SPAD relativement élevées et significatives par rapport aux autres. Les génotypes TOT8926 (56,35 g), ODS15019 (52,48 g), O-S15020 (50,52 g), ELG1907A (49,42 g) et ODS15075 (47,85 g) ont montré une biomasse fraîche cumulée élevée et significative en feuilles, en pousses tendres et en fleurs par plante en g. D'autre part, BUAN1 (15,70 g), Rothwe2 (18,21 g) et Rothwe1 (27,46 g) ont indiqué la production cumulée de biomasse fraîche la plus faible (P 0,05). Des recherches supplémentaires sont recommandées sur ces ressources génétiques potentielles pour l'amélioration des caractéristiques agronomiques de la corète potagère.

Mots-clés: *Cleome gynandra* L, culture volontaire, génotypes, légume à feuilles

## Introduction

Spider plant (*Cleome gynandra* L) is one of several African Leafy Vegetables (ALV) which are used widely in Sub-Saharan Africa (SSA) and Asia. Cleome is reported to be rich in micronutrients and vitamins, making it a potential vegetable in relieving hunger, poverty, and undernutrition in Africa (Mosenda *et al.,* 2020). Tender leaves, stems, and flowers of spider plants are cooked and consumed either with stew or alone as a potherb (Sogbohossou *et al.,* 2019). The juice of crushed spider plant from roots and shoots is known to be used in treating several ailments including stomach pain, constipation, and internal parasite infections in humans (Chweya and Mnzava, 1997). Deficiencies of nutrition like Vit A, Zinc, iron, and iodine are connected to many of the serious health problems experienced around the world. Spider plant is reported to be rich in calcium, magnesium, iron, zinc, Vit A, C, and E, protein, and beta carotene (Emmanuel *et al*., 2016). The yield of local spider plant accessions is still not well documented but some of the Kenyan accessions have been reported to yield between 1 to 5.3 t $ha^{-1}$ on fresh weight basis (Mosenda *et al.,* 2020). However, the plant is said to have a potential of yielding up to 30 t $ha^{-1}$ when improved cultivars and good management practices are employed (Onyango *et al.,* 2016). Spider plant has been receiving relatively insignificant research attention in the past probably because of the misconception that the plant is a “poor man’s vegetable”, wild weed, or a volunteer crop in many communities. Of recent, spider plant has been receiving some research attention possibly due to the potential of the crop to alleviate malnutrition, enhance food security, and generate income among resource-poor rural farmers (Innocent *et al.,* 2017; Munene *et al.,* 2018; Wakhisi *et al.,* 2020). Even with these recent studies, there still exists a huge information gap on agronomic traits assessment. Hence, this study was undertaken to generate information essential to enhancing the crop performance via selections and domestication through crop improvemment. Hence, the study aimed at evaluating the agronomic traits of 25 collected spider plant genotypes for vegetable production.

## Materials and Methods

**Study area description**. The Greenhouse experiment was carried out at the Botswana University of Agriculture and Natural Resources (BUAN), Gaborone, Botswana, located at a latitude of 24.5914$^{o}$ S longitude of 25.9415$^{o}$ E, and an altitude of approximately 1000m above sea level. Botswana falls under a semi-arid agro-ecological zone with an average mean outdoor temperature of 20.7 $^{o}$C (Likuku and Obuseng, 2015).

**Collection and selection of accessions.** Twenty-five accessions were evaluated in this study, 22 accessions were sourced from the University of Namibia, Department of Crop Science, with origins from 11 African and Asian countries. Two (2) accessions were sourced from the National Plant Genetic Resource Centre of Botswana while one (1) accession was collected from the BUAN research field.

**Treatments, experimental design, and crop management**. Twenty-five (25) accessions were evaluated in pots in a greenhouse using a randomized complete block design with three replications. The soil used for potting was collected from BUAN research fields where spider plants were observed growing naturally. A rounded polythene-potting bag with a diameter of 0.363m wide and height of 0.185m tall were filled with 10 kg of air-dried soil, and a complete fertilizer NPK 2:3:2 (30) was administered at a rate of 60kg ha$^{-1}$ (N) and thoroughly mixed with the soil before sowing seeds. Four (4) seeds of each accession were sown in each pot and watered to field capacity. Thinning was done two weeks after seedling emergency leaving two plants per pot. Topdressing with calcium ammonium nitrate (CAN) - 26%N was applied at 100 kg ha$^{-1}$ in the second week after seedling emergence. The plants were watered every day for the first two weeks and thereafter every other day. Plants were sprayed with lambda-cyhalothrin mixed at 1g per liter of water five days after emergence, during the vegetative phase, and just before flowering to control aphids and whiteflies.

**Data collections**. Data collected included; chlorophyll content, plant height (cm), fresh and dry weights of leaves, tender shoots and flowers, number of primary branches, leaf moisture, and number of leaves per plant following the procedure reported by Lokesha (2018). The data were collected at 14 days intervals starting from two weeks after emegernce. Chlorophyll content was measured with SPAD Meter between 07:00 and 10:00 AM hours every 14 days starting from two weeks after emergence. Plant height was measured from the base to the tip of the main stem using a meter ruler. The number of primary branches was determined by counting the primary branches from the tagged plants. The number of leaves per plant was assessed by counting fully expanded edible leaves during the vegetative stage.

**Statistical analysis**. Data collected were subjected to analysis of variance using Statistical Analysis System (SAS) version 9.1 at a 95% confidence level of significance. Separation of the significant mean of treatment effects was done by Fisher's protected least significant difference (LSD) test. Variability within each quantitative trait was calculated using statistical measures of mean, standard deviation, and coefficient of variation. Correlation analyses were performed in SAS to estimate quantitative relationships among the traits.

## Results and Discussions

**Leaf chlorophyll content.** Spider plant accessions varied significantly ($P \leq 0.05$) in their leaf chlorophyll content per plant (Table 1). Leaf chlorophyll content for accessions NC05015, TOT3536, TOT5799, ELG1907A, ODS15045, and LAIOgongo indicated a significantly higher SPAD readings, showing that they synthesized higher leaf chlorophyll content compared to others. On the contrary, accessions acquired from Botswana (Rothwe1, Rothwe2, and BUAN1) recorded significantly lower leaf chlorophyll content. Leaves chlorophyll content showed a positive significant correlation with the number of leaves per plant, plant height, leaf fresh weight, as well as leaf dry weight with r values of 0.66, 0.7, 0.69, and 0.63, respectively (Table 2). Chlorophyll is responsible for the photosynthesis process which manufactures sugars required for plant growth and development including the measured traits. Therefore, one expects these agronomic traits to be positively correlated to leaf chlorophyll content. These results agree with those reported by Munene *et al*. (2018) and Mosenda *et al*. (2020). The difference found in leaf chlorophyll content among the genotypes suggest that the variations are likely to be associated with N uptake and use of the these accessions. High leaf chlorophyll may also indicate that those accessions possess greater N uptake capacity which assists them to synthesize more green leaf color. This can be an interesting indicator for N nutrition studies. Accession's population structure, and adaptation to different environments may also be the reason for the variations between the leaf chlorophyll contents of these genotypes (Schranz, 2016).

**The number of leaves per plant.** The spider plant accessions exhibited high variation in the number of leaves per plant at ($P \leq 0.05$). The number of leaves per plant of spider plant accessions ranged between 6 and 12 leaves per plant. The NC05015 had significantly highest number of leaves, while Rothwe2 recorded the lowest number of leaves per plant. The number of leaves per plant was found to be positively corelated to plant height (r=0.7), the number of branches (r=0.61), leaf fresh weight (=0.66), and leaf dry weight (r=0.64) (Table 2). Leaves grow on the primary branches, and they make up the fresh and dry weight of the plant hence a positive correlation between these traits explains that relationship. A similar positive correlation was reported by Wangolo *et al*. (2015) and Dinssa *et al*. (2018).

**Plant height.** A highly significant variation was recorded in the height of the spider plant accessions at P<5%. As indicated in Table 1, ODS15037, ODS15061, ELG1907A, TOT7196, and TOT6426 recorded significantly higher plant height, while the lowest plant heights were recorded on Rothwe1, Rothwe2, and BUAN1. Plant height is a crucial agronomic parameter that exposes the crop's vegetative growth patterns. Tallness is crucial for good vigor, making the plants to grow to the height needed to ease weeding and harvesting during production. A plant's tallness is also said to facilitate free air circulation in the plant, thus preventing pests and diseases (Mosenda *et al*., 2020). Plant height in this study was positively correlated with the number of branches (r=0.53) and fresh leaf' biomass (r=0.76) as indicated in Table 2. The combination of short vegetable plants with low plant density has been reported to result in a reduced rate of photosynthesis resulting in low yield. On the contrary tall plants coupled with high plant density, can increase the rate of photosynthesis resulting in high leaf yield (Chaudhury and Cherayil, 2007).

**The number of primary branches.** Spider plant accessions varied significantly ($P \leq 0.05$) with respect to the number of primary branches per plant for the 25 accessions tested in the greenhouse (Table 1). The number of primary branches per plant varied from a single primary branch (Rothwe2) to 5 primary branches in NC05015. The study revealed a significant positive correlation between the number of primary branches with the number of leaves (r=0.61) and also with plant height (r=0.53) (P≤0.05). Similar results were also reported by Wasonga (2015). The number of primary branches was also reported to be an indicator of the crop's tolerance to drought stress conditions which can also be reflected in the crop's vegetative productivity (Magloire, 2005).

**Plant biomass**. The results indicated that plant biomass (leaf, tender shoots, and flowers) varied significantly among the genotypes (P≤0.05) with genotypes producing a cummurative mean biomass as follow; Genotypes TOT8926 (56.35g), ODS15019 (52.48g), O-S15020 (50.52g), and ELG1907A (49.42g), ODS15075 (47.85g) (Table 3), indicating relatively high significant leaves fresh biomass. Accessions sourced from Botswana, namely BUAN1 (15.70g), Rothwe2 (18.21g), and Rothwe1 (27.46g) produced significantly lower biomass (Table 3). Further, the results in Table 3 indicate how leaf tender shoots and flowers biomass changed with time from week 3 to week 6 after planting. Fresh biomass production gradually increased in almost all accessions from week 3 through week 4 to week 5, however, a decrease in leaf fresh weight was observed after week 5 into week 6 (Table 3).

**Table 1. Means of quantitative agronomic traits of 25 spider plant accessions grown in the greenhouse at the Botswana University of Agriculture and Natural Resources, Gaborone, Botswana**

| Accessions | Chlorophyll (SPAD values) | No. of leaves/ plant | Plant height (cm) | No. of branches/ plant | Leaves, tender shoots and flowers fresh weight (g) | Leaves, tender shoots and flowers dry weight (g) | Leaves, tender shoots and flowers moisturecontent (%) |
|---|---|---|---|---|---|---|---|
| ODS15121 | 34.33 | 11.33 | 41.17 | 3.92 | 10.99 | 1.65 | 85.48 |
| ROTHWE1 | 24.46 | 10.83 | 26.75 | 2.67 | 6.87 | 1.18 | 85.45 |
| ODS15061 | 39.29 | 11.83 | 48.36 | 3.08 | 14.81 | 1.83 | 84.85 |
| TOT8926 | 31.25 | 10.83 | 40.76 | 2.08 | 14.09 | 1.21 | 89.38 |
| ODS15103 | 30.42 | 10.25 | 40.47 | 3.42 | 8.43 | 1.16 | 86.25 |
| NC05015 | 36.902 | 12.00 | 42.47 | 4.58 | 9.29 | 1.43 | 84.06 |
| TOT3536 | 37.51 | 11.08 | 40.19 | 2.33 | 10.10 | 1.26 | 88.00 |
| BC02B | 30.05 | 8.08 | 38.92 | 1.5 | 9.54 | 1.29 | 87.73 |
| GA01 | 30.47 | 11.83 | 41.89 | 3.17 | 10.03 | 1.75 | 85.28 |
| TOT5799 | 36.39 | 11.5 | 44.47 | 3.25 | 10.63 | 1.63 | 85.64 |
| ODS15044 | 34.94 | 11.17 | 44.95 | 3.33 | 10.46 | 2.05 | 79.66 |
| BUAN1 | 21.49 | 8.83 | 20.50 | 1.92 | 3.92 | 0.83 | 84.10 |
| ELG1907A | 39.12 | 11.50 | 47.61 | 2.00 | 12.36 | 2.39 | 84.06 |
| TOT6426 | 29.35 | 12.42 | 45.61 | 3.33 | 11.25 | 2.13 | 77.96 |
| ODS15037 | 33.86 | 10.25 | 49.83 | 3.33 | 9.21 | 1.55 | 81.43 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| KSI2407A | 34.96 | 10.67 | 34.37 | 2.17 | 9.46 | 1.75 | 86.45 |
| ROTHWE2 | 18.22 | 5.83 | 18.28 | 1.25 | 4.55 | 0.72 | 87.96 |
| TOT8887 | 33.70 | 10.83 | 41.56 | 2.75 | 11.73 | 1.45 | 88.89 |
| ODS15045 | 37.12 | 10.08 | 35.11 | 3.00 | 12.46 | 2.09 | 85.47 |
| ODS1519 | 35.72 | 12.75 | 43.92 | 2.75 | 13.12 | 1.66 | 86.83 |
| ODS15059 | 26.33 | 9.83 | 32.75 | 2.83 | 8.14 | 1.38 | 85.43 |
| ODS15075 | 31.84 | 11.67 | 44.47 | 2.58 | 11.96 | 1.96 | 85.07 |
| TOT7196 | 31.78 | 11.00 | 45.67 | 3.17 | 9.89 | 1.44 | 86.28 |
| LAIOGONGO | 37.78 | 11.08 | 31.14 | 2.33 | 8.97 | 1.51 | 86.74 |
| ODS15020 | 31.44 | 11.42 | 44.39 | 4.25 | 12.63 | 2.03 | 85.22 |
| Means | 32.35 | 10.76 | 39.43 | 2.84 | 10.05 | 1.57 | 85.35 |
| P-values | <0.001 | <0.001 | <0.001 | <0.001 | <0.014 | <0.057 | <0.51 |
| LSD 0.05 | 3.23** | 1.38** | 1.98** | 0.39** | 1.79* | NS | NS |

Chlorophyll – leaf chlorophyll content, No. of leaves - number of leaves per plant, plant height-height of the plant, No of branches - number of primary branches leaves, leaves fresh weight – leaves, tender flowers and shoots fresh weight per plant, leaves dry weight - leaves, tender flowers and shoots dry weight per plant, Moisture content - leaves, tender flowers and shoots moisture content per sample.** Highly significant at P<0.0 level,* significant at P<0.05 level NS-not significant

**Table 3. The cummurative fresh biomass accumulation of 25 spider plant accession over time (weeks) in the greenhouse at the Botswana University of Agriculture and Natural Resources, Gaborone, Botswana**

| Genotypes | Leaf, tender shoots, and flowers fresh weight (g/plant) | | | | |
|---|---|---|---|---|---|
| | Week 3 | Week 4 | Week 5 | Week 6 | Cummulative week mean |
| ODS15121 | 5.10 | 10.59 | 17.81 | 10.44 | 43.94 |
| ROTHWE1 | 1.64 | 4.43 | 10.56 | 10.83 | 27.46 |
| ODS15061 | 4.01 | 8.77 | 23.08 | 8.55 | 44.41 |
| TOT8926 | 3.43 | 6.50 | 12.83 | 33.59 | 56.35 |
| ODS15103 | 5.12 | 10.99 | 8.99 | 8.63 | 33.73 |
| NC05015 | 6.14 | 14.95 | 6.25 | 9.85 | 37.19 |
| TOT3536 | 3.70 | 11.54 | 15.43 | 9.74 | 40.41 |
| BC02B | 3.29 | 7.19 | 18.73 | 8.93 | 38.14 |
| GA01 | 4.93 | 10.51 | 13.43 | 11.24 | 40.11 |
| TOT5799 | 4.38 | 9.46 | 14.92 | 13.76 | 42.52 |
| ODS15044 | 6.54 | 9.71 | 14.46 | 11.13 | 41.84 |

| | | | | | |
|---|---|---|---|---|---|
| BUAN1 | 1.66 | 2.70 | 2.18 | 9.16 | 15.70 |
| ELG1907A | 6.00 | 10.76 | 17.53 | 15.13 | 49.42 |
| TOT6426 | 5.47 | 10.8 | 16.37 | 12.37 | 45.01 |
| ODS15037 | 5.20 | 8.60 | 14.85 | 8.18 | 36.83 |
| KSI2407A | 2.58 | 7.56 | 13.93 | 13.79 | 37.86 |
| ROTHWE2 | 1.25 | 1.74 | 9.16 | 6.06 | 18.21 |
| TOT8887 | 4.00 | 9.63 | 18.03 | 15.27 | 46.93 |
| ODS15045 | 4.42 | 11.12 | 21.48 | 12.82 | 49.84 |
| ODS1519 | 12.69 | 11.93 | 14.74 | 13.12 | 52.48 |
| ODS15059 | 2.54 | 7.71 | 12.77 | 9.55 | 32.57 |
| ODS15075 | 4.31 | 12.17 | 17.33 | 14.04 | 47.85 |
| TOT7196 | 5.55 | 10.55 | 11.49 | 11.96 | 39.55 |
| LAIOGONGO | 2.41 | 5.40 | 15.22 | 12.86 | 35.89 |
| ODS15020 | 5.39 | 9.64 | 17.15 | 18.34 | 50.52 |
| Means | 4.47 | 9 | 14.35 | 12.37 | 40.19 |
| P-Values | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| LSD 0.05 | 3.593** | | | | |

Week 3-6: Weeks after planting

**Table 3. Correlation coefficients for the agronomic traits recorded on 25 accessions of spider plants grown in the greenhouse at the Botswana University of Agriculture and Natural Resources, Gaborone, Botswana**

| | CHL | NOL | PH | NOB | LFW | LDW | MC |
|---|---|---|---|---|---|---|---|
| CHL | - | | | | | | |
| NOL | 0.66* | - | | | | | |
| PH | 0.70** | 0.70** | - | | | | |
| NOB | 0.35 | 0.61* | 0.53* | - | | | |
| LFW | 0.69* | 0.66* | 0.76* | 0.31 | - | | |
| LDW | 0.63* | 0.64* | 0.67* | 0.38 | 0.70** | - | |
| MC | -0.05 | -0.31 | -0.31 | -0.42 | 0.03 | -0.50 | - |

CHL- leave chlorophyll content, NOL-number of leaves per plant, PH-plant height in (cm) per plant, NOB-number of primary branches, LFW- leaves, tender flowers and shoots fresh weight per plant in (g) per plant, LDW- leaves, tender flowers and shoots dry weight per plant and MC-moisture content in (g) per plant. ** Correlation at significant at P 0.01 level, *correlation is significant at P 0.05 level

## Conclusions

In this study the genotypes ODS15061, TOT8926, ODS15019, ODS15020, and ELG1907A were high yielding and should be considered for further spider plant vegetable research improvement programs based on their fresh biomass yield. The three local accessions (BUAN1 Rothwe2 and Rothwe1) were low productive accessions when compared to other tested genotypes.

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