Journal of Medicinally Active Plants

Volume 9
Issue 4 *Vol 9 Issue 4-African Indigenous Plants III.*

12-21-2020

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Recommended Citation

Mosenda, Enock; George Chemining'wa; Jane Ambuko; and Willis Owino. 2020. "Assessment of Agronomic Traits of Selected Spider Plant (*Cleome gynandra* L.) Accessions." *Journal of Medicinally Active Plants* 9, (4):222-241.
DOI: https://doi.org/10.7275/n1wf-6y77
https://scholarworks.umass.edu/jmap/vol9/iss4/4

Assessment of Agronomic Traits of Selected Spider Plant (*Cleome gynandra* L.) Accessions

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Manuscript received: October 7, 2020

Key Words: Genotypes, indigenous vegetable, leave development, seed yield

ABSTRACT

Spider plant (*Cleome gynandra* L.) is an African indigenous vegetable with great potential to improve food and nutritional security and incomes among resource-poor communities in Africa. However, there is limited information on the potential of the existing spider plant genotypes for vegetable and seed production. Knowledge of the agronomic traits and performance of the existing spider plant genotypes is crucial in selecting superior types for crop improvement programs. A study was conducted to assess selected spider plant accessions' agronomic traits pertinent to seed and vegetable production. Two greenhouse and field experiment were carried out. In this study, 40 spider plant accessions were evaluated for agronomic traits on-station at Kabete Field Station (University of Nairobi) and on-farm at Nyabokarange village, in Bukira North location, Kuria West Sub-County (Migori County) in a randomized complete block design with three replications. Data collected included days to seedling emergence, percent seedling emergence, plant height, number of leaves per plant, days to 50% flowering, number of pods per plant, number of seeds per pod, the weight of 100 seeds, and seed yield per plant. They were subjected to analysis of variance using GenStat 15th edition at a 5% probability level. The number of days to seedling emergence and percent seedling emergence varied significantly from 4 (accession GBK-045436) to 12.7 (accessions GBK-031992, GBK-031837 and GBK-032302) and 23% (accession Baringo) to 59% (commercial variety), respectively. The number of leaves per plant varied significantly from 23.2 (accession Mombasa) to 121.7 (accession GBK-028563), while plant height ranged from 16.0 cm (accession Mombasa) to 107.1 cm (accession GBK-045436). The number of pods per plant ranged from 12.3 (accession Mombasa) to 101.5 (accession Kakamega). Seed yield per plant ranged from 0.3 g (accession Mombasa) to 16.8 g (accession GBK-045456 and GBK-045436). The number of leaves per plant was proportional to the number of primary branches (r = 0.81 and 0.78) in the greenhouse and field, respectively. Plant height recorded a significant positive correlation with the number of leaves(r = 0.87) in the field experiment. Results demonstrated that there are significant genotypic variations among the evaluated spider plant accessions. Spider plant landraces generally performed better than the commercial variety (Saga). Genotypes GBK-031991, Kakamega, GBK-045456, GBK-032302 and, accession Migori had superior agronomic traits and can be recommended for farmers' cultivation and used in developing new varieties of spider plant.

INTRODUCTION

Spider plant (*Cleome gynandra* L.) is used widely as a local vegetable in sub-Saharan Africa (Chadha, 2003). Spider plant is rich in micronutrients and vitamins and crucial in relieving hunger, poverty, and under nutrition in Africa (Omondi et al*.,* 2017). Young leaves and stems of *C. gynandra* are cooked and eaten as a vegetable either alone or in stews (Sogbohossou et al*.,* 2018). Sap of crushed spider plant leaves and roots eases childbirth and treats stomachache, constipation and threadworm infections. Seeds and roots have anthelmintic properties (Mnzava and Chigumira, 2004; Iwu, 2014; Sogbohossou *et al.,* 2018; Chinsembu, 2016; Shippers, 2002). Most serious health issues around the globe are deficiencies of vitamin A, zinc, iron and iodine. The evaluation of the nutrient content of spider plants showed high levels of calcium, magnesium, iron, zinc, vitamin A, C and E, proteins and high beta-carotene (Mnzava, 1997; Mahyao et al., 2008; Mbugua et al., 2011).

The estimated yield of spider plants using locally available resources varies from 1 to 5.3 t/ha compared to the potential yield of 20 to 30 t/ha by use of improved cultivars and best management practices (Abukutsa-Onyango, 2003; HCD, 2017). The spider plant's status as a weed, volunteer, and a wild crop has led to the misconception that spider plant is a vegetable for the poor (Vorster and Van Rensburg, 2005).

In the recent past, spider plant has received increased interest from researchers due to its potential to alleviate malnutrition, enhance food security, and generate income among resource-poor rural farmers. The most recent spider plant studies include a roadmap to breeding spider plant by Sogbohossou et al. (2018). The study described how genomic-assisted breeding of orphaned leafy vegetables can lead to improvement of leaf yield, phytonutrient content, and resistance to abiotic and biotic stresses in spider plant. The study by Omondi et al. (2017) reported high genetic variation in 30 spider plant genotypes evaluated in experiment. This study revealed chromosome numbers of 2n = 34 in root tip metaphase cells from one entry. Gonye et al. (2017) evaluated spider plants' field performance and reported an increase in growth, yield, and micronutrient content with organic and inorganic fertilizer application. Zorde et al (2020) reported on the genetic diversity and opportunity in breeding for delayed flowering time to increase vegetative growth and multiple harvests in spider plant.

Most of the aforementioned research activities have not comprehensively evaluated the agronomic traits of spider plant germplasm preserved in the Kenyan gene bank and farmers' currently cultivated landraces and commercial varieties sold by seed companies. Since there is limited information on the agronomic trait variations of existing spider plant germplasm preserved in the gene bank and farmers' fields and such information is necessary to enhance crops performance through selection, domestication, and breeding of spider plants. The main objective of the study was to improve spider plant productivity through adoption of spider plant genotypes with good agronomic traits. The specific objective was to assess the agronomic traits of selected spider plant accessions pertinent for seed and vegetable production. Agronomic trait assessment of the spider plant accessions in our study identified desirable agronomic traits that can be useful in future spider plant improvement programs.

MATERIALS AND METHODS

Study area description. Greenhouse and field experiments were carried out at Kabete field station at the University of Nairobi, Kenya, located at a latitude of $0^0$14’45.00” S longitude of $36^0$44’19.51” E and at an altitude of 1940 m above sea level. The agro-ecological classification of the area is upper midland zone three (UM3) (Jaetzold and Schmidt, 1983). The greenhouse experiment at Kabete Field Station was carried out twice between June 2018 and February 2019. The average outdoor temperature ranges between 16^0 C and 23^0 C. Average annual rainfall precipitation is 1000 mm (Siderus, 1976). The site has deep, well drained dark reddish-brown clay humic nitisols with pH ranging from 5.2 to 7.1 (Michieka, 1978). On-farm trials were carried out at Nyabokarange village in Bukira North location of Kuria West Sub County in Migori County located at 1^0 4’ 0” South of the equator with longitude $34^0$28’0” east of the prime meridian and 1524 meters above sea level. The Agro-ecological zone classification of

Kuria West Sub County is lower midland zone three (LM3). Average annual rainfall precipitation ranges between 950 mm to 1500 mm (Nyamohanga, 2017; Sombroek, 1982). The field study experiments in both locations were carried out between November 2018 and February 2019 during the short rains season. Short rain seasons runs from October to December. At both sites soils were sampled at 30 cm depth before planting and analyzed for soil pH and nutrients at the University of Nairobi's Soil Chemistry Laboratory (Table 1). Weather data were collected at both sites during the experimental period (Tables 2 and 3).

Collection and selection of accessions. Forty spider accessions were evaluated in this study, 23 accessions were sourced from Muguga National Genetic Resource Research Institute in Kenya, 16 sourced from farmers in Western, Nyanza, Rift Valley and Coastal parts of Kenya where the vegetable is commonly grown. The accessions were given the names of the area from which they had been collected. One commercial variety (Saga) was obtained from the Simlaw seed company (Table 4).

Treatments, experimental design, and crop husbandry. Greenhouse experiments. Forty (40) accessions of spider plants were evaluated in pots in a greenhouse using a randomized complete block design with three replications. The soil used for potting was collected within the Kabete Field Station close to the field experiment site. Each rounded pot was 36.3 cm tall x 18.3 cm wide. Pots were filled with a 10 kg air-dried mixture of sterilized soil, sand and composted animal manure in the ratio 2: 1: 1. One teaspoon of di-ammonium phosphate (DAP) fertilizer was applied at 3.15 g/pot just before planting. Watering was done before and after planting the seeds. Water used in the farm was pumped from the Kabete dam that is located within the college. Four seeds were sown in each pot and adequately watered. Thinning was done 14 days after seedling emergence and repeated after 21 days leaving two plants per pot. Seedlings were top-dressed at 30 cm seedling height with calcium ammonium nitrate (CAN) (26%N) at a rate of 5.1 g per pot. The plants were watered three times each week and sprayed with Karate® (active ingredient lambda cylothrin) at 20 g per 20 litres five days after emergence, during the vegetative phase, and just before flowering in order to control aphids and whiteflies. Pots were adequately spaced at 30 cm by 30 cm for proper growth and evaluation. Greenhouse presents a controlled environment unlike field experiment, thus, the greenhouse findings provided a base of comparison for the field experiment findings.

Field experiment. Assessments were performed on 40 spider plant accessions using a randomized complete block design with three replications. The experimental field was tilled and harrowed to a fine tilth using a tractor. The experimental plot size was 21 m × 28.6 m. Plots and blocks were each separated by 1 m path. Hand sowing was done for each accession in four rows and the five seeds per row (20 plants in a plot) with an inter-row spacing of 30 cm and intra-row spacing of 30 cm. Diammonium phosphate (DAP) fertilizer (18:46:00) was applied at a rate of 100 kg/ha and thoroughly mixed with the soil before sowing seeds. Topdressing with CAN (26%N) was done after the first weeding in the third week after emergence at 65 kg N/ha. Spider plant seedlings were sprayed with an organophosphate insecticide lambda-cyhalothrin-250EC (Twiga Chemical Industries, Nairobi, Kenya) at the rate of 5 ml/ 20 litres after emergence and before flowering to control cutworms and aphids. Weeds were controlled through hand-weeding. Both greenhouse and field experiment were necessary to ensure consistency of our conclusions drawn from the study.

Data collection. Agronomic traits data collected in the both greenhouse and field study included the number of days to 50% seedling emergence, seedling emergence percentage, number of days to 50% flowering, plant height (cm), number of primary branches, number of pods per plant, number of leaves per plant, number of seeds per pod, 100-seed weight and seed yield. Three plants were randomly selected and tagged per plot for data collection in the field while in the greenhouse; one plant was tagged in each pot for data collection. The number of days from sowing to seedling emergence was determined by recording the number of days when 50% of the seedlings had emerged. Percent emergence was determined by counting the number of seedlings that emerged divided by the total number of seeds sown and multiplied by 100%. The number of days to flowering was determined by counting the number of days from sowing to when 50% of the plants had started flowering. Plant height was measured after 50% flowering from the plant's base to the tip of the main stem using a meter ruler. The number of primary branches was determined by counting the main branches from the tagged plants after 50% flowering. The number of leaves per plant was determined by counting fully expanded edible leaves during the vegetative stage. The number of pods per plant was determined by counting the number of mature pods per plant. Seed yield per plant was determined by weighing seeds from tagged plants after sun-drying to approximately 13 % moisture level. The numbers of seeds per pod were determined by randomly picking three pods from the harvested portion of each accession and counting the number of seeds in them. The weight of 100 seeds was determined by counting 100 sun-dried seeds and weighing them using an analytical scale with a precision of 0.001 gram.

Collected data were subjected to analysis of variance using GenStat 15th edition at 5% level of significance. Mean separation for treatment effects that were significant was done by Fisher's protected least significant difference (LSD) test using GenStat version 15th edition (Payne et al., 2011). Variability within each quantitative trait was calculated using statistical measures of mean, standard deviation and coefficient of variation. Correlation analyses were performed in GenStat to estimate quantitative relationships among the traits.

RESULTS AND DISCUSSION

The number of days to seedling emergence. Spider plant accessions varied significantly ($P<0.05$) in the number of days to seedling emergence in both greenhouse and field experiments (Table 5 and Table 6). In the field experiment, location and location × spider plant interaction significantly affected the number of days to seedling emergence. Greenhouse-grown accessions had an average of 8.1 days from sowing to emergence compared to an average of 9.4 days to emergence recorded in the field-grown accessions. About 75% of field-grown accessions recorded an average of above 7 days to seedling emergence, while 40% of greenhouse-grown accessions emerged in 7 days. Days to seedling emergence ranged from 4 (accessions Nandi, GBK-045436, Kisii) to 12.7 (accessions GBK-031992, GBK-032302). The observed genotypic variation may be attributed to possible differences in seed maturity level at harvest, seed processing, and seed dormancy. Ekpong (2009), Wasonga et al. (2015), and Onyango et al. (2016) reported similar findings in spider emergence in the field and greenhouse studies. Ochuodho et al. (2005) reported that spider plant seed germination is enhanced by physiologically mature seeds and proper seed processing and storage. The consequence of genotypes that take a long time to germinate may result in a poor final plant stand and hence reveal low leaf yields per unit area (Nennich, 2000). Spider plant harvested when the pods have fully ripened exhibit high seedling emergence. Early and late harvesting lead to poor quality seeds whose emergence tends to be low (Ekpong, 2009). The commercial variety (Saga) emerged after 8 days in the field and 6 days in the greenhouse compared to gene bank accessions, which emerged after 10 days in the field and 9 days in the greenhouse. The early emergence recorded in the commercial variety (Saga) may be attributed to selection and improvement by the seed companies (Onyango et al., 2016). Accessions sowed in the greenhouse generally emerged one day earlier than those grown in the field probably due to the higher temperature in the greenhouse that increased seed metabolic activities, resulting in earlier emergence. Optimal temperatures increase the seed's physiological processes, accelerating seed germination and emergence (Shaban, 2013).

Seedling emergence percentage. Spider plant accessions varied significantly at $P<0.05$ in seedling emergence for field-grown accessions (Table 5 and Table 6). In the field experiment, location × spider plant accession interaction had significant effects on seedling emergence. The heritability of any trait depends on the genotype and the environment it is grown in (Nguyen and Sleper, 1983). Field grown accessions recorded average seedling emergence of 42.9% compared to 41.8 % for greenhouse-grown accessions. Awendo and Baringo accessions had a higher seedling emergence than the commercial variety (Saga) in the field experiments. Accessions Kuria (53.8%) and commercial variety (Saga) (59%) recorded a seedling emergence of above 50% in the greenhouse. In comparison, in the field experiment, accessions Kakamega (54.4%), Kericho (51%), Awendo (58.6%), Baringo (56%), Bungoma (53.4%) and commercial variety (55.9%) recorded seedling emergence of more than 50%. Onyango et al. (2016) reported similar findings for greenhouse-grown accessions. In their study, seedling emergence varied from 16.7% to 50.0%. Seedling emergence percentage among the accessions varied with growing location. This could be attributed to genotype-environment interaction. The differential response of cultivars to diverse environments is referred to as a crossover interaction when cultivar ranks change from one environment to another (Kang, 1998). This may explain the observed differences among the locations. The relative high seedling emergence of the commercial variety (Saga) may be attributed to the proper processing and storage, as well as using physiologically mature seeds. The seed companies prescribe the seed's quality attributes to be adopted by the contracted farmers, including harvesting mature seeds. The variations and poor seedling emergence recorded among gene bank and farmers' accessions may be partly attributed to poor processing before storage of some farmers' accessions and prolonged storage in the gene bank (more than five years) at low temperature (-20°C) which leads to long dormancy. The poor seedling emergence recorded among the accessions presents a key parameter of focus by breeders in spider plant improvement programs. Seeds that have attained physiological maturity will germinate once the dormancy is broken and when the necessary germination conditions avail (Ochuodho and Modi, 2007). Days to emergence recorded strong negative correlations with plant height (r=-0.63) and the number of pods (r=-0.70) in the greenhouse (Table 11), implying that the longer it took for seeds to emerge the shorter the spider plant grew and the lower the number of pods the plant formed. Accessions that took more days to seedling emergence resulted in reduced plant vigor as exhibited in shorter plants and low pod number, leading to low seed and leaf yield. Seeds that take longer in the soil before germinating are prone to higher chances of attack by soil-borne pests and diseases that reduce their emergence (Nennich, 2000). Liu (2000) reported that a high seedling emergence percentage is a pre-requisite for successful commercial vegetable production. Accessions GBK-031997, Kakamega and Kericho, recorded higher seedling emergence than other accessions in the field at Kabete Field Station, while in field-grown at Nyabokarange village, accessions Awendo (68%), Baringo (62.7%) and Bungoma (60%) recorded higher seedling emergence than all other accessions. The variability in seedling emergence in the two locations could be attributed to variations in weather conditions marked during the seedling emergence season. Kabete field station recorded an average rainfall of 110.4 mm while Kuria West Sub-County recorded an average rainfall of 144.7 mm in November, the sowing month (Tables 2 and 3).

The number of primary branches per plant. Spider plant accessions varied significantly at P<0.05 in the number of primary branches per plant for greenhouse and field experiments (Table 5 and Table 6). Location × spider plant accession interactions had significant effects on the number of primary branches per spider plant, but the main location effects for this parameter were not significant. The number of primary branches per plant varied from 7 (accession GBK-031997) to 12.7 (accession GBK-031991) for the field-grown accessions, and 5.7 (accession Mombasa) to 12.7 (accession Eldoret) for the greenhouse-grown accessions. There was no significant difference in the average number of primary branches for field-grown accessions at Kabete Field Station and Nyabokarange village. In the field and greenhouse, commercial variety (Saga) recorded 10.7 and 12.3 primary branches per plant, respectively. In the field experiment accessions GBK-031991 (12.7), GBK-032253R (12.2) and GBK-032302 (12.2) recorded the highest number of primary branches while in the greenhouse, accessions Baringo (12.5), Bungoma (12.7) and GBK-032253R (12.3) recorded the highest number of primary branches. Spider plant accessions recorded a significant positive correlation between the number of primary branches and the number of leaves per plant (r=0.81 and r=0.78, respectively) in both the greenhouse and field experiments (Tables 11 and 12). Munene et al. (2018) also reported a positive correlation between the number of primary branches and the number of leaves per plant. Lawlor (1995) reported that leaf yield per unit area increased with an increase in primary branch formation.

Plant height. Spider plant accessions varied significantly at P<0.05 in plant height for greenhouse and field experiments (Tables 5 and 6). In the field experiment, location and location × spider plant interactions significantly affected plant height per spider plant. The variations reported among the genotypes in the two locations may be attributed to differences in weather and soil conditions. Analysis of soil collected in Kabete Field Station showed more organic carbon, nitrogen, and phosphorus than that of Nyabokarange village (Tables 2 and 3). Plant height varied from 16 cm (accession Mombasa) to 107.1 cm (accession GBK-045436) in the greenhouse, and 17.0 cm (Mombasa) to 100.8 cm (GBK-031991) in the field, suggesting genotypic variations. Their findings correspond with variations reported by Munene et al., (2018) of 21 cm to 113 cm for spider plant. Field grown accessions recorded an average plant height of 71.6 cm compared to 70.75 cm in the greenhouse. The commercial variety (Saga) recorded a height of 72.8 cm. However, 45% of the evaluated local spider plant accessions were taller than the commercial variety (Saga) in the field experiment. In the greenhouse experiment, commercial variety (Saga) recorded a height of 83.3 cm. Accessions Nyamira (99 cm), GBK-031991 (100.8 cm) and GBK-031968 (95.2 cm) recorded the highest plant height in the field while accessions Nyamira (103.0 cm), Kuria (100.3 cm) and GBK-045436 (107.1 cm) recorded the highest plant height in the greenhouse. Plant height is an important agronomic parameter that reveals the crops vegetative growth behaviour (Anjum et al., 2016; Wang et al., 2016). Tallness is important for good vigor, enabling the plant to grow to the height required for easier weeding and harvesting during production (Chowdhury et al., 2007). Tallness facilitates free air circulation in the plant, thus preventing pests and diseases (Chowdhury et al., 2007). There was a strong significant positive correlation between plant height and the number of leaves per plant (r=0.87) in the greenhouse experiment (Table 11). In vegetable crops, short plants and low plant density leads to the low rate of photosynthesis resulting in low leaf yield (Lawlor, 1995).

The number of leaves per plant. Spider plant accessions varied significantly at P<0.05 in the number of leaves per plant in greenhouse and field experiments (Tables 5 and 6). In the field experiment, location and location × spider plant interactions had significant effects on the number of leaves per spider plant. The number of leaves per plant varied from 23.2 (accession Mombasa) to 115.7 (accession GBK-032253R) leaves in the field and 49.3 (accession Mombasa) to 121.7 (accession GBK-028563) in the greenhouse. Wasonga et al., 2015 recorded similar findings in plant leave variation in spider accessions in the field and greenhouse experiments. Commercial variety (Saga) recorded 86.0 leaves per plant in the field experiment and 99.0 per plant leaves in the greenhouse. These were lower than the number of leaves per plant for some local accessions such as Bungoma, Kisii 2, and Kakamega. Leaves are the primary sites of photosynthesis in crop plants; therefore, one might assume that the higher the number of leaves in a crop, the better the interception of sunlight and the higher the leaf yield (Silver tooth, 2014). The number of leaves per plant recorded a significantly positive correlation with the number of pods and days to flowering (r=0.78 and r=0.65), respectively, for greenhouse-grown accessions (Table 11). An increase in the number of leaves is associated with an increase in pod formation. In the field experiment, accessions GBK-031968 (106.2), GBK-031991 (109.5), GBK-031992 (109.7) and GBK-032253R (115.7) recorded the highest number of leaves per plant while in the greenhouse accessions GBK-

028563 (121.7), GBK-031991 (112.0) and GBK-031997 (109.7) recorded the highest number of leaves per plant in the greenhouse. The number of leaves increased with an increase in the number of days to flowering, which resulted in a prolonged vegetative period. When leaf count is high, it is likely that the number of leaves per unit area will also be high with a high rate of photosynthesis, resulting in high productivity per unit area, especially in leafy vegetables (Lawlor, 1995) such as spider plant.

Number of days to 50% flowering. Spider plant accessions varied significantly at P<0.05 in the number of days to 50% flowering in both experiments (Table 9 and Table 10). Location × spider plant accession interaction had no significant effects on the number of days to 50% flowering, but the main location effects for this parameter were significant. The number of days to flowering varied significantly among the spider plant accessions from 29.7 (Nyamira) to 51.7 (GBK-028563), a variation of 22 days. This demonstrates that the accessions studied have relatively high genotypic variation in the number of days to flowering. The differences in the number of days to flowering are higher than those reported by Onyango et al*.,* (2016) of 12 days, possibly because of a broader range of genotypes evaluated in the current study at different locations. Field grown accessions flowered on average at 38.9 days compared to 40.9 days for greenhouse-grown accessions. Accessions grown at Kabete field station bloomed on average in 40 days compared to 37.6 days for Nyabokarange grown accessions (Table 5, Table 9 and Table 10). Farmers prefer late flowering to early flowering genotypes of vegetable species since flowering signals the end of the vegetative phase. In this case, the commercial variety (Saga) and local accessions may be less suitable for vegetable production. They flowered in 38 days compared to genebank accessions that bloomed in 42 days. The reproductive phase in vegetable crops inhibits leaf production (Yamaguchi, 1983; Nonnecke, 1989). Thus, late-flowering enables a genotype to have a more prolonged vegetative stage during the growth period (Omondi, 1990). In this case, accessions GBK-031991, GBK-032302, and GBK-031992, which took 45, 44.8, and 44.7 days to flower, respectively, could be candidates for cultivation by farmers as well as for spider plant crop improvements for vegetable production.

The number of pods per plant. Spider plant accessions varied significantly at P<0.05 in the number of pods per plant in both experiments (Tables 6 and 9). In the field experiment, location and location × spider plant interaction had significant effects on the number of pods per spider plant. The number of pods per plant varied from 19.7 (accession Mombasa) to 101.5 (accession Kakamega) for the field experiment, and 31.7 (accession Mombasa) to 70.7 (accession Kuria) pods for the greenhouse experiment. Field experiments recorded 69.6 pods per plant compared to 52.1 pods for the greenhouse accessions (Table 3.7 and 3.8). More extensive variations were observed in the field experiment than the greenhouse experiment, possibly due to higher variability in soil and weather conditions in the fields. Sixty-eight percent (68%) of the evaluated accessions recorded a higher number of pods per plant (mean 73.5 pods) than the commercial variety (Saga) (63.8 pods). In the greenhouse, accessions Kuria (70.7), GBK-045456) and GBK-045436 (69.7) and in the field accessions Kakamega (101.5), GBK-032253R (95.3) and GBK-031991 (88.2) recorded the highest number of pods per plant. The number of pods per plant and seed weight is the primary driver of seed yield. Variation in the number of pods per plant has also been previously reported for spider plant accessions (Wasonga et al., 2015*;* Onyango et al., 2016). The number of pods strongly correlated with seed yield (r=0.77 and r=0.62) in greenhouse and field experiments, respectively (Table 11 and Table 12). This implies that the greater the number of pods, the higher the seed yield of spider plants. These findings agreed with Oyiga and Uguru (2011) who noted a strong positive correlation between seed yield and the number of pods per plant in Bambara plant.

The number of seeds per pod. Spider plant accessions varied significantly at P<0.05 in the number of seeds per pod in both experiments (Tables 6 and 8). In the field experiment, location and location × spider plant interaction had significant effects on the number of seeds per pod. The number of seeds per pod varied from 14.0 (accession Mombasa) to 180.3 (accession GBK-031850) in the greenhouse, and 23.7 (accession GBK-028563) to 156.1 (accession Migori) in the field (Table 7 and Table 8). In the greenhouse, commercial variety (Saga) recorded 136.3 seeds per pod, which was below the number of seeds per pod for accessions GBK-045456 (164.0 seeds), GBK-032229 (178.7 seeds) and GBK-031850 (180.3 seeds). In the field experiment 77.5 % of the spider plant accessions evaluated recorded a higher number of seeds per pod (120.5 seeds) than the commercial variety (Saga) (93.8 seeds) Similar findings have also been reported in spider plant accessions evaluated in a greenhouse (Onyango et al., 2016). In their study, evaluated accessions recorded a variation of 12 to 170 seeds per pod. The more significant variations observed in the greenhouse and field suggests high genotypic variations in the number of seeds per pod among spider plant genotypes. Seed counts per pod can vary widely among plant species and individual accessions within a species (Stephenson, 1984). Field grown accessions recorded a higher average number of seeds per pod (108.3 seeds) than the greenhouse accessions (99.8 seeds). This may be attributed to low soil volume in the pots used in the greenhouse, unlike the field experiment where the spider plants had a large soil volume to explore nutrients and water. The number of seeds per pod and seed yield recorded a strong positive correlation. This denotes that a high number of seeds in a pod is likely to increase seed yield. A similar observation was also recorded by Esmail et al. (1994). This suggests that the number of pods per plant can aid in the selection of accessions for seed production. In this case, accessions Awendo (151.4), GBK-031997 (151.8), and Migori (156.1) and accessions GBK-031850 (180.3), and GBK-032229 (178.7) recorded the highest number of seeds per pod in the field and greenhouse, respectively, and can be recommended for seed production.

Mass of 100 seeds per plant. Spider plant accessions varied significantly at $P<0.05$ in 100-seed weight for both experiments. The hundred seed weights were dependent on the genotype and the growing environment. Heritability of any trait depends on the genotype, as well as the environment (Nguyen and Sleper, 1983). The 100-seed weight strongly correlated with seed yields (r=0.53 and 0.63) in field and greenhouse experiments respectively (Tables 11 and 12). One of the essential criteria in determining seed quality is the 100-seed weight. It estimates the size of the embryo and food reserves of seeds for germination and emergence (Moshatati, 2012). Germination percent and seedling emergence increase with high 100-seed weight (Noor-Mohammadi et al., 2000). In the field experiment, accessions GBK-031996 (146.7mg), GBK-045456 (146.7mg) and Kisii 2 (146.7mg) (Table 8), and in the greenhouse experiment GBK-031994 (170mg) (Table 6) recorded the highest 100-seed weights among the spider plant accessions and the commercial variety (Saga). The commercial variety (Saga) (118.3mg) was outperformed by 90% of the local spider plant accessions (average of 132.6mg) evaluated in the field. This implies that local accessions contain genes that could be exploited to improve seed weight in spider plants. It also suggests local accessions can be recommended for use by farmers.

Seed yield per plant. Spider plant accessions varied significantly at $P<0.05$ in seed yield per plant in greenhouse and field experiments. In the field experiment, location and location × spider plant interactions had significant effects on the seed yield per spider plant. The yield of seeds per plant varied from 0.3g (accession Mombasa) to 16.8g (accessions GBK-045436 and GBK-045456) in the greenhouse, and 0.7g (accession Mombasa) to 16.0g (accession GBK-031991) in the field (Tables 6 and 8). The field experiment recorded an average seed yield of 10.2g compared to 7.3g in the greenhouse experiment (Tables 9 and 10). The greater variations recorded suggests a high genotypic variation in seed yield among the genotypes. Seed yield is a complex trait having polygenic inheritance (Azhar and Neem, 2008). Wasonga et al. (2015) also reported significant variation in seed yield in spider plant accessions in field and greenhouse experiments. In this study, seed yield recorded a strong positive correlation with parameters that drive seed yield in spider plants that include the number of pods, number of seeds per pod, days to emergence, and weight of 100 seeds. Salehi et al. (2010) reported that results of stepwise multiple regression analysis based on seed yield as a dependent variable and other traits as independent variables, pods per plant explained 83.2% of the total variation. This suggests that the number of pods per plant may be the main factor influencing seed yield. Eighty-three percent (83%) of the spider plant local accessions recorded a higher seed yield than the commercial variety (Saga).

There are significant genotypic differences in growth and seed yield traits among the evaluated local spider plant accessions and the commercial variety (Saga). Genotypes that expressed superior agronomic traits for vegetable and seed yield such as accessions GBK-031991, Kakamega, GBK-045456, GBK-032302, and Migori are recommended for adoption by farmers for spider plant production aimed at attaining high yields for increased profitability. The accessions are also recommended for breeding programs for possible development of high yielding spider plant commercial varieties that are rich in both micro and macro-nutrients. These accessions performed better than the commercial variety (Saga). The study also revealed significant variations among the performance of the accessions in both locations. Such significant variations in qualitative characters observed among the spider plant accessions evaluated in these two sites suggests that the most promising line or variety may be site specific for different agro-ecological zones.

Table 1: Soil chemical characteristics of the experimental sites at Kabete Field Station and Nyabokarange village in Kuria West Sub County, Kenya.

Parameters	Kabete	Nyabokarange	Critical level
Soil Ph	6.2	6.7	<5.0
Total Nitrogen (g kg^{-1})	3.0	*1.0*	<3.0
Total Organic Carbon (g kg^{-1})	19.0	8.0	<0.5
Calcium (mol kg-^{1})	2.4	2.2	<1.0
Magnesium (mol kg^{-1})	0.7	1.0	<0.4
Potassium (mol kg^{-1})	1.2	0.8	<0.8
Manganese (mol kg^{-1})	65.9	80.2	<2.3
Iron (mg kg^{-1})	55.0	65.8	<30.0
Zinc (mg kg^{-1})	*8.5*	*7.5*	<25.0
Copper (mg kg^{-1})	*1.1*	*1.0*	<4.0
Phosphorus (mg kg^{-1})	24.1	21.7	<0.3

Table 2: Weather conditions at Kabete field station between June 2018 and March 2019 cropping season.

	Temperature (°C)		Rainfall (mm)	Relative humidity (%)
Month	Mean Max	Mean Min	Total	Mean
June	19.5	12.9	270.3	67.2
July	18.8	12.0	27.3	66.2
August	20.3	11.7	1.1	59.9
September	25.0	12.7	8.3	46.5
October	23.0	14.0	65.5	57.6
November	27.1	15.1	110.4	54.7
December	21.6	14.5	95.9	58.8
January	23.6	13.6	9.8	40.1
February	26.0	14.2	3.5	38.9
March	27.5	15.7	2.9	30.6

Source: Kenya Meteorological Department, Kabete Agro-met Station (May 2019).

Table 3: Weather conditions at Nyabokarange village in Kuria West Sub-County (Migori County) between November 2018 and February 2019 cropping season.

	Temperature (°C)		Rainfall (mm)	Relative humidity (%)
Month	Mean Max	Mean Min	Total	Mean
November	26.2	15.8	144.7	56.9
December	25.2	15.7	161.8	61.5
January	27.2	16.5	21.6	43.2
February	28.9	16.7	26.1	40.4

Source: Kenya Meteorological Department, Head Quarters Met station (May 2019). Max-maximum, Min-minimum.

Table 4: List of spider plant (*Cleome gynandra*) accessions evaluated in the study.

Entry	Accessions	Source*	Region
1	Awendo	Awendo	Nyanza
2	Baringo	Baringo	Rift Valley
3	Bungoma	Bungoma	Western
4	Eldoret	Eldoret	Rift Valley
5	GBK-028542	Elgeyo Marakwet	Rift Valley
6	GBK-028554	Siaya	Nyanza
7	GBK-028563	Elgeyo Marakwet	Rift Valley
8	GBK-031833	Bungoma	Western
9	GBK-031837	Bungoma	Western
10	GBK-031850	Kakamega	Western
11	GBK-031866	Kakamega	Western
12	GBK-031968	Kakamega	Western
13	GBK-031991	Busia	Western
14	GBK-031992	Busia	Western
15	GBK-031993	Busia	Western
16	GBK-031994	Busia	Western
17	GBK-031996	Busia	Western
18	GBK-031997	Busia	Western
19	GBK-031998	Busia	Western
20	GBK-032210	Makueni	Eastern
21	GBK-032229	West pokot	Rift Valley
22	GBK-032253	West pokot	Rift Valley
23	GBK-032253R	West pokot	Rift Valley
24	GBK-032302	Mbale	Western
25	GBK-045426	Vihiga	Western
26	GBK-045436	Kisumu	Nyanza
27	GBK-045456	Central Kiambu	Central
28	Homabay	Homabay	Nyanza
29	Kakamega	Kakamega	Western
30	Kericho	Kericho	Rift Valley
31	Kisii 1	Elgeyo Marakwet	Nyanza
32	Kisii 2	Elgeyo Marakwet	Nyanza
33	Kuria	Kuria	Nyanza
34	Marakwet	Marakwet	Rift Valley
35	Migori	Migori	Nyanza
36	Mombasa	Mombasa	Coast
37	Nakuru	Nakuru	Rift Valley
38	Nandi	Nandi	Rift Valley
39	Nyamira	Nyamira	Nyanza
40	Commercial	Commercial	Simlaw

GBK-GeneBank of Kenya, source*-where seed was obtained

Table 5: Number of days to seedling emergence, percent seedling emergence, primary branches and plant height of 40 spider plant accessions grown in the field at Kabete Field Station and Nyabokarange village, Kenya.

	DTE			EM%			NPB			PH		
Accession	Kabete	Nyabo	Mean	Kabete	Nyabo	Mean	Kabete	Nyabo	Mean	Kabete	Nyabo	Mean
Awendo	7.3	8.0	7.7	49.2	68.0	58.6	6.0	9.0	7.5	44.3	55.3	49.8
Baringo	7.3	7.0	7.2	49.2	62.7	56.0	7.0	8.3	7.7	54.3	47.0	50.7
Bungoma	8.0	7.7	7.8	46.7	60.0	53.4	8.3	9.0	8.7	63.3	54.0	58.7
Eldoret	11.7	7.3	9.5	38.3	53.3	45.8	11.3	11.3	11.3	81.0	72.0	76.5
GBK-028542	10.7	8.7	9.7	41.7	42.7	42.2	11.0	11.3	11.2	77.7	73.3	75.5
GBK-028554	12.0	9.0	10.5	38.3	36.0	37.2	9.0	10.7	9.8	68.7	60.0	64.3
GBK-028563	9.0	7.7	8.3	45.0	32.0	38.5	9.7	9.3	9.5	69.0	52.3	60.7
GBK-031833	9.7	7.7	8.7	43.3	46.7	45.0	9.0	8.0	8.5	66.7	47.3	57.0
GBK-031837	9.0	9.3	9.2	45.0	45.3	45.2	10.0	9.3	9.7	76.3	50.7	63.5
GBK-031850	10.0	9.0	9.5	42.5	42.7	42.6	10.3	10.3	10.3	83.7	59.0	71.3
GBK-031866	10.7	11.7	11.2	40.8	45.3	43.1	11.0	10.3	10.7	82.0	58.3	70.2
GBK-031968	11.7	9.7	10.7	38.3	40.0	39.2	10.7	12.7	11.7	80.7	109.7	95.2
GBK-031991	11.7	11.3	11.5	38.3	29.3	33.8	13.3	12.0	12.7	100.7	101.0	100.8
GBK-031992	12.0	13.3	12.7	37.5	34.7	36.1	11.0	13.0	12.0	86.3	89.0	87.7
GBK-031993	9.7	9.0	9.3	43.3	45.3	44.3	9.3	9.7	9.5	69.0	68.3	68.7
GBK-031994	10.7	11.0	10.8	40.8	36.0	38.4	10.7	9.7	10.2	84.7	68.7	76.7
GBK-031996	8.7	6.7	7.7	45.8	32.0	38.9	7.7	8.0	7.8	60.7	52.0	56.3
GBK-031997	7.0	7.3	7.2	50.0	41.3	45.7	7.0	7.0	7.0	53.3	45.7	49.5
GBK-031998	10.0	8.3	9.2	42.5	37.3	39.9	10.0	9.7	9.8	76.3	64.7	70.5
GBK-032210	11.0	10.0	10.5	40.0	32.0	36.0	11.0	11.0	11.0	82.7	75.7	79.2
GBK-032229	10.7	10.7	10.7	40.8	41.3	41.1	11.3	10.0	10.7	84.7	69.3	77.0
GBK-032253	11.0	11.0	11.0	40.0	49.3	44.7	13.0	11.0	12.0	103.7	75.0	89.3
GBK-032253R	10.3	10.3	10.3	41.7	29.3	35.5	12.7	11.7	12.2	100.0	82.0	91.0
GBK-032302	11.3	14.0	12.7	39.2	54.7	47.0	12.0	12.3	12.2	101.3	81.7	91.5
GBK-045426	10.0	9.0	9.5	42.5	28.0	35.3	8.7	9.7	9.2	65.0	80.7	72.8
GBK-045436	11.0	13.3	12.2	40.0	33.3	36.7	11.0	11.3	11.2	86.0	72.7	79.3
GBK-045456	11.0	9.3	10.2	40.0	45.3	42.7	12.0	10.7	11.3	91.0	76.0	83.5
Homabay	10.0	9.0	9.5	42.5	57.3	49.9	10.7	9.7	10.2	80.3	81.7	81.0
Kakamega	8.3	9.0	8.7	50.0	58.7	54.4	11.7	10.7	11.2	91.7	75.0	83.3
Kericho	7.0	8.0	7.5	50.0	52.0	51.0	9.7	8.3	9.0	74.0	52.0	63.0
Kisii 1	8.0	6.7	7.3	35.8	37.3	36.6	10.7	12.3	11.5	74.0	82.3	78.2
Kisii 2	7.7	6.7	7.2	40.8	44.0	42.4	9.7	11.0	10.3	78.0	70.7	74.3
Kuria	6.3	7.3	6.8	41.7	53.3	47.5	8.0	10.7	9.3	62.0	72.0	67.0
Marakwet	11.7	7.0	9.3	35.0	53.3	44.2	8.7	9.3	9.0	66.7	60.7	63.7
Migori	6.3	9.3	7.8	33.3	42.7	38.0	9.7	8.0	8.8	79.3	53.7	66.5
Mombasa	12.3	8.7	10.5	36.7	25.3	31.0	9.0	5.0	7.0	17.7	16.3	17.0
Nakuru	10.0	9.0	9.5	42.5	38.7	40.6	8.3	9.3	8.8	62.0	67.7	64.8
Nandi	10.3	10.3	10.3	40.8	26.7	33.8	8.7	10.7	9.7	65.0	65.7	65.3
Nyamira	8.7	8.7	8.7	45.8	48.0	46.9	11.7	9.7	10.7	92.0	106.0	99.0
Commercial (Saga)	9.0	7.3	8.2	55.8	56.0	55.9	11.7	9.7	10.7	84.3	61.3	72.8
Mean	**9.7**	**9.1**	**9.4**	**42.3**	**43.4**	**42.9**	**10.1**	**10.0**	**10.1**	**75.5**	**67.7**	**71.6**
P-Value (A)	<.001			<.001			<.001			<.001		
P-Value (L)	<.001			0.07			0.8			<.001		
P-Value (A×L)	<.001			<.001			0.04			<.001		
$LSD_{\leq 0.05}$ (A)	1.5**		,	5.6**			1.7**			8.1**		
$LSD_{\leq 0.05}$ (L)	0.3**			NS			NS			1.8**		
$LSD_{\leq 0.05}$ (A×L)	2.1**			7.9**			2.4*			11.4**		
CV%	13.9			11.4			14.7			9.9		

DTE-Days to emergence, EM%-Seedling emergence percentage, NPB-Number of primary branches, PH-Plant height; ** highly significant at P<0.05 level, * significant at P<0.05 level, NS-not significant; A-Accession, L-Location, Nyabo-Nyabokarange village

Table 6: Means of quantitative trait means of 40 spider plant accessions grown in the greenhouse at Kabete Field Station, Kenya.

Accession	DTE	EM%	NPB	PH	NLP	DTF	NPP	NSP	100sw(g)	SYP (g)
Awendo	8.0	46.2	11.0	74.3	85.7	42.3	53.0	69.7	110.0	4.0
Baringo	5.0	23.1	12.5	82.0	98.3	35.3	60.7	98.0	120.0	7.0
Bungoma	6.0	43.6	12.7	92.0	102.3	36.3	66.3	79.0	130.0	6.9
Eldoret	8.0	28.2	10.7	76.7	86.0	42.7	56.0	88.7	120.0	6.0
GBK-028542	10.3	25.6	11.0	74.0	87.3	42.7	51.0	79.7	120.0	4.7
GBK-028554	8.3	38.5	11.7	78.3	94.0	40.0	60.7	76.7	120.0	5.6
GBK-028563	12.3	43.6	12.0	21.0	121.7	51.7	37.7	34.0	90.0	1.2
GBK-031833	11.3	38.5	9.0	56.0	79.7	43.7	44.0	55.7	90.0	2.2
GBK-031837	12.7	38.5	7.7	52.3	82.7	47.3	41.0	141.3	120.0	6.8
GBK-031850	9.3	46.2	11.0	74.3	101.3	41.3	44.0	180.3	110.0	8.5
GBK-031866	10.3	48.7	11.3	40.0	93.3	46.0	33.3	161.3	100.0	5.4
GBK-031968	9.3	41.0	8.7	54.7	82.7	46.0	38.3	125.3	120.0	5.9
GBK-031991	12.7	43.6	12.0	44.0	112.0	50.3	36.3	85.0	100.0	3.3
GBK-031992	8.3	41.0	10.0	68.6	82.7	42.3	51.0	79.3	120.0	5.0
GBK-031993	8.3	41.0	10.0	73.3	80.7	43.2	40.0	61.7	130.0	3.3
GBK-031994	10.0	46.2	9.0	63.7	72.7	46.0	43.0	79.0	170.0	5.8
GBK-031996	10.7	48.7	7.7	56.0	64.7	47.3	40.7	32.7	120.0	1.6
GBK-031997	10.3	43.6	12.0	56.3	109.7	45.6	46.7	31.3	130.0	1.9
GBK-031998	9.0	46.2	9.2	61.0	99.3	43.3	47.3	128.0	140.0	8.3
GBK-032210	8.7	48.7	11.3	76.0	104.3	41.0	54.7	95.7	160.0	8.6
GBK-032229	8.3	38.5	10.3	70.3	76.3	41.7	51.3	178.7	130.0	12.3
GBK-032253	7.0	33.3	11.3	76.3	86.3	37.7	54.3	92.7	150.0	7.6
GBK-032253R	6.7	33.3	12.3	83.3	96.3	38.3	60.3	76.7	150.0	7.0
GBK-032302	8.3	41.0	11.7	82.0	108.0	41.3	53.0	99.0	150.0	7.7
GBK-045426	7.0	41.0	11.7	84.7	102.7	38.5	61.0	149.0	150.0	13.4
GBK-045436	4.7	51.3	6.7	107.1	59.0	33.3	69.7	152.3	160.0	16.8
GBK-045456	5.0	48.7	7.3	98.7	57.7	34.7	69.7	164.0	150.0	16.8
Homabay	8.3	38.5	11.3	76.3	87.3	43.3	55.0	108.3	160.0	9.5
Kakamega	5.3	43.6	7.3	91.3	67.0	34.7	64.7	105.7	150.0	10.5
Kericho	10.3	41.0	9.0	59.7	71.3	43.0	44.7	100.0	130.0	6.0
Kisii 1	7.3	46.2	12.3	82.0	94.0	39.0	60.7	109.3	150.0	10.0
Kisii 2	7.3	38.5	10.3	70.0	80.7	39.0	62.0	109.7	150.0	10.3
Kuria	4.7	53.8	8.0	100.3	67.3	34.0	70.7	113.7	150.0	12.1
Marakwet	8.3	38.5	7.0	44.3	57.0	47.0	35.0	77.0	130.0	3.5
Migori	6.0	43.6	12.0	82.0	97.0	38.3	60.7	134.0	140.0	11.4
Mombasa	5.0	30.8	5.7	16.0	49.3	34.0	31.7	14.0	60.0	0.3
Nakuru	6.3	46.2	7.3	82.3	80.7	34.7	59.3	134.0	130.0	10.5
Nandi	9.3	38.5	9.3	62.3	75.0	43.3	42.7	59.0	140.0	3.7
Nyamira	4.3	46.2	7.7	103.0	65.7	29.7	69.3	97.7	140.0	9.8
Commercial	6.3	59.0	12.3	83.3	99.0	36.7	62.3	136.3	140.0	11.6
Mean	**8.1**	**41.8**	**10**	**70.8**	**85.5**	**40.9**	**52.1**	**99.8**	**130**	**7.3**
P-Value	<.001	0.256	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
$LSD_{\leq 0.05}$	1.4**	NS	1.9**	6.9**	10.1**	2.7**	5.5**	9.3**	20.0**	2.3**
CV%	10.6	27.4	11.9	6	7.3	4	6.5	5.7	11.7	19.6

DTE-Days to emergency, EM%-Seedling emergence percentage, NPB-Number of primary branches, PH-Plant height NLP-Number of leaves per plant, DTF-Days to flowering, NPP-Number of pods per plant, NSP-Number of seeds per Pod, 100 sw-weight of 100 seeds. SYP-Seed yield per plant. ** Highly significant at P<0.05 level,* significant at P<0.05 level NS-not significant.

Table 7: Number of leaves, days to 50% flowering and number of pods per plant of 40 spider plant accessions grown in the field at Kabete field station and Nyabokarange village, Kenya.

	No. of leaves/ plant (NLP)			Days to flowering (DTF)			No. of pods per plant (NPP)		
Accession	Kabete	Nyabo	Mean	Kabete	Nyabo	Mean	Kabete	Nyabo	Mean
Awendo	54.3	81.7	68.0	37.0	34.3	35.7	48.7	53.0	50.8
Baringo	62.0	64.3	63.2	35.7	33.0	34.3	58.3	50.0	54.2
Bungoma	75.3	75.7	75.5	38.0	35.0	36.5	68.7	49.3	59.0
Eldoret	100.0	89.3	94.7	41.7	37.7	39.7	89.3	75.0	82.2
GBK-028542	94.3	92.3	93.3	41.0	36.7	38.8	77.0	67.7	72.3
GBK-028554	80.3	94.3	87.3	39.3	38.0	38.7	72.0	58.0	65.0
GBK-028563	89.3	75.3	82.3	40.0	34.0	37.0	77.0	50.3	63.7
GBK-031833	83.3	65.7	74.5	37.7	33.7	35.7	71.3	47.0	59.2
GBK-031837	87.0	76.0	81.5	40.3	36.3	38.3	73.3	54.3	63.8
GBK-031850	86.0	83.0	84.5	39.7	37.3	38.5	74.7	66.0	70.3
GBK-031866	101.7	84.3	93.0	41.7	38.7	40.2	83.7	64.7	74.2
GBK-031968	97.7	114.7	106.2	40.3	44.7	42.5	83.7	83.0	83.3
GBK-031991	117.3	101.7	109.5	46.0	44.0	45.0	104.0	72.3	88.2
GBK-031992	103.7	115.7	109.7	42.0	47.3	44.7	86.7	78.3	82.5
GBK-031993	79.7	81.3	80.5	42.0	35.0	38.5	70.3	68.0	69.2
GBK-031994	99.0	85.0	92.0	43.3	42.3	42.8	89.0	54.7	71.8
GBK-031996	75.0	65.7	70.3	36.7	32.3	34.5	59.7	63.7	61.7
GBK-031997	62.7	55.0	58.8	35.7	32.7	34.2	55.3	37.7	46.5
GBK-031998	87.7	85.3	86.5	40.7	37.7	39.2	73.3	63.7	68.5
GBK-032210	99.3	93.3	96.3	41.7	38.3	40.0	86.3	66.0	76.2
GBK-032229	98.3	86.3	92.3	41.7	37.3	39.5	84.3	78.0	81.2
GBK-032253	107.7	94.7	101.2	46.3	42.0	44.2	86.3	63.3	74.8
GBK-032253R	125.7	105.7	115.7	44.3	42.0	43.2	87.7	103.0	95.3
GBK-032302	108.3	102.7	105.5	43.3	46.3	44.8	101.0	70.7	85.8
GBK-045426	79.7	91.7	85.7	38.3	35.7	37.0	81.3	61.3	71.3
GBK-045436	99.7	97.0	98.3	42.0	41.3	41.7	88.3	62.3	75.3
GBK-045456	108.0	89.0	98.5	42.7	38.7	40.7	97.0	58.3	77.7
Homabay	96.7	75.3	86.0	42.0	35.7	38.8	79.3	62.0	70.7
Kakamega	108.0	96.0	102.0	44.3	41.7	43.0	104.3	98.7	101.5
Kericho	90.7	58.7	74.7	40.3	36.7	38.5	77.7	47.7	62.7
Kisii 1	91.7	115.7	103.7	46.0	42.3	44.2	85.0	83.0	84.0
Kisii 2	89.3	96.3	92.8	40.3	38.0	39.2	75.3	74.3	74.8
Kuria	71.3	92.3	81.8	34.0	34.3	34.2	64.7	65.0	64.8
Marakwet	78.7	75.3	77.0	35.7	32.3	34.0	66.7	54.3	60.5
Migori	87.3	60.0	73.7	36.3	33.7	35.0	78.7	49.3	64.0
Mombasa	24.0	22.3	23.2	38.0	35.0	36.5	27.0	12.3	19.7
Nakuru	69.7	78.0	73.8	38.3	35.0	36.7	61.7	55.0	58.3
Nandi	68.0	78.3	73.2	38.3	39.0	38.7	71.0	57.0	64.0
Nyamira	67.0	120.3	93.7	37.0	34.0	35.5	83.7	61.3	72.5
Commercial (Saga)	85.7	86.3	86.0	38.0	35.7	36.8	71.7	56.0	63.8
Mean	**87.3**	**85.0**	**86.2**	**40.2**	**37.6**	**38.9**	**76.9**	**62.4**	**69.6**
P-Value (A)	<.001			<.001			<.001		
P-Value (L)	0.03			<.001			<.001		
P-Value (A×L)	<.001			0.26			<.001		
$LSD_{\leq 0.05}$ (A)	8.8**			3.2**			7.5**		
$LSD_{\leq 0.05}$ (L)	2.0*			0.7**			1.7**		
$LSD_{\leq 0.05}$ (A×L)	12.4**			4.6ns			10.6**		
CV%	8.9			7.5			9.4		

** highly significant at P≤0.05 level, * significant at P≤0.05 level ns-not significant, A-Accessions, L-Location, Nyabo-Nyabokarange village

Table 8: Number of seeds per pod, 100 seed weight and seed yield per plant of 40 Spider plant accessions grown in the field at Kabete Field Station and Nyabokarange village in Kuria West Sub-County, Kenya.

	No. Seeds/pod (NSP)			Weight (100-seed) (mg)			Seed yield/plant (SYP) (g)		
Accession	Kabete	Nyabo	Mean	Kabete	Nyabo	Mean	Kabete	Nyabo	Mean
Awendo	164.7	138.0	151.4	136.7	133.3	135.0	11.0	9.7	10.4
Baringo	135.8	149.4	142.6	130.0	126.7	128.3	10.2	9.5	9.9
Bungoma	89.6	104.0	96.8	140.0	126.7	133.3	8.6	6.5	7.6
Eldoret	138.8	152.5	145.7	133.3	126.7	130.0	16.4	14.5	15.5
GBK-028542	79.0	147.5	113.3	140.0	110.0	125.0	8.4	10.9	9.7
GBK-028554	190.3	57.0	123.7	136.7	110.0	123.3	18.7	3.6	11.2
GBK-028563	28.4	18.9	23.7	120.0	116.7	118.3	2.7	1.1	1.9
GBK-031833	190.7	108.8	149.8	126.7	120.0	123.3	17.4	6.1	11.8
GBK-031837	156.9	56.5	106.7	130.0	116.7	123.3	15.0	3.6	9.3
GBK-031850	146.7	105.4	126.1	136.7	120.0	128.3	15.0	8.3	11.7
GBK-031866	78.0	93.7	85.9	156.7	126.7	141.7	10.2	7.7	9.0
GBK-031968	142.7	102.7	122.7	143.3	113.3	128.3	17.0	9.6	13.3
GBK-031991	137.0	117.5	127.3	146.7	130.0	138.3	20.9	11.1	16.0
GBK-031992	148.5	51.9	100.2	130.0	126.7	128.3	16.7	5.2	11.0
GBK-031993	93.0	48.8	70.9	133.3	116.7	125.0	8.7	3.9	6.3
GBK-031994	102.7	81.4	92.1	133.3	136.7	135.0	12.2	6.1	9.2
GBK-031996	136.7	89.2	113.0	146.7	146.7	146.7	12.0	8.4	10.2
GBK-031997	183.7	119.8	151.8	140.0	126.7	133.3	14.1	5.6	9.9
GBK-031998	104.3	97.0	100.7	143.3	116.7	130.0	11.0	7.2	9.1
GBK-032210	153.7	120.5	137.1	110.0	120.0	115.0	14.7	9.6	12.2
GBK-032229	142.3	119.2	130.8	130.0	136.7	133.3	15.6	12.8	14.2
GBK-032253	76.2	45.2	60.7	150.0	126.7	138.3	9.8	3.6	6.7
GBK-032253R	40.1	57.0	48.6	146.7	126.7	136.7	5.3	7.4	6.4
GBK-032302	140.0	67.6	103.8	146.7	120.0	133.3	20.7	5.8	13.3
GBK-045426	133.0	96.2	114.6	126.7	116.7	121.7	13.9	6.9	10.4
GBK-045436	139.5	52.7	96.1	143.3	120.0	131.7	17.7	4.0	10.9
GBK-045456	151.3	62.9	107.1	170.0	123.3	146.7	24.9	4.5	14.7
Homabay	175.8	86.8	131.3	120.0	140.0	130.0	16.6	7.5	12.1
Kakamega	68.3	126.3	97.3	136.7	143.3	140.0	9.7	17.9	13.8
Kericho	146.0	105.4	125.7	140.0	126.7	133.3	15.9	6.3	11.1
Kisii 1	95.0	104.8	99.9	133.3	130.0	131.7	10.9	11.4	11.2
Kisii 2	85.3	114.5	99.9	160.0	133.3	146.7	10.3	11.4	10.9
Kuria	82.3	116.3	99.3	150.0	103.3	126.7	7.9	7.9	7.9
Marakwet	81.0	62.8	71.9	150.0	126.7	138.3	8.0	4.3	6.2
Migori	173.3	138.8	156.1	150.0	120.0	135.0	20.5	8.3	14.4
Mombasa	54.5	36.4	45.5	73.3	60.0	66.7	1.1	0.3	0.7
Nakuru	140.7	139.3	140.0	123.3	140.0	131.7	10.7	10.6	10.7
Nandi	149.7	90.4	120.1	146.7	130.0	138.3	15.6	6.7	11.2
Nyamira	83.7	128.5	106.1	120.0	126.7	123.3	8.4	9.9	9.2
Commercial (Saga)	119.1	68.5	93.8	123.3	113.3	118.3	10.5	4.3	7.4
Mean	**122.0**	**94.5**	**108.3**	**136.3**	**123.3**	**129.8**	**12.9**	**7.5**	**10.2**
P-Value (A)	<.001			<.001			<.001		
P-Value (L)	<.001			<.001			<.001		
P-Value (A×L)	<.001			<.001			<.001		
$LSD_{\leq 0.05}$ (A)	6.1**			13.6**			1.7**		
$LSD_{\leq 0.05}$ (L)	1.4**			3.0**			0.4**		
$LSD_{\leq 0.05}$ (A×L)	8.7**			19.2**			2.4**		
CV%	5.0			9.2			14.6		

** Highly significant at P≤0.05 level. Nyabo-Nyabokarange village in Kuria West Sub County.

Table 9: Quantitative trait measurements of 40 field grown spider plant accessions at Kabete Field Station and Nyabokarange village in Kuria West Sub County, Kenya with their minimum and maximum values.

Variate	MIN	MEAN	MAX	SED	P-Value	$LSD_{\leq 0.05}$
No. of days to 50% seedling emergence	5.0	9.4	15.0	1.1	<.001	2.1**
Emergence Percentage	20.0	42.9	68.0	4.0	<.001	7.9**
Number of primary branches	4.0	10.0	14.0	1.2	0.04	2.4*
Plant height (cm)	12.0	71.6	113.0	5.8	<.001	11.4**
Number of leaves per plant	18.0	86.2	136.0	12.0	<.001	12.4**
Number of days to 50 % flowering	30.0	38.9	49.0	2.3	0.264	NS
Number of pods per plant	10.0	69.6	108.0	5.4	<.001	10.6**
Number of seeds per pod	17.7	108.2	196.0	4.4	<.001	8.7**
100-seed weight (mg)	1.0	1.0	2.0	0.1	<.001	0.02**
Seed yield (g)	0.2	10.2	26.9	1.2	<.001	2.4**

**=Highly significant, *=Significant, NS=not significant, SED=Standard error of difference. P-probability. Data are means of three replications of three plants each for the 40 Spider plant accessions.

Table 10: Quantitative trait measurements of 40 greenhouse grown spider plant accessions at Kabete Field Station, Kenya, with their minimum and maximum values.

Variate	MIN	MEAN	MAX	SED	P-Value	$LSD_{\leq 0.05}$
Number of days to seedling emergence	4.0	8.1	14.0	0.7	<.001	1.4**
Emergence percentage	15.4	41.8	69.2	9.4	0.256	18.6ns
Number of primary branches per plant	5.0	10.0	14.0	1.0	<.001	1.9**
Plant height (cm)	14.0	70.8	112.0	3.5	<.001	6.9**
Number of leaves per plant	44.0	85.5	129.0	5.1	<.001	10.1**
Number of days to 50% flowering	29.0	40.9	52.0	1.3	<.001	2.7**
Number of pods per plant	29.0	52.1	74.0	2.8	<.001	5.5**
Number of seeds per pod	12.0	99.8	185.0	4.6	<.001	9.3**
100-seed weight (mg)	0.0	0.1	0.2	0.0	<.001	0.0
Seed yield (g) per plant	0.1	7.3	20.1	1.2	<.001	2.3**

**=Highly significant, ns=not significant, SED=Standard error of difference. P-probability. Data are means of three replications of three plants each for the 40 Spider plant accessions.

Table 11: Correlation coefficients for the quantitative traits recorded for 40 accessions of spider plant grown in the greenhouse at Kabete Field Station, Kenya. Number of observations: 120

	DTE	%SE	NPB	PH	NLP	DTF	NPP	NSP	100-sw
DTE	-								
%SE	-0.02	-							
NPB	0.13	-0.10	-						
PH	-0.63*	0.12	0.12	-					
NLP	0.32	0.00	0.81**	-0.07	-				
DTF	0.88	-0.03	0.11	-0.70	0.30	-			
NPP	-0.70**	0.09	0.17	0.90**	-0.02	-0.77**	-		
NSP	-0.22	0.18	0.02	0.44	0.02	-0.26	0.35	-	
100-sw	-0.31	0.11	0.16	0.64	-0.02	-0.30	0.56	0.30	-
SYP	-0.56**	0.20	0.01	0.75**	-0.10	-0.61	0.77**	0.78**	0.63**

DTE-Days to seedling emergence, %SE-percent seedling emergence, NPB-Primary branches per plant, PH-Plant height (cm), NLP-Number of leaves per plant, DTF-Days to flowering, NPP-Number of pods per plant, NSP-Number of seeds per pod, SYP-Seed yield (g) per plant. 100 sw-100 seed weight (mg). ** Correlation at significant at P≤0.01 level, *correlation is significant at P≤0.05 level.

Table 12: Correlation coefficient table for the quantitative traits recorded for 40 accessions of spider plant grown in the field at Kabete Field Station and Nyabokarange in Kuria West Sub County, Kenya. Number of observations: 240.

	DTE	% SE	NPB	PH	NLP	DTF	NPP	NSP	100-sw
DTE	-								
% SE	-0.38	-							
NPB	0.38	-0.10	-						
PH	0.29	-0.09	0.76**	-					
NLP	0.29	-0.08	0.78**	0.87**	-				
DTF	0.52*	-0.21	0.77	0.63	0.65**	-			
NPP	0.28	-0.09	0.69**	0.80**	0.78**	0.67**	-		
NSP	-0.07	0.15	-0.10	0.10	0.01	-0.06	0.18	-	
100-sw	0.04	0.05	0.10	0.36	0.31	0.16	0.42	0.26	-
SYP	0.13	-0.01	0.24	0.44	0.36	0.30	0.62**	0.80**	0.53**

DTE-Days to seedling emergence, %SE-percent seedling emergence, NPB-Primary branches per plant, PH-Plant height (cm), NLP-Number of leaves per plant, DTF-Days to flowering, NPP-Number of pods per plant, NSP-Number of seeds per pod, SYP-Seed yield (g) per plant, 100 sw-100-seed weight (mg). ** Correlation is significant at P≤0.01 level, *correlation is significant at P≤0.05 level.

ACKNOWLEDGEMENT

This research was made possible through the support of the National Commission of Science, Technology and Innovation (NACOSTI), and the National Research Foundation (NRF-South Africa). The content presented in this paper is the authors' responsibility and does not necessarily reflect the views of NACOSTI or NRF.

REFERENCES

Abukutsa-Onyango, M.O. 2003. Unexploited potential of indigenous African vegetables in western Kenya. Maseno Journal of Education Arts and Science 4(1): 103-122.

Anjum, S.A., Wang, R., Niu, J., Ali, Z., Li, J., Liu, M., and Zong, X. 2016a. Exogenous application of ALA regulates growth and physiological characters of *Leymus chinensis* (Trin.) Tzvel under low temperature stress. Journal of Animal and Plant Sciences 26(5): 1354-1360.

Azhar, F. M. and Naeem, M. 2008. Assessment of cotton (*Gossypium hirsutum*) germplasm for combining abilities in fiber traits. Journal of Agriculture and Social Sciences 4: 129-131.

Chadha, M.L. 2003. AVRDC's experiences within marketing of indigenous vegetables–A case study on commercialization of African eggplant AVRDC-Regional Center for Africa. Duluti, Arusha, Tanzania.

Chinsembu, K.C. 2016. Ethnobotanical study of plants used in the management of HIV/AIDS- related diseases in Livingstone, Southern Province, Zambia. Evidence-based complementary and alternative medicine: eCAM, 4238625-4238625.

Chweya, J.A. and Mnzava, N.A. 1997. Cat's whiskers, *Cleome gynandra* L: Promoting the conservation and use of underutilized and neglected crops. Institute of Plant Genetics and Crop Plant Research, Gatersleben/IPGRI, Rome, Italy.

Chowdhury, M., Ahmad, S., Rahman, M., Hossain, M., and Karim, A.J. 2007. A study on morphological characterization and yield performance of eggplant genotypes. International Journal of Sustainable Agricultural Technologies 3(2): 30-35.

Ekpong, B. 2009. Effects of seed maturity, seed storage and pre-germination treatments on seed germination of cleome (*Cleome gynandra* L.). Scientia Horticulturae 119(3): 236-240.

Esmail, A.M., Mohamed, A.A., Hamid, A., and Rabie, E.M. 1994. Analysis of yield variation in lentil (Lens culinaris Medik). Annals of Agricultural Sciences 32(3): 1073-1087.

Gonye, E., Kujeke, G.T., Edziwa, X., Ncube, A., Masekesa, R.T., Icishahayo, D., and Chabata, I. 2017. Field performance of spider plant (*Cleome gynandra* L.) under different agronomic practices. African Journal of Food, Agriculture, Nutrition and Development 17(3): 12179-12197.

HCDA. 2017. Horticulture Data 2016-2017 Validation Report. Horticultural Crops Development authority 1-26.

Iwu, M.M., 2014. Handbook of African medicinal plants, 2nd ed. Boca Raton, USA: CRC Press. JIRCAS 2010 pp. 446 Local vegetables of Thailand https://www.jircas.affrc.go.jp/project/value_addition/Vegetables/030.html

Jaetzold, H. and Schmidt, H. 1983. Farm management handbook of Kenya. Vol. II B. Ministry of Agriculture, Kenya cooperation with German Agricultural Team (GAT) Typodruck printers, Rossdorf. 454-463.

Kang, M.S. 2002. Genotype–environment interaction: progress and prospects. In 'Quantitative genetics, genomics and plant breeding.' (Ed. MS Kang) 221–243.

K'Opondo, F.B.O., van Rheene, H.A., and Muasya, R.M. 2009. Assessment of genetic variation of selected spider plant (*Cleome gynandra* L.) morphotypes from Western Kenya. African Journal of Biotechnology 8: 4325-4332.

Lawlor, D.W. 1995. Photosynthesis, productivity and environment. Journal of Experimental Botany 46(10): 1449-1461.

Liu, L., and Wu, Y. 2012. Development of a genome-wide multiple duplex-SSR protocol and its applications for the identification of selfed progeny in switchgrass. BMC Genomics 13(1): 522.

Mahyao, A., N'zi, J.C., Fondio, L., Agbo, E., and Kouame, C. 2008. Nutritional importance of indigenous leafy vegetables in Côte d'Ivoire. In International Symposium on Underutilized Plants for Food Security, Nutrition, Income and Sustainable Development 806: 361-366.

Mbugua, G.W., Gitonga, L., Ndungu, B.,

Gatambia, E., Manyeki, L., and Karoga, J. 2009. African indigenous vegetables and farmer-preferences in Central Kenya. In All Africa Horticultural Congress 911: 479-485.

Michieka, D.O., van derPouw, B.J.A., and Vleeshouwer, J.J. 1978. Soils of the Kwale Mombasa- Lungalunga Area, Vol. I & II and Soil maps 1:100,000. Nairobi: Ministry of Agriculture, Kenya Soil Survey.

Mnzava, N.A., and Chigumira, F. 2004. *Cleome gynandra* L, In: Grubben GJH, Denton OA, eds. Vegetables. Plant Resources of Tropical Africa (PROTA) 2. Wageningen, Netherlands: PROTA Foundation, Backhuys, CTA. 191-195.

Moshatati, A., and Gharineh, M.H. 2012. Effect of grain weight on germination and seed vigor of wheat. International Journal of Agriculture and Crop Sciences 4(8): 458-460.

Munene, K.A., Nzuve, F., Ambuko, J., and Odeny, D. 2018. Heritability analysis and phenotypic characterization of spider plant (*Cleome gynandra* L.) for yield. Advances in Agriculture 2018: 1-11

Nennich, T. 2000. Vegetable seed germination and soil temperatures. Minnesota, Vegetable IPM newsletter Minnesota Extension Service, University of Minnesota. USA. 2(3).

Nguyen, H.T. and Sleper, D.A. 1983. Theory and application of half-sib matings in forage grass breeding. Theoretical and Applied Genetics 64(3): 187-196.

Nonnecke, I.L. 1989. Solanaceous crops: Potato, tomato, pepper, eggplant. Vegetable Production. Van Norstrand Reinhold, New York, USA. 240-250.

Noor–Mohammadi, G.H., Siadat, A., and Kashani, A. 2000. Agronomy (First Volume of Cereals). Ahwaz University Press, Pakistan. 1: 446

Nyamohanga, P.W. 2017. Factors influencing maize crop production among small-scale farmers in Kuria East Sub-County, Migori County, Kenya (Doctoral dissertation, Egerton University).

Ochuodho, J.O., and Modi, A.T. 2007. Temperature and light requirements for the germination of *Cleome gynandra* seeds. South African Journal of Plant and Soil 22(1): 49-54.

Ochuodho, J.O. 2005. Physiological basis of seed germination in *Cleome gynandra* (L.) Doctoral dissertation, University of KwaZulu-Natal, Pietermaritzburg, Republic of South Africa.

Omondi, E.O., Engels, C., Nambafu, G., Schreiner, M., Neugart, S., Abukutsa-Onyango, M., and Winkelmann, T. 2017. Nutritional compound analysis and morphological characterization of spider plant (*Cleome gynandra* L.)-an African indigenous leafy vegetable. Food Research International 100: 284-295.

Omondi, C.O. 1990. Variation and yield prediction analyses of some morphological traits in six Kenyan landraces population of spider flower (*Gynandropsis gynandra* (L.) Briq). Nairobi, Nairobi, Kenya.

Onyango, C.M., Onwonga, R.N., and Kimenju, J.W. 2016. Assessment of spider plant (*Cleome gynandra* L.) germplasm for agronomic traits in vegetable and seed production: a greenhouse study. American Journal of Experimental Agriculture 10(1): 1-10.

Oyiga, B.C. and Uguru, M.I. 2011. Interrelationships among pod and seed yield traits in bambara groundnut (*Vigna subterranean* L. Verdc) in the derived savanna agro-ecology of South–Eastern Nigeria under two planting dates. International Journal of Plant Breeding 5(2): 106-111.

Payne, R.W., Murray, D.A., Harding, S.A., Baird, D.B., and Soutar, D.M. 2011. An introduction to GenStat for Windows.

VSN International: Hemel Hempstead, UK.

Salehi, M., Faramarzi, A., and Mohebalipour, N. 2010. Evaluation of different effective traits on seed yield of common bean (*Phaseolus vulgaris* L.) with path analysis. American Eurasian Journal of Agriculture and Environmental Science 9: 52-54.

Schippers, R.R. 2002. African indigenous vegetables: An overview of the cultivated species. on CD-Rom. Natural Resources Institute International, University of Greenwich and Horticultural Development Services. Chatham, UK.

Shaban, M. 2011. Effect of water and temperature on seed germination and emergence as a seed hydrothermal time model. International Journal of Advanced Biological and Biomedical Research 1(12): 1686-1691.

Siderius, W. 1976. Environment and characteristics of nitisols at Kabete NAL, Nairobi, Ministry of Agriculture and Livestock Development.

Silver tooth, JC. 2014. Row spacing, plant population, and yield relationships. Extension Agronomist-Cotton, College of Agriculture, the University of Arizona. 1999. (Accessed 28th March 2014) Available: http://ag.arizona.edu/crop/cotton/comments/april1999cc.html

Sogbohossou, E.D., Achigan-Dako, E.G., Maundu, P., Solberg, S., Deguenon, E.M., Mumm, R. H., and Schranz, M.E. 2018. A roadmap for breeding orphan leafy vegetable species: a case study of *Gynandropsis gynandra* (Cleomaceae). Horticulture Research 5(1): 1-15.

Sombroek, W.G., Braun, H.M.H., and Van der Pouw, B.J.A. 1982. Exploratory soil map and agro-climatic zone map of Kenya, 1980. Scale 1: 1,000,000. Kenya Soil Survey.

Stephenson, A.G. 1984. The regulation of maternal investment in an indeterminate flowering plant (*Lotus corniculatus*). Ecology 65(1): 113-121.

Vorster, H.J. and Jansen Van Rensburg, W.S. 2005. Traditional vegetables as a source of food in South Africa: Some experiences. In African Crop Science Conference Proceedings 7(2): 669-671.

Wang, R., Anjum, S.A., Niu, J., Liu, M., Li, J., Zohaib, A., and Zong, X. 2016. Exogenous application of brassinolide ameliorate chilling stress in *Leymus chinensis* (trin.) Tzvel. by modulating morphological, physiological and biochemical traits. Bangladesh Journal of Botany 45(1): 143-150.

Wasonga, D.O., Ambuko, J.L., Chemining'wa, G.N., Odeny, D.A., and Crampton, B.G. 2015. Morphological characterization and selection of spider plant (*Cleome gynandra*) accessions from Kenya and South Africa. Asian Journal of Agricultural Sciences 7(4): 36-44.

Yamaguchi, M. 1983. World vegetables: Principles, production and nutritive values. Van Nostrand Reinhold, New York.

Zorde, M., Byrnes, D.R., Dinssa, F.F., Weller, S., and Simon, J.E. Selection for delayed flowering time in response to long photoperiod to increase vegetative growth and multiple harvests in spider plant (*Cleome gynandra*). J. Medicinally Active Plants, Special Issue on African Indigenous Plants 9(2):60-70.