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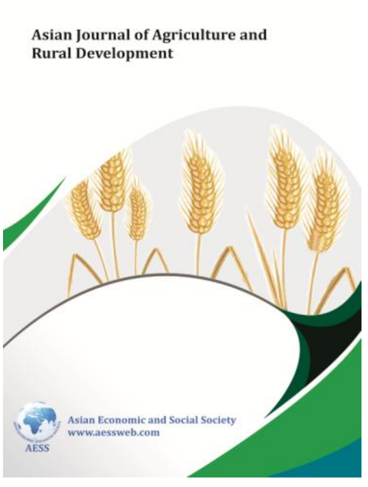


# Morphological Characterization of Four Selected Spider Plant (*Cleome Gynandra* L.) Morphs from Zimbabwe and Kenya

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# Morphological Characterization of Four Selected Spider Plant (*Cleome Gynandra* L.) Morphs from Zimbabwe and Kenya

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**Abstract**

Faced with climate change one way of adaptation is to reach into the genetic resource of the so-called miner crops. These crops are thought to be more resilient to climate change while being more nutritious than the modern vegetables. It is vital to characterise these crops in order to gather information that will help in their widespread usage. The objective of this study was to morphologically characterise four morphs; three from Zimbabwe and one from Kenya under greenhouse conditions at the Crop Science Department of the University of Zimbabwe, Harare, Zimbabwe. This work assessed number of days to seedling emergence, number of days to flowering, number of leaflets/compound leaf and number of pods/plant and other parameters. The analysis of variance for all the traits exhibited significant differences (P=0.05). There was significant variation among spider plant morphs in plant height, petiole length, length of leaflet, fruit length, fruit width, days to seedling emergence, days to flowering, number of leaflets per compound leaf and number of pods per plant. Morphs from different locations exhibited variability for stem pigmentations. The Kenyan morph differed from the Zimbabwean morphs as it was smaller and produced a higher number of pods per plant. We recommend further studies to reveal the molecular markers associated with the morphological differences we observed.

**Keywords:** Nutritious, crops, morphs, Zimbabwe

## Introduction

The cat's whiskers or spider plant (*Cleome gynandra* L. /*Gynandropsis gynandra* (L.) Briq.) grows as a weed in Zimbabwe. It is not formally cultivated as a commercial crop but for years has been a semi-domesticated volunteer crop in farmers' fields and on fertile soils near and around most homesteads in the world although there is some limited cultivation of commercial leafy varieties in several countries in East Africa such as Kenya, Uganda and Tanzania (Mnzava and Ngwerume, 2004). Its tender leaves and shoots are gathered for use as a vegetable in most parts of Zimbabwe although the palatability of the crop maybe low, especially without appropriate preparation. The high fibre content of the leaves enables them to be stored for a long time. In some cultures, the boiled leaves of cat's whiskers are also regarded as a medicinal meal whilst in Asia, cat's whiskers are cultivated for their seed oil (Chweya and Mnzava, 1997). The status of the crop as a wild and weedy volunteer renders it unattractive for attention, especially as it is often seen as a poor man's crop. The cultivation of wild edible plants is necessary in widening the nutrition and food base in developing countries but they are regarded by scientists as minor crops and hence receive little attention in most research and development programs (The Australian New Crops Newsletter, 1999).

Available local knowledge by the rural folk in Kenya shows that spider plant is beneficial medicinally (Opole et al., 1995). In some communities, it is believed that regular consumption of the leaves by expectant mothers eases childbirth by reducing the length of labour. It is also believed to help them to regain health faster and to stimulate milk production (Kokwaro, 1976). The concoction made from the leaves is believed to treat scurvy and marasmus, while malaria and epileptic fits can be treated using the sap from pounded leaves by squeezing it into ears, eyes and nostrils (Opole et al., 1995). It is also believed that spider plant can be used to kill and repel insects as well as preventing them from feeding (Verma and Pandey, 1987). The leaves have anti-tick, repellent and acaricidal properties to larvae, nymphs and adult ticks (*Rhipicephalus appendiculatus*) (Chandel et al., 1987). The plant has anti-feedant action against the tobacco caterpillar, while the extract from the mature seeds is toxic to brinjal aphid and larvae of American bollworm (*Heliothis armigera*), and lipids from the seeds can be used in soap manufacture (Verma and Pandey, 1987). The plant is a highly nutritious leafy vegetable rich in vitamin A and C, calcium, iron and proteins (Abe and Imbamba, 1977). Existing evidence suggest that spider plant is endowed with high levels of nutrients (Chweya and Mnzava, 1997). Some people believe that plants referred to as "indigenous vegetables" (although some are exotics) are more nutritious and healthy than more usual vegetables (Van and Gericke., 2000). During the period of abundance especially during the rainy season, the leaves and young tender shoots can be sold at urban markets and hence, the crop can become a source of income to the rural poor and the unemployed.

Available information is limited and short on several important and basic components, an issue that hinders the development of the crop and its sustainable conservation, let alone commercialization. The crop therefore falls into the category of "neglected and underutilized crops". One major factor hampering the development of the crop is that in cases where information is present, it is usually not consolidated and therefore not readily accessible (existing only as 'grey literature'), written in local dialects that are hard to understand. More so, there is limited information on the genetic potential of spider plant. In fact, knowledge of plant breeding and agronomy is still very scarce. This has resulted, frequently, in uncoordinated research efforts, as well as in inefficient approaches to the conservation of its genetic resource (Chweya and Mnzava, 1997).

Studies in Kenya and Zimbabwe indicate that there is significant variation among plant populations for many characteristics. Further studies are needed to determine to what extent these differences are due to climatic, soil fertility or stress conditions. Clearly different populations can be found in the coastal regions of Kenya and Tanzania, with relatively small plants that are much branched and have distinctly dark, almost black, straight and stiff fruits. They appear to be very different from plants encountered elsewhere in Africa, where the fruits are far from stiff and often green or yellow to pale brown (Chayamarit, 1993). Studies in Kenya on germplasm collected from farmers have shown that differences do exist between plant characteristics of plants from seed lots collected from various areas although there was variability in most morphological characters between the seed lots (The Australian New Crops Newsletter, 1999). This study investigated variations in morphological characters among existing spider plant accessions gathered from different parts of Zimbabwe and Kenya.

## Materials and Methods

### Study Site

The experiment was carried out in a greenhouse at the Crop Science Department, Faculty of Agriculture of the University of Zimbabwe, Harare, Zimbabwe (17.78$^0$S, 31.05$^0$E , 1523 meters above sea level). The site is in Natural Region II with an annual rainfall of 600-1000mm and average temperatures of 20-30$^0$C.

### Propagation Material

Sexual propagation was used and the seed for the spider plant types used for this study were obtained from three different locations, two from Zimbabwe and one from Kenya. The first Zimbabwean seed source was Marondera Horticulture Research Centre (HRC) (18.11$^0$ S, 31.28$^0$ E, 1630m elevation). The second Zimbabwean seed source were collections from wildly growing plants in the Zaka communal lands ($20.34^0$ S, $31.46^0$ E, 776 m elevation). Seed for the spider plant type from Kenya was obtained from a harvested commercially grown spider plant crop in May 2012 from a farm in Uasin Gishu District, Rift Valley County (0.310 N, $35.17^0$ E, altitude 2400 m).

Morphs are herein referred to as strains of a species having established morphological differences (Ramaiah *et al*, 1983). Morphology as explained by Dutta, (1979) deals with the study of forms and features of different plant organs such as roots, stems, leaves, flowers, seeds and fruits, while Singh, (1990) describes character or trait as a morphological, anatomical or physiological feature of an organism, which is usually a product of the action of both genotype and environment.

The design was based on the premise of a highly heritable and easily identifiable morphological characteristic, the stem colour (purple and green) which could be expressed in all environments. The location of collections (Marondera, Zaka and Kenya), representing the four morphological types identified and selected were Marondera Green stem (MRG), Marondera Purple stem-(MRP), Zaka Green stem (ZKG) and Kenya Purple stem (KEP).

**Experimental Design and Management**

The four morphs were laid out as a Randomized Complete Block Design (RCBD) experiment with eight blocks and four replicates by sowing seeds in 2.4L pots. The pots were filled with pine bark substrate and Compound 'S' 7:21:7 fertilizer was applied 2g/pot just before sowing. The seeds were broadcasted sparingly within the pots and wood ash was sprinkled over the seeds. Watering was done prior to and after sowing.

After emergence, thinning was done 30 days after seedling emergence (DAS), leaving four plants per pot. The pots were irrigated three times a week until 45 DAS and every day thereafter. Forty two days after seedling emergence, Calcium Nitrate (CAN) (15.5N:P0: 0K: 20Ca:24S) was applied at 5g/pot.

At 60 days after seedling emergence the following measurements (cm) were recorded:

- length of leaflet, measured from the pulvinus of the leaflet to the tip of the leaflet;
- petiole length, measured from the pulvinus to the base of the leaflets;
- plant height, measured from the base of the plant to the tip of the main stem;
- fruit length, measured from the end of the fruit stalk to the tip of the fruit and
- fruit width, measured at the middle part of the fruit and considered to be broadest point at 80 days after seedling emergence.

In addition counts were taken of number of days to seedling emergence, number of days to flowering, number of leaflets/compound leaf and number of pods/plant. The morphological characterization was done using FAO spider plant crop descriptor states.

All measurements, counts and observations of a given trait were done on the same day to avoid any differences in the developmental stage of plant growth. All the data collected was subjected to an analysis of variance (ANOVA) using Genstat 64-bit Release 14.1 Statistical Programme. The differences were accepted as significant at $p<0.05$ and post hoc separation of means was done using Fischer's Protected Least Significant Difference (LSD) test.

## Results

The existence of morphological types (morphs) for *Cleome gynandra* was evident as there were variations in forms and features of the different plant organs measured and counted. The morphs collected from different locations revealed variability in all aspects: plant height; petiole length; length of leaflet; fruit length; fruit width; days to seedling emergence; days to flowering; number of leaflets per compound leaf and number of pods per plant (Table 1). Spider plant morphs showed significant differences ($P<0.05$) for all the variable measurements which were fruit length, fruit width, leaflet length, plant height and petiole length (Table 1).

With regards to flowering and stem pubescence the Zimbabwean morphs (MRG, MRP and

ZKG) seemed to cluster for traits, fruit position (throughout the plant), flower colour (white) and plant structure (erect).

The flower colour ranged from white to purple. The white corolla colour was noted in the Zimbabwean morphs (MRP, MRG and ZKG) and purple tinged inflorescence was seen for the Kenyan morph (KEP) (Figure 1).

MRP white flowers

KEP flowers tinged with purple

ZKG purely white flowers

MRG white flowers

**Figure 1: Variations in flower colour of four spider plant (*Cleome gynandra*) morphs from Zimbabwe and Kenya**

KEP produced densely glandular stems as compared to the glabrous stems of MRG (Figure 2). Generally the purple stem types of plants were more glandular compared to the green stem type of plants which were either glabrous or close to glabrous (Figure 2) while the colours were either green or purple (Figure 3).

MRP( moderate pubescence)

KEP (densely glandular)

MRG (glabrous)

ZKG (almost glabrous)

**Figure 2: Comparison of stem pubescence of four spider plant (*Cleome gynandra*) morphs from Zimbabwe and Kenya**

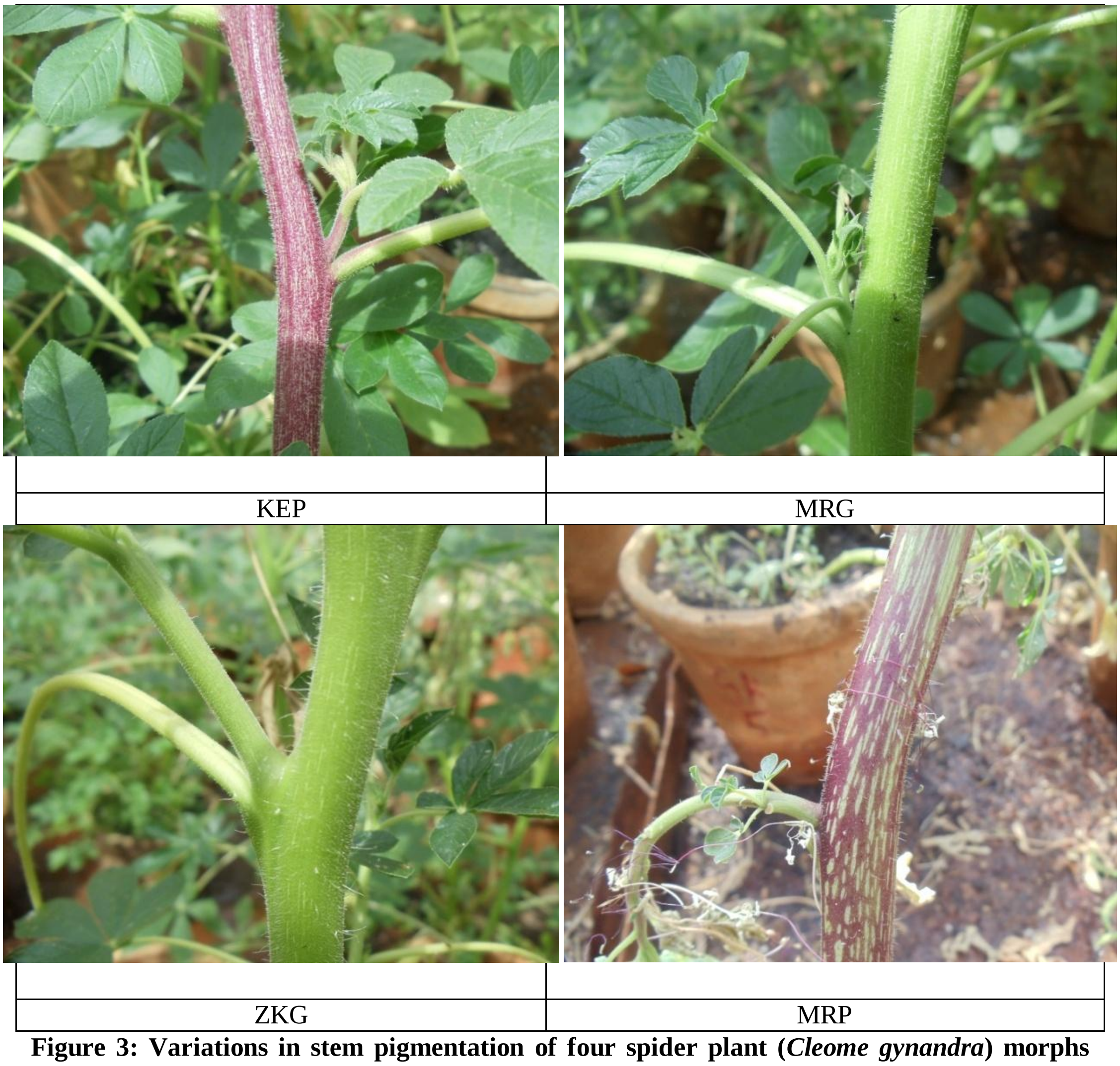


**Figure 3: Variations in stem pigmentation of four spider plant (*Cleome gynandra*) morphs from Zimbabwe and Kenya**

**Effect of Morph Type on Measured Fruit Characteristics**

The highest fruit lengths were obtained from the purple stem type of plants (KEP and MRP) whose means were significantly different ($P<0.05$) from the green stem type of plants (MRG and ZKG). The means for the green stem type of plants (ZKG and MRG) were however not significantly different from each other (Table 1). The purple stem type plants had the greatest fruit width but their width were not significantly different ($P>0.05$) although they were significantly different from the green stem type plants which were also not significantly different from each other (Table 1).

**Table 1: Morphological Trait Measurements and Their Treatment Means of Four Spiderplant (*Cleome Gynandra*) Morphs from Zimbabwe and Kenya**

**KEP– Kenya purple stem type of plants; MRG– Marondera green stem type of plants; MRP– Marondera purple stem type of plants; ZKG– Zaka green stem type of plants.**

| Trait Index | KEP | MRG | MRP | ZKG |
|---|---|---|---|---|
| Fruit length | 9.906c | 7.125a | 8.688b | 6.750a |
| Fruit width | 0.8531b | 0.6625a | 0.7781b | 0.5906a |
| Leaflet length | 4.625ab | 5.500b | 3.938a | 4.750ab |
| Plant height | 45.41a | 76.19c | 59.03b | 75.66c |
| Petiole length | 5.281a | 15.625c | 6.469a | 11.312b |
| | **S.E.D** | **$LSD_{0.05}$** | **P value** | **Significance** |
| Fruit length | 0.452 | 0.896 | <.001 | * |
| Fruit width | 0.0496 | 0.0982 | <.001 | * |
| Leaflet length | 0.453 | 0.897 | 0.009 | * |
| Plant height | 2.89 | 5.72 | <.001 | * |
| Petiole length | 0.633 | 1.253 | <.001 | * |

Figures followed by different letters within the same row are significantly (P=0.05) different according to Fisher's protected least significant difference test. * = Significant at the 5% level, NS= Not significant. S.E.D Standard error of difference. Data are means of four replications of four plants each for the four spider plant morphs

**Effect of Morph Type on Measured Leaf Characteristics**

MRG was significantly different from MRP (P<0.05) with regards to the length of leaflet while all the other morphs were not significantly different (Table 1). The green stem type of plants were significantly different from each other (P<0.05) and also significantly different from the purple stem type of plants for petiole length. The purple stem type of plants were however not significantly different from each other. Purple stem types of plants were the same and green stem types of plants were also the same (Table 1).

**Effect of Morph Type on Plant Height**

For the plant height, only the morph KEP was significantly (P<0.05) different from the rest whilst there was no significant difference for the green stem type of plants (Table 1). MRG and ZKG were not different but are significantly (P<0.05) taller than MRP and KEP (Table 1).

**Counts Comparisons**

The range of variation for the different characteristics showed significant variability (P<0.05) for all the counts which were days to flowering, days to seedling emergence, number of leaflets per compound leaf and number of pods per plant (Table 2).

**Table 2: Morphological Trait Counts and Their Treatment Means of Four Spider Plant (*Cleome Gynandra*) Morphs from Zimbabwe and Kenya**

**KEP– Kenya purple stem type of plants; MRG– Marondera green stem type of plants; MRP– Marondera purple stem type of plants; ZKG– Zaka green stem type of plants.**

| Trait Index | KEP | MRG | MRP | ZKG |
|---|---|---|---|---|
| Days to flowering | 33.72c | 22.00a | 27.25b | 21.62a |
| Days to seedling emergence | 4.219a | 4.156a | 4.625b | 6.594c |
| No. of leaflets/compound leaf | 3.406a | 5.531b | 3.844a | 5.250b |

| | | | | |
|---|---|---|---|---|
| No. of pods/plant | 14.66c | 9.53a | 11.50b | 9.19a |

| | **S.E.D** | **$LSD_{0.05}$** | **P value** | **Significance** |
|---|---|---|---|---|
| Days to flowering | 0.828 | 1.641 | <.001 | * |
| Days to seedling emergence | 0.1955 | 0.3872 | <.001 | * |
| No. of leaflets/compound leaf | 0.2597 | 0.5143 | <.001 | * |
| No. of pods/plant | 0.832 | 1.648 | <.001 | * |

Figures followed by different letters within the same row are significantly (P=0.05) different according to Fisher's protected least significant difference test. * = Significant at the 5% level, NS= Not significant. S.E.D Standard error of difference. Data are means of four replications of four plants each for the four spider plant morphs.

**Effect of morph on days to seedling emergence**

There was no significant difference (P>0.05) between KEP and MRG with regard to days to seedling emergence. There was significant difference between MRP and ZKG as well as from the rest (Table 2). Germination was observed within five days for all the morphs except ZKG which took longer (>5 days).

**Effect of morph type on days to flowering**

The purple stem type of plants (KEP and MRP) flowered later than the green stemmed morphs (MRG and ZKG). The purple stem type of plants were also significantly different from each other (P<0.05) whilst there was no significant differences between the green stemmed morphs (Table 2)

**Effect of morph types on number of leaflets per compound leaf**

The purple stem type of plants were significantly different (P<0.05) from the green stem type of plants in terms of number of leaflets per compound leaf (Table 2). Both the green stem and the purple stem type of plants were not significantly different from each other within their grouping by stem coloration. The green stem type of plants exhibited on average five leaflets per compound leaf (Figure 4).

| | |
|---|---|
| Green stemmed plant showing seven leaflets on one compound leaf | Purple stemmed plant showing the most common number of leaflets per compound leaf |

**Figure 4: Variations in number of leaflets per compound leaf between purple and green stem spiderplant (*Cleome gynandra*) morphs**

**Effect of morph type on number of pods per plant**

Generally, the purple stem type of plants had more pods per plant compared to the green stem type of plants (Figure 5).The purple stem type of plants were significantly different from each other (P<0.05), and also significantly different from the green stem type of plants (Table 2). There was, however, no significant difference between the green stem types of plants (MRG and ZKG).

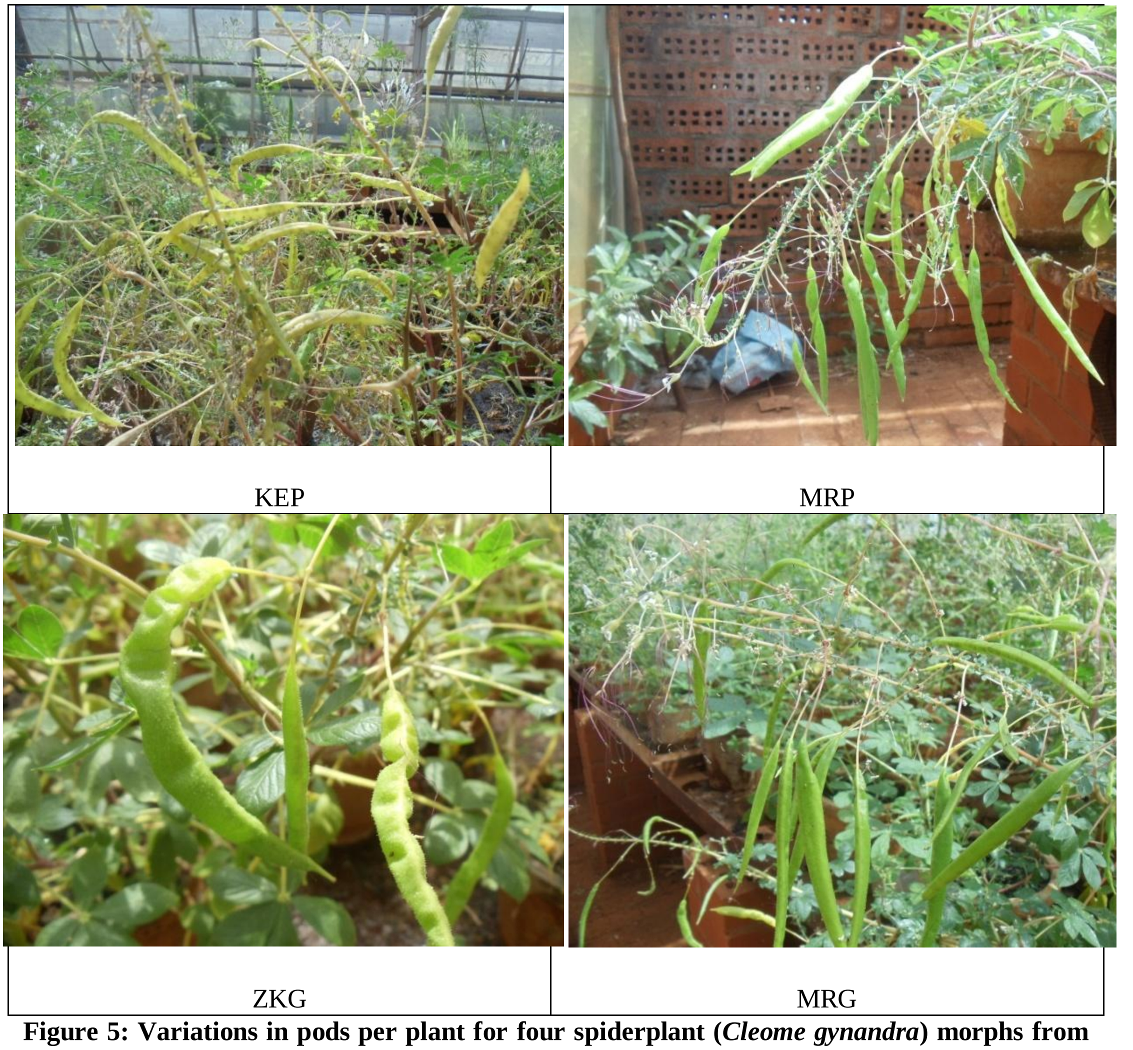


**Figure 5: Variations in pods per plant for four spiderplant (*Cleome gynandra*) morphs from Zimbabwe and Kenya**

**Discussion**

The present study revealed the existence of variability in morphological characteristics measured, counted and scored for during phenotypic characterization of four spider plant morphs from Zimbabwe and Kenya. The traits characterized displayed a high level of morphological diversity among spider plant morphs. The analysis of variance for all the traits exhibited significant differences (P= 0.05), something which is in close agreement with earlier findings by K'Opondo (2011) in Kenya. The existence of morphological types (morphs) of *Cleome gynandra* was based on the premise of a highly heritable character, easily seen by the eye and which could be expressed in all environments, the stem pigmentation, representing four morphological types collected from different locations. Earlier researchers identified that the stem colour could be used to distinguish and recognize different plant types (Chweya, 1990). It was however yet to be seen whether other characteristics could also be used to distinguish between the plants.

**Vegetative phase**

Only Morph ZKG varied from others with regards to days to seedling emergence, but the values were almost within the range of those reported by other authors (Kemei, *et al.*, 1995; Chweya et al., 1997). All the other three morphs took between 4 and 5 days to emerge from the soilless media. There was germination in all the pots planted and it was noticed that the seeds did not all germinate readily with the germination occurring over an extended period probably because seeds have a rest period. Physiologically mature seeds are either dormant or nondormant and would germinate once the dormancy is relieved or optimum conditions are provided (Ochuodho and Modi, 2007).

The results showed that for all the four morphs the compound leaves were palmate (leaflets attached to the tip of the petiole) and the most common number of leaflets for each compound leaf was five (Figure 4). The green stemmed plants (MRG and ZKG) sometimes however exceeded this number whilst the purple stemmed plants (MRP and KEP) sometimes had less than five, this observation apparently contrary to what is stated by Chweya and Mnzava (1997), that leaflets were rarely three to four per each compound leaf.

Green stemmed plants had the longest petioles while the petiole length for the purple stems was much lower. The results do not concur with findings of K'Opondo (2011) where the longest petioles were produced by purple stem type of plants indicating, perhaps, variability in morps with regard to stem colour. ZKG had the tallest plants overall while KEP had the shortest. It was however noted that the shortest plants had the highest number of pods per plant KEP as compared to those which were tall. The plant height measured from 24cm to 140cm figures which are somewhat higher than those recorded by Makgakga (2011) in South Africa (25-60cm). It is highly conceivable that morph stem colour cannot be globally related to stem height.

**Reproductive phase**

Green stemmed plants flowered earliest, with ZKG flowering earliest. Purple stemmed plants which took the longest. KEP produced the highest number of pods per plant as compared to ZKG. KEP produced longer and broader plants compared to the other morphs. This result confirms studies by K'Opondo (2011) who reported that morphs took over 40 days to flower, with purple stemmed plants producing broader fruits compared to green stemmed plants. All morphs exhibited high degree of flowering, an important character when considering seed production since more flowering is likely to lead to high fruit and seed production (K'Opondo, 2011). Water stress can however trigger flowering even at the seedling stages, therefore distorting the count; number of days to flowering (Chayamarit, 1993). ZKG, MRG and MRP all produced white flowers whereas KEP had flowers tinged with purple (Figure 5). There is therefore need to study the relationship between early flowering and a higher fruit and seed production.

Fruits occurred in zones at the inflorescence stalk for all the morphs although in some cases, KEP fruits were found on top of the canopy. Chweya and Mnzava (1997) stated that spiderplant fruits may occur on either the top of the canopy or throughout the plant, and position of the fruit is highly affected by nutritive conditions. KEP produced yellow fruits while all the Zimbabwean morphs had green fruits.

All the morphs were erected and much branched although KEP was highly affected by lodging. The green stem type of plants had glabrous stems as compared to the abundant pubescence of the purple stems (Figure 6), an observation that is in conformity with the findings of Makgakga, (2011), that purple stemmed plants are usually more glandular than green stemmed plants. KEP had a sticky and densely glandular stem as compared to the other morphs.

In general, the Kenyan purple stem morph (KEP), was significantly different from all the other morphs (collected from Zimbabwe; MRG, MRP and ZKG) in terms of four traits out of the nine traits considered i.e. plant height, days to flowering, fruit length and number of pods per plant. There was no variation between KEP and MRP for fruit width, petiole length and number of leaflets per compound leaf. KEP only showed no variation with the green stem morphs in terms of leaflet length and days to seedling emergence. Different evolutionary pathways of development could be responsible for these observed differences among the morphs as it is suggested that while genes interact with other genes, the way they are expressed is influenced by their environment (Phillips, 2006). These differences could therefore be as a result of adaptations to the environmental conditions from which the morphs were collected. Some of the variations shown among the Kenyan and Zimbabwean spider plant morphs studied, particularly the agronomic traits, could partly be attributed to selection pressure being effected by farmers in Kenya for those characters they consider to be of importance to them, as they continue putting spider plant under domestication through cultivation (K'Opondo, 2011); whereas in Zimbabwe, domestication is still only confined to Research stations. Phillips, (2006) reported that spider plant belongs to the genus *Cleome* which has over 200 species (about 50 of them occurring in Africa) consisting of highly polymorphic herbaceous plants, a point which could explain why more than half of the morphological traits considered showed significant differences among the morphs.

## Conclusion and Recommendations

### Conclusion

From this study it can be deduced that:

- There is significant variation among spider plant morphs (a group of different types of individuals of the same species in a population) for important characteristics: plant height (29-140cm); petiole length (3-21cm); length of leaflet (2-11cm); fruit length (5-13cm); fruit width (0.3-1cm); days to seedling emergence (4-8); days to flowering (17-36); number of leaflets per compound leaf (3-7) and number of pods per plant (3-21).
- Although these characteristics differ, overlaps do occur and thus such characteristics cannot be used in isolation to identify differences between different morphs.
- Morphs collected from different locations exhibited variability for stem pigmentations; green and purple a character which can be used to distinguish and recognize different plant types.
- The Kenyan morph was different from the Zimbabwean morphs as it produced relatively small plants that produced a very high number of pods per plant.

### Recommendations

- Further studies are needed to determine to what extent differences in morphological characters are due to climatic, soil fertility or stress conditions.
- Since morphological characteristics are influenced by the environment, molecular markers should be used to supplement this study by identifying the polymorphism that is not due to environmental conditions.
- Further characterization trials should be done using more accessions and looking at more characteristics other than the ones used in this study and also growing the crop in a range of localities especially in the field.

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