EFFECTS OF MANAGEMENT PRACTICE AND MATURITY STAGE ON SEED QUALITY AND YIELD OF SPIDER PLANT (*Cleome gynandra* L.)

***Kamotho GN[1]., Mathenge PW[1]., Muasya RM[2], Dulloo ME[3].**

[1] Karatina University, P.O.Box 1957-10101, Karatina, Kenya.

[2]South Eastern University, P.O. Box, 170-90200, Kitui, Kenya.

[3]Researcher, International Plant Genetic Resources Institute,Via dei Tre Denari 472/a 00057, Maccarese, Rome, Italy.

ABSTRACT

Cleome gynandra L. is gaining popularity for its importance in human nutrition. In the recent past, Kenya has witnessed a renewed interest in production of this local vegetable. The prevalence of obesity, HIV and AIDs and food-related illnesses makes better nutrition a critical need. Nutrition is a major, modifiable and powerful factor in promoting health, preventing and treating disease and improving quality of life. The relationship between food, nutrition and health is one of the global challenges being faced today. Increasing research on this indigenous vegetable could improve nutrition among poor people. Existing evidence suggest that spider plant is endowed with higher level of nutrients than its exotic counterparts. However, seed quality and yield of spider plant are affected by one or more factors that cause negative response during seed production. The purpose of this research was to increase insight into how the seed quality and yield of spider plant is affected by different management practices and seed maturity stages with a view to finding out the best method of production of these seeds. According to the findings of this study it is recommended that in the production of spider plant seed, farmers should nip the first flower heads and harvest at yellow pod maturity stage.

Key words: *Cleome gynanadra* L., yield, viability, vigour

INTRODUCTION

Cleome gynandra L. is an erect herb that grows up to 1.5m tall (Chweya and Mnzava, 1997). When the germinated seedlings are about 6cm high, the plants can be harvested by uprooting whole plants, or by nipping, cutting back to ground level (ratooning), or picking individual leaves or leafy branches at frequent intervals. Frequent picking and deflowering encourage lateral growth, thus extending the harvesting period of leaves. However, if the crop is intended for seed production, the nipped-off plants should be allowed to flower and picking of leaves as vegetables minimised (Chweya and Mnzava, 1997).

Cleome gynandra L. is being recognized for its importance in human nutrition and its 'functional' value in maintaining good health (Howes *et al*., 2003; Asis *et al.,* 2010). In the recent past, Kenya has witnessed a renewed interest in production of this local vegetable. The prevalence of obesity, HIV/AIDs and food-related illnesses makes better nutrition a critical need. Among many consumers, there is an increasing value placed on organically grown produce, and this heightens its demand. Increasing research on this indigenous crop could improve nutrition among poor people and help achieve the UN Millennium Development Goal of halving the number of people suffering from hunger by 2015 (Hulme and Scott., 2010). Interpreting the goal as meaning that each person gets more food ignores the fact that malnutrition is also about people not getting

enough micronutrients, vitamins and minerals — a problem that could be described as "hidden hunger". Nutrition is a major, modifiable and powerful factor in promoting health, preventing and treating disease and improving quality of life. The relationship between food, nutrition and health is thus one of the global challenges that we are facing today.

Existing evidence suggest that *Cleome gynandra* is endowed with higher level of nutrients than its exotic counterparts (Chweya and Mnzava, 1997). The leaves contain over and above the normal recommended adult daily allowance of vitamins A and C, calcium and iron (Arnold *et al*., 1985). The amino-acid composition of *Cleome gynandra* leaf-protein has a high chemical score, comparable to that of exotic vegetables. High levels of nutritionally critical amino acids, like lysine, arginine, aspartic acid, glutamic acid, tyrosine and histidine have been reported (Mnzava, 1990*).*

Table 1: Mean composition per 100 gram edible portion of spider plant (*Cleome gynandra* L) compared to cabbage (*Brassica oleracea capitata*).

NUTRIENT	SPIDER PLANT	CABBAGE
Water g	86.6	91.4
Iron mg	6.0	0.7
Protein g	4.8	1.7
Calcium mg	288	47
Phosphorus mg	111	40
B-Carotene µg	10452	100
Fibre g	1.4	1.2

Source: Mnzava, N.A. & Chigumira Ngwerume, F., 2004.

Pre-harvest factors, such as the degree of seed maturity influence viability and vigour which in turn affect the potential storability of seeds (Justice and Bass, 1978). During germplasm collection missions, collectors often encounter crops at different stages of maturity because of either genotypic differences in crop duration or differences in planting time, (Appa *et al*., 1992). From the storage point of view, although it is desirable to collect fully mature seeds, often immature seeds are also collected during collecting missions. Therefore, knowledge on seed maturity in relation to seed quality is important to gene bank managers, germplasm collectors and farmers. However, little information of this type is available for *Cleome gynandra*.

Nipping is an important agronomic practice carried out on horticultural crops. It involves the removal of apical buds to aid in reducing apical dominance. As a result it encourages lateral growth hence increasing the fruiting potential (Gujar and Srivastava, 1972). Reddy and Patil reported an increase in seed yield by nipping groundnuts at 60 days after planting. In okra, apical bud pinching at 30 days after sowing recorded higher germination and seedling vigour compared to pinching at 20 days after sowing (Sajjan *et al*., 2002). Sharma *et al*., (2003) studied the effects of nipping of apical bud at 50, 70, and 90 days after sowing on seed yield of pigeon pea and noticed that nipping at 50 days recorded a significant increase in pod numbers resulting to maximum seeding. Khan *et al*., (2006) reported that in chickpea, nipping at 94 days after emergence recorded significant difference in the number of pods per plant, seeds per pod, and seed yield as compared to control.

Seed quality can be tested through seed viability and seed vigor. Seed viability is a measure of how many seeds in a lot are alive and could develop into plants that will reproduce under appropriate field conditions (ISTA, 2003). Seed vigor however, is the quality of a seed which is responsible for the rapid, uniform germination, increased storability, good field emergence and ability to perform well over a wide range of field conditions (Hampton and Coolbear, 1990). Seed vigor is a qualitative attribute of the seed which is ultimately related to seed viability and loss of viability is usually preceded by loss of vigor (Tekrony and Spears, 2001).

MATERIALS AND METHODS

Dry seeds of *Cleome gynandra*, (accession number, GBK-032229-Uasin-Gishu), sealed in a foil packet (6cm x 6cm) were obtained from the Gene Bank of Kenya, Muguga. The seeds in hermetically sealed foil packet were transported by road over night to Chepkoilel Campus (2100 meters above sea level), Moi University. Prior to sowing and in order to avoid imbibition injury, the sealed packets were opened and allowed to stand at room temperature over night. This allowed seeds to humidify by taking up water slowly for one night. Three hundred seeds per plot were drilled at a depth of 0.5 centimeter in six plots each measuring one meter square. Randomized complete block design (RCBD) was used to lay down the experiment. Each practice was replicated three times. At sowing time well-decomposed farmyard manure was broadcast and mixed with topsoil at 4 kilograms of manure per square meter. Seedbeds were watered daily until seeds germinated, after which watering was done on alternative days. Seeds germinated after five days of sowing. The two management practices (allowing plants to grow to maturity without nipping the first flower heads and nipping of first flower heads) were applied when 70% of the plants had formed flowers (37 days after seed sowing). To ensure that seeds were harvested at different maturity stages on a single plant, individual flowers with anthers exposed at a time when pollination was expected were tagged using strings of different colours for each date of tagging. Thereafter seeds were harvested at once in three-pod maturity classes characterized by distinct visual colours as determined by Mussel colour chart. Yellow pods were at 55 days after tagging (DAT), yellow-green pods were at 45 DAT and green pods were at 15 DAT. Seeds were threshed manually and initial moisture content, viability and vigour tests conducted.

Germination tests.

Germination test was done according to international seed testing association (ISTA, 1995).The seed replicates from the three maturity stages (yellow pods, yellow/green pods and green pods) of each management practice (nipping and no nipping of first flower heads) were allowed to imbibe on 1% agar-water at 25^{o}C ($\pm$ 0.5) in a germination cabinet (LMS cooled incubators, Jencons-PLS,) with a 12-hour photoperiod daily. Sterilin petridishes (of 9 cm) from Bibby Sterilin Limited, Stone, U.K. were used. Prior to placing seeds on agar-water, seeds were sterilized in 1% sodium hypochlorite, (Rackitt Colman, Nairobi) for 10 minutes to reduce fungal growth.

Electrical conductivity test

Four replicates of 25 seeds obtained from the three maturity stages of each management practice were weighed to three decimal places before being soaked into 100 ml distilled water in plastic bottles, at ambient temperatures (25-30^{o}C). A control bottle containing distilled water only was set up with each test run. All bottles were maintained in a room at ambient temperatures for 24 hours. After the soak period, the solution

and seeds in each bottle were gently swirled for 10 to 15 seconds, and conductivity (μScm^{-1}) of the soak water measured using a Fieldlab-Lf conductivity meter and LF 513T-electrode dip-type cell (Schott Gerate Glass Company, Mainz, Germany). Several measurements were taken until a stable result was obtained. Between measurements the dip cell was rinsed twice in distilled water and dried using clean dry paper towels. After subtracting the control bottle measurements (the mean of the readings) conductivity was expressed per gram of seed ($\mu Scm^{-1}g^{-1}$). The conductivity measurement was conducted according to recommendations by International Seed Testing Association (ISTA, 1995).

Moisture content determination

Initial moisture content expressed on fresh weight basis was determined gravimetrically in five replicates each of 50 seeds in a well-ventilated oven at 103^{o}C for 17 hours according to ISTA (1995). Moisture content was determined on a whole seed basis but not component parts. The rest of the bulk pods and seed lots not used for desiccation were left overnight at room temperature until moisture contents results were calculated after 17 hours. After removing the seeds from the oven, seeds in the dishes were allowed to cool for about 30 - 45 minutes inside a desiccator before their weights were taken and seed moisture content expressed on a fresh weight basis as:

$$\% \text{ Seed moisture content} = \frac{\text{Initial seed weight (g) - seed weight after drying (g)}}{\text{Initial seed weight (g)}} \times 100$$

Data Analysis

Data sets obtained were analysed using Scientific Package for Social Scientists (SPSS), where data was subjected to analysis of variance (ANOVA), and descriptive analysis. Levels of significance, means and standard deviations were obtained for various data sets and separation of means was by least significant difference.

RESULTS

Management Practice

The two management practices (no nipping and nipping of first flower heads) did not show significant differences (P=0.05) on percent germination, mean germination time and electrical conductivity. However, the trend in Table 2 shows that viability and vigour as measured by percent germination and electrical conductivity respectively were higher in the practice of no flower nipping.

Management Practice	Germination (%)	Mean germination time (days)	Electrical conductivity ($\mu Scm^{-1}g^{-1}$)
No nipping	14.5 (±0.580)	2.04 (±0.008)	25.94 (±0.008)
Nipping	14.0 (±0.820)	2.05 (±0.005)	25.96 (±0.006)
$LSD_{(0.05)}$	0.97 Ns	0.11 Ns	2.33 Ns

In brackets are standard deviation values. Ns= not significant at $P = 0.05$

Table 2: Effect of management practice on percent germination, mean germination time and electrical conductivity of *Cleome gynandra* seeds harvested at yellow pod maturity stage.

There was a significant difference (p=0.05) in seed yield between the practices of nipping and not nipping of the first flower heads. The practice of nipping produced higher seed yield (178.5g/m^2) than the practice where the first flower heads were not nipped (135.7g/m^2) as indicated in table 3.

Management Practice	**Seed yield(g/m^2)**
No nipping	135.7(±2.1) a
Nipping	178.5(±2.2) b
$LSD_{(0.05)}$	16.8

Means having different letters within a column are significantly different at 5% level of significance according to the least significant difference (LSD) test. In brackets are standard deviation values.

Table 3: Effect of management practice on yield of *Cleome gynandra* seeds harvested at yellow pod maturity stage.

Maturity stage

The results shown in Table 4 indicate that there were significant (*P*=0.05) effects of maturity stages on percent germination, mean germination time and electrical conductivity of Cleome seeds. Seeds from green pods did not germinate and recorded zero percent germination. Lowest vigour as indicated by a high value of electrical conductivity (629.05μScm^{-1}g^{-1}) was also recorded for seeds from green pods. Seeds from Yellow-green pods were intermediate and those from yellow pods had the highest viability (percent germination of 14.5%) and vigour (mean germination time of 2.04 days and an electrical conductivity of 25.94μScm^{-1}g^{-1}), Table 3.

Maturity stage	Germination (%)	Mean germination time (days)	Electrical conductivity (μScm^{-1}g^{-1})
Green pods	0.00 (±0.000)a	0.00 (±0.000)a	629.05 (±0.006)a
Y/green pods	12.25 (±0.500)b	2.06 (±0.005)b	27.10 (±0.005)b
Yellow pods	14.50 (±0.580)c	2.04 (±0.008)c	25.94 (±0.006)c
LSD (0.05)	1.45	0.01	0.93

Any two means having different letters within a column are significantly different at 5% level of significance according to the least significant difference (LSD) test. In brackets are standard deviation values.

Table 4: Effect of maturity stage on percent germination, mean germination time and electrical conductivity of *Cleome gynandra* seeds.

DISCUSSION

Management practices and stage of seed maturity have important consequences on seed viability and vigour. In general, germination was poor probably due to dormancy. Yepes (1978) observed that freshly harvested seeds of *Cleome gynandra* exhibit after-ripening dormancy. According to Ellis *et al*. (1985a), such dormancy prevents seeds from germinating on the mother plant and also usually for some time after the ripe seed is shed or harvested. Thus, given that *Cleome gynandra* seeds used in this study were freshly harvested there was a high possibility of primary dormancy being expressed in the initial germination tests. This type of dormancy is broken when seeds are stored for some period. After-ripening dormancy loss in stored seed has been observed in *Amaranthus retroflexus* (Omami *et al*., 1992), *Avena fatua* (Foley, 1994) and *Festuca idahoensis* (Goodwin *et al*., 1995).

The results obtained in this study showed that the two management practices had similar effects on quality of *Cleome gynandra* seeds, though the management practice of nipping of first flower heads encouraged formation of lateral branches for more seed production. This study is in agreement with Grzesik *et al*. (1997) that Callistephus seed harvested from primary and secondary capitula had same seed quality. Khan *et al*.,

(2006) reported that in chickpea, nipping at 94 days after emergence recorded significant difference in the number of pods per plant, seeds per pod, and seed yield as compared to no nipping.

The results of this study showed that there was an increase in viability and vigour as seeds developed to full maturity. Seeds from green pods had the least germination percentage, while seeds from yellow pods had the highest germination percentage and seeds from yellow-green pods were intermediate. According to Harrington (1972), Tekrony and Egli (1997), Muasya *et al*. (2002), highest seed quality is attained at physiological maturity, which in this study could be the yellow pod maturity stage. Xu and Bewley, (1991); Leprince *et al*., (1993); Bewley and Black, (1994); Kermode, (1995), pointed out that following fertilization, there is the histo-differentiation phase, followed by cell expansion phase and finally physiological maturity. From the findings of this study the green maturity stage was probably at the histo-differentiation stage, the yellow-green stage at cell expansion phase, while the yellow-pod maturity stage was close to physiological maturity of Cleome seeds and hence gave higher seed quality than green and yellow-green pod maturity stages.

CONCLUSION

The findings of this study indicate that in production of *Cleome gynandra* seeds, nipping of first flower heads and allowing plants to mature without nipping gave seeds that did not differ significantly in quality. However, the practice of nipping encouraged production of lateral branches for more seed production. Therefore, based on this study, it is recommended that in production of *Cleome gynandra* seeds, the first flower heads should be nipped. Pods should be harvested when yellow since the yellow-pod maturity stage gave seed of higher seed quality. However, prior to sowing, dormancy breaking methods should be applied in order to achieve higher germination percentage.

ACKNOWLEDGEMENT

The authors acknowledge with gratitude funding for this work from International Plant Genetic Resources Institute (IPGRI) and “Seed for Life Project”, national museums of Kenya..

REFERENCES

1. Arnord, T. H., Wells, M. J., Wehmeyer, A. S., 1985. Khoisan food plants. Taxa with potential for future economic exploitation. In plant for arid lands (Wickens, G.E., Goodin and Field D.V., eds.). George Allen and Unwin, London, UK.
2. Appa R., Kameswara R., Mengesha M., 1992. Germinability and seedling vigour of pearl millet seeds harvested at different stages of maturity. *Field Crops Research* , 32.
3. Asis Bala, Biswakanth Kar, Pallab K. Haldar, Upal K. Mazumder and Samit Bera, 2010. Evaluation of anticancer activity of *Cleome gynandra* on Ehrlich's Ascites Carcinoma treated mice. *Journal of Ethnopharmacology*;129(1):131-134
4. Bewley,J. D., Black, M., 1994. *Seeds*: *physiology of development and germination.* New York*:* Plnum Press. Pp.52-53.
5. Chweya, J. A., Mnzava, N. A., 1997. Cat’s whiskers, *Cleome gynandra* L. Promoting the conservation and use of underutilized and neglected crops.11. Institute of Plant Genetics and Crop Plant Research, Gatersleben/ Inter-national Plant Genetic Resources Institute, Rome, Italy.

6. Ellis, R. H., Hong, T. D., Roberts, E. H., 1985a. Handbook of seed technology for genebanks vol. Principles and methodology. IBPGR, Rome.
7. Foley, E. M., 1994. Temperature and water status of seed affect after-ripening in wild oat (*Avena fatua*). *Weed Science,* 42: 200 - 204.
8. Goodwin, R. J., Doescher, P. S., Eddleman, L. E., 1995. After-ripening in *Festuca idahoensis* seeds: Adaptive dormancy and implications for restoration. *Restoration Ecology,* 3:137 -142.
9. Grzesik, K., Gornik, K., Chojnowsk, G., 1997. Effect of harvest time on the quality of Callistephus chinensis Nees C.V. Aleksandra seeds collected from different parts of plant. *Seed Science and Technology*, 26: 263-265.
10. Gujar, K. D. and Srivastava, U. K., 1972. Effect of maleic hydrazide and apical pinching in okra. *Indian J. Hort.,* 26(1): 63-66.
11. Hampton JG and Coolbear P Potential Versus Actual Seed Performance - Can Vigour Testing Provide an Answer? *Seed Science and Technology*, 1990; 18: 215-228.
12. Harrington, J. F., 1972. Seed storage longevity.Pp.145-245 in Kozlowski,T.T.(Ed.) Seed biology,Vol.111.New York, Academic Press. Pp.145-245.
13. Howes MJ, Perry NS and Houghton PJ 2003. Plants with traditional uses and ctivities, relevant to the management of Alzheimer's disease and other cognitive disorders. Phytother Res.;17 (1):1-18.
14. Hulme, D. and Scott, J., 2010. "The Political Economy of the MDGs: Retrospect and Prospect for the World's Biggest Promise", *New Political Economy*, 15(2), pp.293-306
15. ISTA, 2003. International Rules for Seed Testing. *Seed Science and Technology*; supplement 31.
16. ISTA, 1995. Handbook of vigour test methods (3rd edition). J.G., Hampton and D.M. Tekrony (eds.). ISTA, Zurich.
17. Justice, O. L., Bass, L. N., 1978. *Principles and Practices of Seed Storage.Agriculture Handbook* No. 506.Washington, D.C., US Government Printing Office.
18. Kermode, A. R., 1990. Regulatory mechanism involved in the transition from seed development to germination. *Plant Science* 9:155-195.
19. Khan, H., Latif, A., Mahmood, S. and Khan, M.S.S., 2006. Effect of nipping at various stages on yield and yield components of chickpea(Cicer aeritinum L.).J.Res.,(Sci.),pp.235-240.
20. Leprince, O., Hendry, G. A., McKersie, B. D., 1993. The mechanics of desiccation tolerance in developing seeds. *Seed Science Research,* 3: 231-246.
21. Mnzava, N.A. & Chigumira N. F., 2004. Cleome gynandra L. In: Grubben, G.J.H. & Denton, O.A. (Ed). PROTA 2: Vegetables/Légumes. Wageningen, Netherlands.
22. Mnzava, N. A., 1990. Studies on tropical vegetables. 2. Amino and fatty acid composition in seed of Cleome (*Gynanadropsis gynandra* (L.) Briq). Selections from Zambia. *Food Chemistry*, 35: 287-293.
23. Muasya, R. M., Lommen, W. M., Struik, P. C., 2002a. Differences in development of common bean (*Phaseolus vulgaris* L.) crops and pod fractions within a crop.1. Seed growth and maturity. *Field Crops Research,* 75: 63-78.
24. Omami, E. N., Medd, R. W., Haigh, A., 1992. Germination and after-ripening responses in *Amaranthus retroflexus* seed. *Proceedings of the 1st International Weed Control Congress*. vol. 2: 372-374.
25. Sajjan, A. S., Shekhargouda, M. and Badanur, V. P., 2002. Influence of apical pinching and fruit picking on growth and seed yield of okra. *Karnataka J. Agric. Sci.,* 15(2), 367-372.
26. Sharma, A, Potdar, P., Pujari, T. and Dharmaraj, S., 2003. Studies on response of pigeonpea to canopy modification and plant geometry. *Karnataka J. Agric. Res.,* 16(1):1-3.

27. Tekrony, D. M., Egli, D. B., 1997. Accumulation of seed vigour during development and maturation. In: Ellis, R.H., Black, M.,Murdoch, A.J.,Hong, T.D. (Eds.),Basic and Applied Aspects of seed Biology. Kluwer Academic Publishers, Dordrecht, Pp. 369-384.
28. Tekrony DM and Spears JF Seed Vigour Testing. In: Seed Technologist Training Manual. 2001: 11–20.
29. Xu, N., Bewley, J., 1991. Sensitivity to abscisic acid and osmoticum changes during embrogenesis of alfalfa (Medicago sativa L.). *Journal of Experimental Botany,* 42:841-826.
30. Yepes, J. H., 1978. Estudio de lamaleza Platanito (Cleeome gynandra L.) Study of the weed *Cleome gynandra* L. Rev. Comalfi., 5: 49-53.