Morphological floral characterization in accessions of *Jatropha curcas* L.

A. M. S. Pessoa[1]; R. S. Mann[2]; A. G. Santos[2]; M. L. F. Ribeiro[2]

[1]*Master in Agroecossystems, Federal University of Sergipe, 49100-000, São Cristóvão-Se, Brazil*

[2]*Federal University of Sergipe, 49100-000, São Cristóvão-Se, Brazil*

pbalegna@gmail.com

renatamann@ufs.br

Knowledge of the structure of floral species is essential to achieving appropriate pollination techniques for the success ful breeding of controlled crosses. The goal of this work was to characterize the floral morphology of different accessions of physic nut (*Jatropha curcas* L.). Seventeen accessions were evaluated for proportions of staminate and pistillate flowers, average number of inflorescences per accession, and size of flowers. The *J. curcas* species is a monoecious plant, whose flowers are grouped in inflorescences. The average number of inflorescences per accession varied from 1.6 for JCUFS-014 to 23.7 for JCUFS-017. The staminate and pistillate flowers are pentamerous with actinomorphic symmetry and green coloration. The physic nut plant presented morphological variation for floral structure, related to the number of petals, sepals, floral glands, and stamens, and also presented hermaphrodite flowers.

Keywords: Reproductive system; Euphorbiaceae; floral structure

O conhecimento da estrutura floral de uma espécie é fundamental para que o melhorista trabalhe técnicas de polinização adequadas visando à polinização em cruzamentos controlados. O objetivo desse trabalho foi caracterizar a morfologia floral de acessos de pinhão-manso (*Jatropha curcas* L.). Foram avaliados 17 acessos de pinhão-manso para proporção de flores estaminadas e pistiladas, quantidade média de inflorescência por acesso e comprimento das flores. O *J. curcas* é uma planta monóica, cujas flores agrupam-se em inflorescências. A média de inflorescências por acesso variou de 1,6 para o acesso JCUFS-014 a 23,7 para o JCUFS-017. As flores estaminadas e pistiladas são pentâmeras com simetria actinomorfa, de coloração verde. O pinhão-manso é uma planta monóica, que apresenta variação morfológica na estrutura floral, relacionadas ao número de pétalas, sépalas, glândulas florais, estames e apresenta flores hermafroditas.

Palavras-chave: Sistema reprodutivo; Euphorbiaceae; estrutura floral

1. INTRODUCTION

The physic nut (*Jatropha curcas* L.) is an important species, providing raw materials for biodiesel production. It belongs to family Euphorbiaceae, occurs in many Latin American, Asian and African regions, and is adapted to both tropical and subtropical ecosystems[9].

It is characterized as a shrub, with numerous scars formed where leaves have fallen from the stem. It reaches a height of 2-3 m under favourable conditions, and has alternate, lobed and cordiform green leaves with a long petiole[6]. The plant is monoecious with a variable number of flowers per inflorescence, with a higher number of male than female flowers. Each inflorescence remains on the plant for 13-19 days: some male flowers open in the first two days, followed by rapid opening of female flowers[7, 3].

Some species of the family Euphorbiaceae have been described, due to its economic importance. For example, morphological variation for flowers of ethno-varieties DG-55 and DG-65 of cassava have been the subject of studies, describing hermaphrodite flowers and fewer eggs per ovary[14]. Thus, descriptions of floral morphology allow better understanding of the physic nut, contributing to an understanding of its reproductive biology[1] and field production.

Knowledge of floral structure and reproductive biology in a crop is a basic requirement for the development of better techniques suitable for emasculation and pollination. An understanding of floral morphology is important when assessing interactions between the pollen

and stigma, flowers and pollinators, as well as the reproductive success of vegetable species[5, 8] for fruit yield.

In the germplasm bank, *J. curcas* presents great genetic variability, allowing breeders to select the accessions of greatest economic importance. However, to determine a suitable access ionfora breeding programme, it is necessary to understand the particular characteristics of each accession. The goal of this work was to characterize the floral morphology of different accessions of physic nut (*Jatropha curcas* L.).

2. MATERIALS AND METHODS

The experiment was performed with accessions of physic nut held in the Active Germplasm Bank of the Agricultural Engineering Department at the Federal University of Sergipe, in the municipality of São Cristóvão, State of Sergipe (10° 5' 43"S and 37º 06' 10" W). We used 17 provenances from the states of Minas Gerais, Goiás, Espírito Santo, Bahia and Sergipe (Table 1).

Floral structure was analyzed at the Laboratory of Tissue Culture and Plant Breeding, using inflorescences collected and preserved in a solution of 70% alcohol for later analysis with a stereoscopic microscope (Model Leica DM500). The floral morphology was determined from analysis of 100 flowers of each accession, using 10 pistillate flowers, 10 buds and 80 staminate flowers.

The evaluation was based on botanical descriptions[15], number of floral glands, type of stigma and number of opening flowers, number and arrangement of each flower in the whorls, and position of ovary. Flower samples were cut longitudinally in Petri dishes in order to determine the ovary's position. The dissected material was observed and photographed at a magnification of five times.

The size of flowers was evaluated, taking the distance from the bottom of the pedicel for stigmata in pistillate flowers, or the anther in staminate flowers, as a measure of height. The proportion of staminate to pistillate flowers was determined every 15 days for 12 months, with observation of four inflorescences per accession. For the same period, the average of inflorescences per accession was determined.

The results were tabulated, comparing data and values relating to accessions with those reported in the scientific literature. To determine the size of flowers, a completely randomized design was used with 17 treatments and four replicates, and the average values were compared by Scott-Knott test at 5% of probability.

Exsiccates of accessions were deposited for taxonomical identification in the Herbarium of the Federal University of Sergipe.

Table 1. Identification and origin of accessions of physic nut (Jatropha curcas L.) in the Active Germplasm Bank of the UFS, São Cristóvão - SE, UFS, 2011.

Accession	Municipality/State of origin	Code in the herbarium of the UFS
JCUFS-001	Lavras-MG	15256
JCUFS-002	Lavras-MG	15259
JCUFS-003	Lavras-MG	15249
JCUFS-004	Lavras-MG	15258
JCUFS-005	Lavras-MG	15257
JCUFS-006	Lavras-MG	15243
JCUFS-007	Lavras-MG	15250
JCUFS-008	Lavras-MG	15246
JCUFS-009	Lavras-MG	15254
JCUFS-010	Rio Verde-GO	15253
JCUFS-011	Rio Verde-GO	15252
JCUFS-012	Lavras-MG	15251
JCUFS-013	Rio Verde-GO	15262
JCUFS-014	Alegre-ES	15255
JCUFS-015	Rio Verde-GO	15248
JCUFS-016	Lagarto-SE	15261
JCUFS-017	Valente-BA	15260

3. RESULTS AND DISCUSSION

Evaluation of the flowers of the physic nut enabled us to identify this species as a monoecious plant, with staminate and pistillate inflorescences (Figure 1). In other species of the family Euphorbiaceae, has been reported the occurrence of other monoecious species has been reported, such as *Croton urucurana*, which has flowers grouped in inflorescences[11], similar to the physic nut.

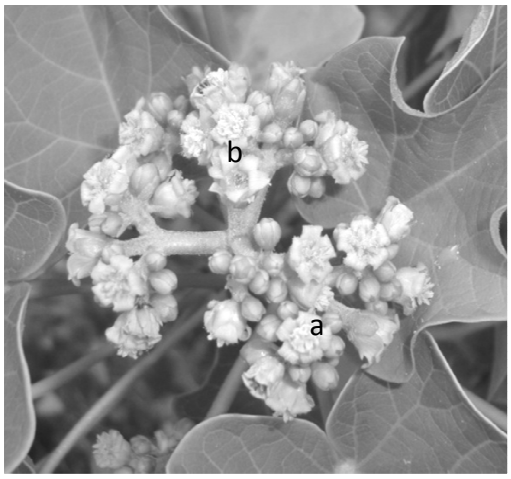

Figure1: Inflorescence of Jatropha curcas L. With staminate flowers (a) and pistillate (b) in the same inflorescence.UFS, São Cristóvão- Se, 2011.

The average number of inflorescences per accession ranged from1.6 (JCUFS-014) to 23.7 (JCUFS-017). Variation among the accessions was observed as a result of the analysis of the proportion of staminate flowers in relation to the pistil (E/P) (Table 2). This variation was demonstrated by a proportion of 11 pistillate to on estaminate flower for the accession identified asJCUFS-013, compared to a ratio ofonestaminateto36 pistillate flowers for the JCUFS-006 and JCUFS-002 accessions. This ratio (E/P) increased in the flowering season after the falling of leaves and early sprouting.

A similar study carried out in the semi-arid region of Pernambucano to evaluate the agronomic performance of genotypes of physic nut, reported average values of 12 inflorescences per plant[14]. In a study of the same species, reteda ratio of 17 staminate flowers to 105 pistillate flowers was reported in two to 19 flowers per inflorescence[2]. It was observed that there are inflorescences in physic nut with a greater number of male flowers.

The accessions presented significant differences at 5% probability for the size of flower (Table 2). Flowers of greater length were found in JCUFS-005 (1.17cm), JCUFS-010 (1.12cm), JCUFS-011 (1.08 cm), JCUFS-016 (1.13cm) and JCUFS-017 (1.06cm), followed by JCUFS-002 (0.95cm), JCUFS-006 (0.89cm), JCUFS-007 (0.97cm), JCUFS-008 (0.99cm), JCUFS-009 (0.96cm), and JCUFS-015 (0.95cm).

Only two accessions showed low values of flower size: JCUFS-001 at 0.75 cm, and JCUFS-013 at 0.86 cm. It is likely that large flowers ensure the formation of large seeds: there are however no studies concerning this particular relationship for this species. The accessions JCUFS-003, JCUFS-004, JCUFS-012 and JCUFS-014 did not produce enough flowers for size to be evaluated.

This variation was also observed in physic nut plants in Minas Gerais, which produced inflorescences with a ratio of 87 staminate flowers to 222 pistillate flowers e.g.138.5:7.2[7]. This variation was possibly due to genetic and environmental variables affecting conditions where the plant materials were grown, and there is no relationship between the proportion of inflorescences for male and female flowers.

In this study, staminate flowers began to open before the pistillate flowers, and the number of staminate flowers in an inflorescence was much greater than pistillate flowers. Similar results were found in other studies reporting the occurrence of flowers of physic nut displaying geitonogamy, for example, staminate flowers initiating the opening of the pistillate flowers.

Table 2: Code, origin, the average number of inflorescences per accession, average ratio of staminate/pistillate flowers and size of flowers of physic nut (Jatropha curcas L.). UFS, São Cristóvão-Se, 2011.

Accession	Inflorescences/plant	Flower ratio E/P	Size of flower (cm)
JCUFS-001	12.9	32:1	0.75 c
JCUFS-002	9.9	36:1	1.01 b
JCUFS-003	4.8	16:1	-
JCUFS-004	12.0	23:1	-
JCUFS-005	19.2	16:1	1.17 a
JCUFS-006	5.9	36:1	0.98 b
JCUFS-007	7.3	26:1	0.97 b
JCUFS-008	14.5	21:1	0.99 b
JCUFS-009	14.6	29:1	0.96 b
JCUFS-010	11.0	21:1	1.12 a
JCUFS-011	8.2	20:1	1.08 a
JCUFS-012	4.8	22:1	-
JCUFS-013	6.0	11:1	0.86 c
JCUFS-014	1.6	17:1	-
JCUFS-015	17.0	33:1	0.95 b
JCUFS-016	3.8	24:1	1.13 a
JCUFS-017	23.7	19:1	1.06 a

Means followed by the same letter in columns are not different at 5%probability by Scott-Knott test

The staminate flowers are generally pentamerous (five petals and five sepals) with actinomorphic symmetry. The sepals are free, and green in colour. However, JCUFS-006 produced flowers with four sepals (Figure 2a). This variation consequently also occurred for petals and glands.

There are five free, green petals, with presence of white hair. The nectar glands are yellow and white, in the bottom of open flowers at the base of the stamens (Figure 2b). The JCUFS-005 and JCUFS-017 accessions presented five white floral glands in open flowers. The white colour of floral glands indicates non-functionality.

Ina study of individuals of *Cnidosculus juercifoluis* (Euphorbiaceae), the presence of five free sepals with white hairs and yellow nectar glands was reported[13]: similar results were found in this work.

The androecium consists of 10 heterodyne stamens, or stamens with different sizes named gamostemone, characterized by a bundle of five large stamens and five small free stamens. Similar results were found in staminate flowers of *J. curcas*, with the presence of ten stamens arranged in two bundles of five stamens[3].

The JCUFS-002 and JCUFS-009 accessions presented variation, with a bundle of three large stamens and three small free stamens (Figure 2c), and there was also variation in the number of stamens in a bundle, with four large and four free stamens (Figure 2d) for JCUFS-001, JCUFS-002, JCUFS-005, JCUFS-006, JCUFS-007, JCUFS-008, JCUFS-009, JCUFS-013 and JCUFS-017. For JCUFS-002, we observed the occurrence of underdeveloped stamens. There are diteca anthers with insertion of the bead at the bottom, and longitudinal dehiscence (Figure 2e).

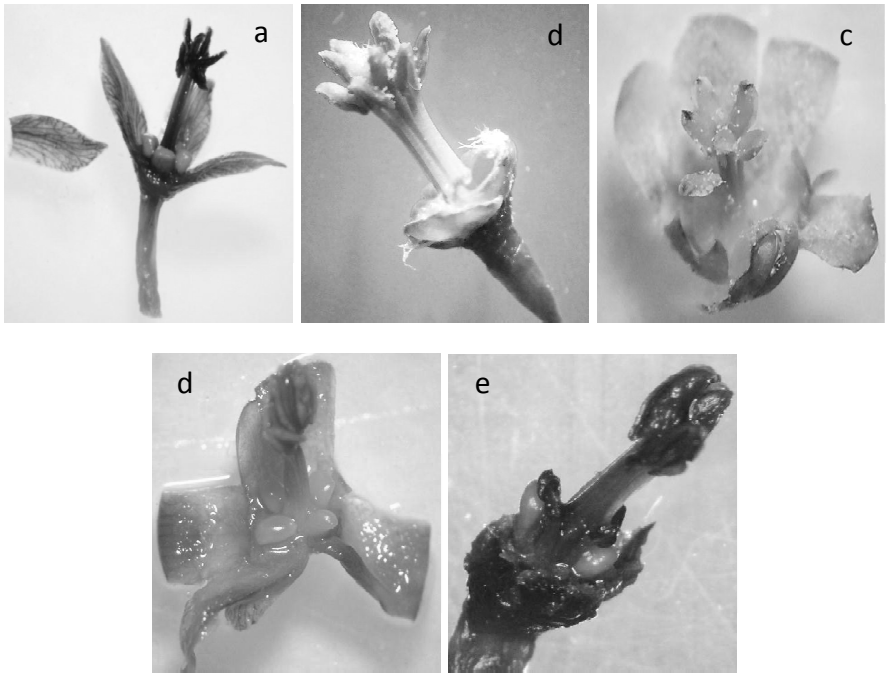

Figure 2.Different aspects of floral morphologyin staminate flowers of accessions of Jatropha curcas L. a) *open flower with four sepals*; *b*) *presence of flower nectar glands*; *c*) *bundle of three large stamens and three small free stamens*; *d*) *bundle of four large stamens and four small free stamens*; *e*) *underdeveloped stamens. UFS, São Cristóvão-Se, 2011.*

The pistillate flowers are pentamerous, with actinomorphic symmetry, and are green in colour. There are five petals and sepals, which are similar to those of staminate flowers. In JCUFS-017, the presence of flowers with six sepals was noted (Figure 3a). The petals have white hair, and when the flowers are fertilized, they wither and fall, with the remaining sepals related to the initial formation of the fruit.

There are five yellow nectar glands, which are distributed in a disc shape structure, surrounding the ovary. In JCUFS-017 there were four such glands, one large and three small, and fused (Figure 3b). In the pistillate flowers of *J. mutabilis* and *J. mollissima*, the nectar is disc-shaped, located at the bottom of the ovary, where the nectar accumulates[12].

The gynoecium has three short light green stigmas, forked with a foliaceous surface. The ovary is superior (Figure 3c), trilocular, tricarpelar, with an egg in each locule (Figure 3d). When fertilization does not occur, the ovary shrivels, becomes dark in color and falls.

We identified variance in numbers of hermaphrodite flowers: one was found for the JCUFS-009 accession and three for the JCUFS-017 accession, with variation of number and size of the anthers (Figure 3e).

Hermaphrodite flowers were not observed in accessions of physic nut from the Germplasm Bank in Mato Grosso do Sul[10].

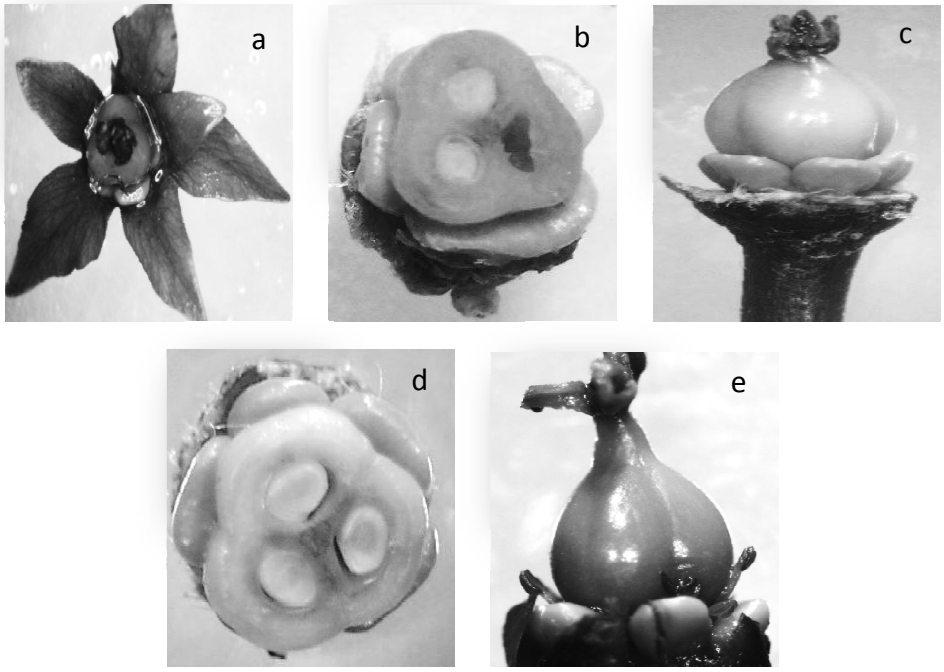

Figure 3.Different aspects of floral morphology in pistillate flowers of accessions of Jatropha curcas L. a) *open flower with six sepals*; *b*) *dried flower petals*; *c*) *flower with four floral glands*; *d*) *flower with superior ovary*; *e*) *trilocular ovary with an ovule in each locule*; *f*) *hermaphrodite flowers.UFS, São Cristóvão-Se, 2011.*

Authors studying plants belonging to the Euphorbiaceae family emphasize that these species presenta very primitive floral morphology and hermaphroditism, and monoecious plants show variability [14]. However, the sporadic occurrence of hermaphrodite flowers may indicate that the process has not yet been completed.

4. CONCLUSION

The physic nut plant is monoecious, with morphological variation in floral structure between accessions for number of petals, sepals, floral glands, stamens and the presence of hermaphrodite flowers.

The JCUFS-009 and JCUFS-017 accessions present hermaphrodite flowers.

The JCUFS-005, JCUFS-010, JCUFS-011, JCUFS-016 and JCUFS-017 accessions present large flowers.

There is a difference in number of stamens in Flowers of physic nut accessions present differences in the number of stamens.

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1. BACELAR-LIMA, C. G.; MENDONÇA, M. S.; BARBOSA, C. T. Morfologia Floral de uma População de Tucumã, *Astrocaryum aculeatum* G. Mey. (Arecaceae) na Amazônia Central. *Acta Amazônica*, v. 36, n. 4, p. 407–412, 2006.
2. BHATTACHARYA, A.; DATTA, K.; DATTA, S. K. Floral biology, floral resource constraints and pollination limitation in *Jatropha curcas* L. *Pakistan Journal of Biological Sciences*, v. 8, p.456−460, 2005.
3. CHANG-WEI, L.; KUN, L.; YOU, C.; YONG-YU, S. Floral display and breeding system of *Jatropha curcas* L. *Forestry Studies in China*, v. 9, n. 2, p. 114–119, 2007.

4. GOMES, S. M.; CAVALCANTI, T. B. Morfologia floral de *Aspidosperma* MART. & ZUCC. (APOCYNACEAE). *Acta Botânica Brasileira*, v. 15, n. 1, p. 73–88, 2001.
5. HELLER, J. *Physic nut. Jatropha curcas* L. Promoting the conservation and use of underutilized and neglected. 1. Institute of Plant Genetics and Crop Plant Research. Gaterleben / International Plant Genetic Resources Institute, Rome. 66p, 1996.
6. JUHÁSZ, A. C. P.; PIMENTA, S.; SOARES, B. O.; MORAIS, D. L. B.; RABELLO, H. O. Biologia floral e polinização artificial de pinhão-manso no norte de Minas Gerais. *Pesquisa Agropecuária Brasileira*, v. 44, n. 9, p.1073–1077, 2009.
7. LENZI, M.; ORTH, A. I. Fenologia reprodutiva, morfologia e biologia floral de *Schinus terebinthifolius* Raddi (Anacardiaceae), em restinga da Ilha de Santa Catarina, Brasil. *Biotemas*, v. 17, n. 2, p. 67–89, 2004.
8. MISHRA, D. K. Selection of candidate plus phenotypes of *Jatropha curcas* L. using method of paired comparisons. *Biomass and bioenergy*, v. 33, p. 542–545, 2009.
9. PAIVA NETO, V. B.; BRENHA, J. A. M.; FREITAS, F. B.; ZUFFO, M. C. R.; ALVAREZ, R. C. F. Aspectos da biologia reprodutiva de *Jatropha curcas* L. *Ciência e Agrotecnologia*, v. 34, n. 3, p. 558–563, 2010.
10. PIRES, M. M. Y.; SOUZA, L. A.; TERADA, Y. Biologia floral de *Croton urucurana* Baill. (Euphorbiaceae) ocorrente em vegetação ripária da ilha Porto Rico, Estado do Paraná, Brasil. *Acta Scientiarum. Biological Sciences*, v. 26, n. 2, p. 209–215, 2004.
11. SANTOS, M. J.; MACHADO, I. C.; LOPES, A. V. Biologia reprodutiva de duas espécies de *Jatropha* L. (Euphorbiaceae) em Caatinga, Nordeste do Brasil. *Revista Brasileira de Botânica*, v. 28, n. 2, p.361–373, 2005.
12. SILVA, L. M. M.; AGUIAR, I. B.; VIÉGAS, R. A.; MENDONÇA, I. F. C. Biologia reprodutiva de *Cnidosculus juercifolius* Pax&Hoffm (Euphorbiaceae). *Revista de Biologia e Ciências da Terra*, v. 6, n. 2, p.24–34, 2006.
13. SILVA, R. M.; BANDEL, G.; FARALDO, M. I. F.; MARTINS, P. S. Biologia reprodutiva de etnovariedades de mandioca. *Scientia Agrícola*, v. 58, n. 1, p.101–107, 2001.
14. VIDAL, W. N.; VIDAL, M. R. R. *Botânica organografia: quadros sinóticos ilustrados de fanerógamos*. 4 ed., Viçosa: UFV, 124p, 2000.