

Observed autogamy in Baobab (*Adansonia digitata* L.)

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Abstract

Baobab (*Adansonia digitata* L.) is an important wild tree of African origin which is currently attracting interest for domestication. Flower polymorphism observed on baobab trees at the Ho Technical University (HTU), Ghana, raised interest in understanding the phenomenon since it may have implication for reproduction in the species. This led to the objective of examining if baobab flowers could self-fertilize. In furtherance of this, flowering in five, two-year-old baobab trees were monitored. Two of the trees had preanthesis cleistogamous flowers while the other three had dichogamous flowers. The trees with the preanthesis cleistogamous flowers fruited, while those with dichogamous flowers did not. These observations suggested that the preanthesis cleistogamous trees might have self-compatible flowers, while the other type might not have. This seems to be the first report of autogamous fruiting in baobab. Self-compatible trees have a high probability of fruiting and therefore would be higher yielding. In addition, fixing of superior traits is easier in self-compatible trees. Confirmation of the finding is recommended and consequent attempts at domesticating the species should focus on preanthesis cleistogamous baobab trees with desired characters.

1.0 Introduction

Research over the years has focused on a few cultivated crops – a situation which has resulted in many important crops receiving very limited attention (Bollington et al., 2021; Tadele, 2019). This imbalance in research on crops has resulted in the world being dependent on only a few crops for its dietary needs. Even with these few major crops, only a limited number of their improved varieties are cultivated by many farmers across the globe (Gatto et al., 2021). For example, wheat alone serves as the staple food for 35% of the human population (Grote et al., 2021). Consequently, vast tracts of cultivated land are devoted to a few major crops leading to the displacement of many landraces that are important for food and nutrition security and adaptation to biotic and abiotic stresses.

Although, several crops across the globe have the potential to improve food security, they are underutilized (Baa-Poku, 2018). These lesser used or underutilized crops are also referred to as orphan crops because of the lack of research and development attention devoted to them (Hendre et al., 2019). Orphan crops however, have been reported to be generally rich in nutritional profile, good for medicinal purposes, and well adapted to suboptimal growing conditions (Mabhaudhi et al., 2019; Talabi et al., 2022). In addition, due to most of these orphan crops being perennial staples, they do not need to be replanted year after year and they are therefore essential components of permaculture and improved habitats (Kreitzman et al., 2020).

Baobab, *Adansonia digitata*, is a very good example of an orphan perennial staple crop. Baobab has several nutritional, medicinal, ecological and cultural attributes that are of particular importance to millions of people in sub-Saharan Africa. The status of the crop as an orphan crop however, means that it has not received the needed research attention leading to a paucity of information, particularly on its reproductive biology (Cullis and Kunert, 2017; Tadele, 2019). The improvement of any crop to enhance its

utilization requires a good knowledge of the crop's reproductive biology, particularly the mode of pollination of the species. Eckert (2000), distinguishes two types of flower self-pollination, namely within-flower self-pollination referred to as autogamy and between-flowers of the same plant self-pollination referred to as geitonogamy.

Cleistogamy is a breeding system in plants in which closed flowers are self-pollinated (Culley and Klooster, 2007). These flowers are autogamous as pollination takes place while their flowers remain closed. The situation where opening of the perianth occurs after pollination is called preanthesis cleistogamy (Philbrick and Vomela, 2006). Another type of flower opening was described by Kwiatkowska et al. (2019), where flowers open during the day but close at night, making those plants "mixed outcrossing-selfing".

The Ho Technical University (HTU) in Ghana has initiated research to domesticate baobab (Egbadzor and Akuaku, 2022) and this has also led to the study of variation in flower morphology of the plant. Preliminary observations made as part of this research indicated that the flower opening of a particular cultivated baobab tree was different from other planted and wild trees; instead of the common protogyny type of dichogamy, the opening of the flowers of the particular tree resembled preanthesis cleistogamy. This led to the objective of examining if baobab could self-fertilize.

2.0 Materials And Methods

2.1 Experimental location

The study was conducted at the campus of HTU in the Volta Region of Ghana. The baobab trees were planted 15 m apart in a single row in the field. The geographic position of the mid-point of the row is 6° 35' 3" N, 0° 27' 45" E. The vegetation around the HTU is savannah woodland. The mean annual rainfall is 750 mm (minimum) to 1020 mm (maximum). The mean monthly rainfall varies from 20.1 mm in December to 192 mm in June. The mean monthly temperature ranges from 22 °C to 32 °C, whilst the mean annual minimum and maximum are 16.5 °C and 37.8 °C respectively (Adanu et al., 2014).

2.2 The experimental plants

Baobab seeds were germinated in March, 2019, seedlings were transferred to nursery bags and raised for seven months before being used as the rootstock for grafting. Scions were cut from three different mature baobab trees known to have been fruiting for several years at a community that is about 10 km from the HTU. Seedlings were grafted in September, 2019 and transplanted in October 2019. Apart from organic manuring and watering at the time of transplanting, there were no irrigation nor fertilizer application. The main cultivation activity carried out was regular weed control.

2.3 Observation

Two plants, each from a different clone, started flowering two years after transplanting and three others started about five months later. Three of the flowering trees were from the same clone while the

remaining two, were from two different clones. Flower buds were monitored daily by visual inspection for signs of calyx splitting. Once calyx splitting was observed from the apex of a bud, observations continued until 10 pm. Photographs were taken to document critical and distinct stages of floral development.

3.0 Results And Discussion

Figure 1 shows different stages of dichogamous and preanthesis cleistogamous flowers of baobab observed in the study. The breaking of the calyx at the apex in “A” and the eventual opening of the entire perianth in “B” can be described as protogynous type of dichogamy (Philbrick and Vomela, 2006). Preanthesis cleistogamy is shown in “C” to “F” (Lloyd and Webb, 1986; Zhang et al., 2021).

[Dichogamous (Stigma emerged following the breaking of the calyx at the apex in “A” before the eventual splitting of the entire perianth “B”, for anther emergence. Preanthesis cleistogamy (calyx split in “C”, and some anthers emerged in “D”, however, stigma remained within the perianth and with interference with pollen and was only exposed after full opening of flowers shown in “E” and “F”. Breaking of calyx to full opening of perianth takes about four hours.)]

Preanthesis cleistogamy occurred in two of the three clones while dichogamy occurred in one. The various stages of development at which the preanthesis cleistogamous flowers were photographed showed contact between anthers and the stigma. A visit back to the wild plants from which the scions were taken showed similar traits to the cultivated clones. The opening of the various flowers in the study took place on different days and the closest wild baobab tree which was more than 300 m away was not flowering at the time. This provided the assurance that baobab pollen could not have come from a different tree. The two clones with preanthesis cleistogamous flowers developed fruits. Fruit development from a flower that was the only one formed on the tree at the time of the observations, coupled with no other baobab flower being in the vicinity strongly suggests that the flower was self-pollinated. The probability that the developed fruit in this case exhibited within-flower self-pollination (autogamy) is very high. This observation is contrary to the report of Venter et al. (2017) that baobab is highly self-incompatible. It should, however, be noted that self-compatible mutants are known in some highly self-incompatible species like pear (*Pyrus communis*) (Claessen et al., 2019). Thus, the observation made in this study, although rare, was not strange.

Although, self-incompatibility ensures cross-pollination and genetic diversity, it makes the fixing of useful genes difficult (Cropano et al., 2021). In addition, self-compatible clones will not need pollinators when used to establish plantations (Munoz-Sanz et al., 2020). Domestication and cultivation of preanthesis cleistogamous baobab trees would thus have some advantages over the dichogamous types (Eckert, 2000). According to Winn and Moriuchi (2009), cleistogamous trees have greater fruit set. Further, preanthesis cleistogamous trees might even have greater chance of fruit set as they could be self-pollinated as well as cross-pollinated.

The inability of the dichogamous flowers to develop fruits could be attributed to the high self-incompatibility reported for baobab by Venter et al. (2017). Self-incompatibility is known in 50% of angiosperms (Montalt et al., 2022). The finding suggests that both self-compatibility and incompatibility are present in baobab trees, therefore self-pollination and cross-pollination are both possible. Mixed outcrossing-selfing has also been reported in some other species (Kwiatkowska et al., 2019).

4.0 Conclusion

Our results have shown that some baobab trees have preanthesis cleistogamous flowers and are self-compatible. Preanthesis cleistogamous flowers have a better chance of being fertilized and developing into fruits. It would be of interest to farmers to plant self-compatible trees to have the assurance of higher fruit yields. This is especially important in the face of the dwindling numbers of pollinators. Baobab domestication efforts should therefore target superior preanthesis cleistogamous flowering trees for cloning. Studying natural populations of baobab to assess the rate of occurrence of preanthesis cleistogamy is also recommended.

Declarations

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Conflict of interest statement

The authors do not have any conflict of interest to declare.

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Figures

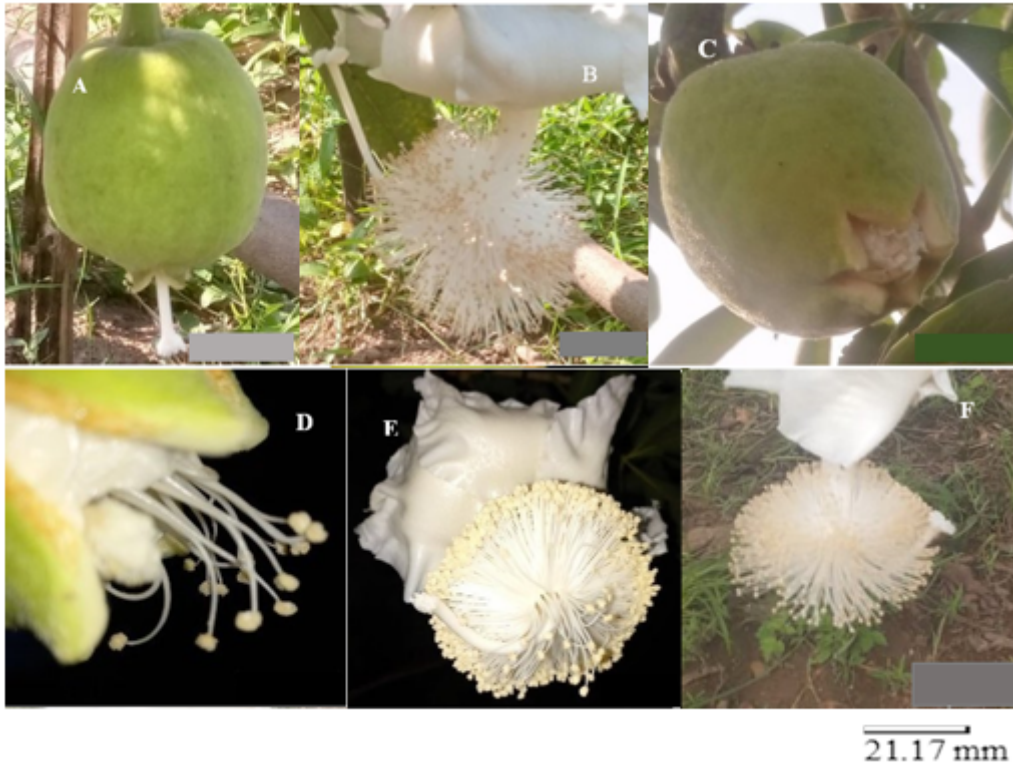


Figure 1

Dichogamous and preanthesis cleistogamous flower opening in baobab

[Dichogamous (Stigma emerged following the breaking of the calyx at the apex in "A" before the eventual splitting of the entire perianth "B", for anther emergence. Preanthesis cleistogamy (calyx split in "C", and some anthers emerged in "D", however, stigma remained within the perianth and with interference with pollen and was only exposed after full opening of flowers shown in "E" and "F". Breaking of calyx to full opening of perianth takes about four hours.)]