Sex organs of baobab flowers solve puzzle of trees that bear more fruit

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Researchers crack the conundrum about why African Baobab trees in southern Africa differ in terms of fruit production. Credit: Sarah Venter

Baobabs are the mainstay of rural communities in some parts of

Africa—they provide food in the form of leaves that are cooked like spinach, and large oval fruit which are rich in vitamin C. Oils are extracted from the crushed seeds (used in the cosmetic industry), and bark may be used for making rope.

Recently the trees have provided a source of income as local people collect the fruits and sell them to companies that extract the white fruit powder for the food industry and crush the seeds for their oils.

In southern Africa, some baobab trees are known for consistently producing large amounts of fruit, while others produce only a few fruits every year, despite flowering profusely. These trees are sometimes referred to as "female" and "male," respectively, by local people.

The reason for this discrepancy in fruit production has puzzled scientists for many years. For example, scientists have looked at whether soil types affect fruit production. One study in the Vhembe district located at the north-western tip of South Africa failed to find a link to land use or soil type . But another in Benin, West Africa found that there was a link to soil type and productivity. But even this didn't fully explain why some trees produced so much more fruit than others in the region.

We looked at aspects of the trees' reproduction for clues to explain the discrepancy in fruit production. We asked the question: do trees with different fruit production levels have different floral features? African baobabs (*Adansonia digitata*) are hermaphrodites; flowers have both male and female reproductive organs within the same flower. Most plants are hermaphrodite so this isn't uncommon.

Our study found that the flowers of trees that produce more fruit had better developed female reproductive organs. And that the trees that did not produce many fruit had flowers with more prominent male parts.

This has ecological and economic implications. Both types of trees should be protected in the wild or cultivated for the survival of baobab populations and for long-term sustainable harvest of the fruit.

Flowers are bisexual, but biased

Even though baobabs are hermaphrodites, the sex organs fulfil different roles.

The male stamens manufacture the yellow pollen that produces the sperm (male sex cell). The pollen must be transferred to the female stigma (of a flower on another tree) so that it can deliver the sperm to the egg cell in the ovule.

The pollen grows a tube down to the ovule in the ovary in order to do so. After fertilisation, the ovule forms a seed and the ovary develops into a fruit. So each flower may produce a single fruit with many seeds if fertilisation is successful.

Our study shows that while all baobab flowers possess both male and female parts, the flowers of good fruit producers and poor fruit producers differ markedly in the size and functionality of their male and female sex organs. This means that some trees are taking on a male role (pollen production), while others are performing the female function (seed production).

The "male" trees (poor producers) have much larger stamen balls (with anthers that produce pollen) than "female" trees (producers), which in turn have larger stigmas to receive the pollen on their greater surface area. In addition, the stigmas of "female" trees are more receptive to pollen grains than those of "male" trees.

The stamens of the "male" trees therefore produce much more pollen

than the "female" trees. And their pollen is more viable, meaning it's more likely to germinate and grow a tube to deliver sperm to fertilise the egg—which then forms the seed. When mature and released from the fruit, the seed may germinate to produce a seedling that could grow into a new baobab tree.

It is important to note that most baobabs are self-incompatible, meaning they don't fertilise themselves even though they have both male and female parts in their flowers. Therefore, they cannot produce fruit without pollen from another tree. Pollinators are needed to perform this task.

The baobab's large, pendulous white flowers open at night, and must be pollinated by the next morning if they are to produce fruit. They rotate their stigma during the night to avoid depositing their own pollen on the stigma within the same flower. During the night, they attract pollinators with nectar and scent to pick up the pollen from one flower and deposit it onto the stigma of another flower (preferably on another tree).

In southern Africa, the main pollinators are insects, especially hawk moths—unlike other parts of Africa, where bats are the pollinating agents. These pollinators may deposit self-pollen on flowers of the same tree, but it is important that they pollinate flowers on another tree to ensure fruit production.

Baobabs taking on a male or female role

It appears from our study that individual baobab trees are investing resources predominantly in either male or female sex organs. Though they are still bisexual, they are effectively moving towards one sex or the other. Both kinds of trees are needed for continued health of the baobab populations. Without the pollen to provide the sperm and the ovule to provide the egg, no seeds or fruits will form.

The importance of protecting both types of tree, against elephant damage for example, needs to be communicated to the conservationists in southern Africa (and other parts of Africa) where the trees are recognised as "male" or "female." Similarly, for future cultivation of trees in areas where populations have been reduced, it would be important to ensure that both types of tree are present.

We are following up with a study to investigate the pattern of pollen dispersal and contribution to seed formation. This will tell us which trees are most important in "fathering" the next generation and whether our interpretation of the roles of "male" and "female" trees is correct.

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