Exploring morphovariations in bael (*Aegle marmelos*)

A K Singh*, Sanjay Singh and P L Saroj

Central Horticultural Experiment Station (ICAR-CIAH),
Godhra, Panchmahals, Gujarat

Received: January 2017; Revised: May 2018

ABSTRACT

Bael (*Aegle marmelos* Correa), an indigenous tree having wide genetic diversity, is found growing in different parts except at high altitude and in cold region of the country. Most of the woody plants produce flowers and fruits on new growth or on young leafy shoots, but a few plants bear fruits on main stems, primary and secondary woody branches. This phenomenon is known as cauliflory. Such flowering and fruiting are also observed in bael germplasm established at field gene bank at CHES, Godhra. It has been noticed that bael produce flowering and fruiting on main stems and primary, secondary, tertiary, fourth and fifth branches, and even on previous and current season’s growth of shoots. Simultaneously, it has also been also observed that fruits may appear on first, second, third, fourth, fifth, sixth, seventh and eighth year growing woody stems of bael tree under semi-arid conditions in western India. Therefore, bael is a cauliflorus and ramiflorus tree, such type of flowering and fruiting are found in bael, but it is common in bael variety, Goma Yashi and NB-16. Vivipary is of unusual occurrence in bael. Generally, such fruits are not good in taste. If cut exposed, germinated seeds inside the fruits are visible very clearly. High humidity and warm weathers appear to be associated with viviparous fruits in bael. The pollen-grains of bael are found to exert a direct effect on size, shape and styler end cavity of fruits, seeds and speed of development of fruits and on time of ripening of fruits of asexually propagated bael plant. Such effect on fruits may be due to metaxenia effect in bael. Variations in number of petals and sepals, number of leaflets and thorns are also observed.

**KEY WORDS:** Morphovariations, Cauliflory, Flowering, Metaxenia, Vivipary, Ramiflorus

---

Bael (*Aegle marmelos* Correa), an important indigenous fruit of India, is known since ancient times. It is found growing in Nepal, Sri Lanka, Malaysia, Pakistan, Bangladesh, Myanmar, Thailand and most of the South-East Asian countries. Because of its status as sacred tree, it is also grown in north Malaya, dry area of Java and to a limited extent in northern Luzol of Philippines and gardens of Egypt, Surinam and Thailand. It is distributed throughout the country, but concentrated area under bael is in eastern parts of Gangetic plains and nearby areas, particularly in Uttar Pradesh, Bihar, Madhya Pradesh, Chhattisgarh and Jharkhand, and it can also be seen growing in West Bengal, Punjab and Odisha. In Gujarat, bael trees are found growing naturally in the forest with great diversity.

Most of the genotypes available in forest areas of Gujarat having small-sized fruits, but plants growing in temple promise or in courtyard of house having big size fruits were brought by travelers, saints, pilgrims from north India (Singh et al., 2014). In India, bael is being grown throughout the country and is also known by other vernacular names (John and Stevenson, 1979). Om Prakash (1961) found bael in Yajur Veda and also observed that in early Buddhist and Jain literature (c 800 B.C. - C 325 B.C.). In the ‘Ramayana’ period, bael fruit was known and its trees were reported to be growing in ‘Chitrakuta’ hills and ‘Panchvati’.

In the ‘Upavana Vinod’ a Sanskrit treatise on silviculture (Majumdar, 1935) and in ‘Brihat Samhita’ mention had been made of bael fruit, and as the legend goes, in the forest, the Lord Rama performed religious rites by offering various fruits including bael (Aiyer, 1956). Bael fruit has been portrayed in painting of Ajanta Caves along with other fruits (Om Prakash, 1961).
MORTHOVARIATIONS IN BAEI

Cauliflory

Most woody flowering plants produce inflorescences on new growth and or young leafy shoots. A few, however, flower and fruit directly on their trunks or main branches. This phenomenon is known as cauliflory (from the latin words 'stem' and 'flower'), and plants themselves are considered cauliflorous. Many fruits are most interesting examples of cauliflory in fig (F. auriculata), jackfruit (Artocarpus heterophyllus), papaya (Carica papaya), cacao (Theobroma cacao) and loquat (Eriobotrya japonica) grown in India commercially, whereas brazilian grape trees (Plinia cauliflora), cannonball tree (Couroupita guianensis) growing in tropical forest (Armstrong, 1998).

In contrast, no instance of this phenomenon has ever been described in bael. At CHES, Godhra, 190 germplasm have been established in field repository which were characterized for various horticultural traits. The flowers and fruits appeared on trunk, primary, secondary tertiary, fourth, fifth and sixth branches, and first, second, third, fourth, fifth, sixth, seventh and eighth year growth of growing shoots (Fig. 1). Bael is an ideal cauliflorous example of fruit tree. Similar results have been reported by Ullah and Haque (2008) in jackfruit. Generally, cauliflorous blossoms are sturdy and well attached and can withstand in aberrant conditions. The adaptive significance of cauliflory is mainly associated with cross pollination.

Metaxenia

Metaxenia is the effect of pollen-grains on fruit shape and other fruit characters. Metaxenia may able to be used to identify best pollinizer parents to decrease fruit development period and increase yield in mixed cultivar planting. This direct effect of pollen-grains on parts of fruit lying outside the embryo and endosperm is called metaxenia. The simplest and most probable theory to explain metaxenia is that embryo or endosperm or both of them secrete hormones, or soluble substances analogous to them. Probably, no instance of this phenomenon has ever been described in bael earlier. The source of pollen exert a direct effect on size, shape and styler end cavity of fruits, seeds and speed of development, and on time of ripening of fruits (Fig. 3)
This direct effect of male parent on development of fruit is precise and definite and varies with a particular male to fecundate female flowers which diffuse out into tissues of mother plant that constitute seed and fruit, exerting a specific effect on these tissues varying according to a particular male parent used to fecundate embryo and endosperm (metaxenia). The effect of pollen source on fruit development has been reported in several species of different families, including date palm (Swingle, 1928), raspberry (Colbert and de Oliveria, 1990), blueberries (Gupton and Spiers, 1994), pomegranate (Purohit, 1987) and cherimoya (Khan et al., 1994). However, effect of pollen source on sugar accumulation should be carefully examined since pollen source might affect taste qualities of fruit. These results are similar to those reported for dates, cherimoya, grapes and mandarins, in which the source of pollen had an effect on maternal tissue characteristics (Denney, 1992; Wallace and Lee, 1999).

Bael is a cross-pollinated crop. At the time of flowering (May-June), large number of honey bees; beetles, house flies, ants and different kinds of butterflies less in number arrive and start visiting the flowers for foraging purpose (6 AM to 1.0 PM), and they directly enter on central portion of flowers whether it is completely opened or just started to open due to which large number of pollens stick to their abdomen and legs (Fig. 4). Effective pollination occurred through honeybees followed by butterflies. Honeybees have been recognized as ultimate and legitimate pollinators in bael (Singh et al., 2014).

Vivipary

In vivipary, germination of seed takes place inside the fruits while still attached to the mother plant. Viviary is noticed naturally in some species of mangrove like Rhizophora mangle, R. Mucronata, Bruguiera gymnorrhiza,
Kandelia candel, K. canel, Ceriops decandra (all belong to Rhizophoraceae) in which it is considered as an aid to adaptation in wet ecosystem where germinated seeds after falling in mud establish itself and grow as a plant (NHB, 2012). It is very often noticed in Avicennia sp (Verbenaceae); Aegialitis rotundifolia (Plumbaginaceae); Aegiceras majus (Myrsinaceae); Cocos nucifera (Areaceae); Cucumis melo, Sechium edule (both Cucurbitaceae plants); Oryza sativa, Triticum aestivum, Zea mays (Graminae) etc. For most plant species, vivipary is considered undesirable. This holds especially true in cultivated types which are grown mainly for their edible fruits.

Bael fruits as usually remain free from viviparous seeds. Till now, no instance of this phenomenon has ever been described in bael. In contrary, while cutting the fruits for study, an unusual occurrence of vivipary was observed in one of the bael germplasm. The fruit was having a weight of 650 g, its pulp was yellow in colour and was slightly insipid in taste. The cavity formed in fruit pulp were full of amber or honey coloured viscous very sticky or glutinous (mucilage), translucent pulp, which is slightly sweet and feebly aromatic. As appeared physically, it was tree ripen fruits harvested from field gene bank at CHES, Godhra, during 2015. The seeds manifest light yellow coloured radical embedded in mucilage of locule cavity (Fig. 5. a, b and c). Vivipary is considered genetic mutation but its manifestation can be modified by the environment (Stoutmeyer, 1960). Increased precious germination has been reported in susceptible species during wet season (Allard, 1999). The genetics of viviparous mutant has been studied in corn and it has been reported to be associated with nine genes (Libby and Router, 1984). Reduced production or insensitivity of fruit to abscisic acid has also been marked as a feature of vivipary (Hartmann et al. 2002). High humidity might play inciting role in expression of vivipary in papaya (Singh, 2013).

Morphological diversity

All varieties of bael showed considerable morphological variation with respect to shape, margin, base and apex of leaf (Singh et al., 2015). Leaves alternate, compound, trifoliate with one pair of shortly stalked opposite showing pulvinus leaflet, ovate or ovate lanceolate, crenate, acuminate and membranous, and midrib prominent beneath which is common in bael. It has also been observed that in place of thee leaflets (trifoliate), in very few leaves, 4-8 leaflets are also found rarely in bael plant emerged directly from root sucker of bael germplasm (Fig. 6). Quantification of total leaflet number is different in different leaves arose from root sucker of single plant of bael. Nicotra et al. (2011) reported that different leaf shapes can be found in association with variation in other leaf traits due to different climatic factors.

Variation in thorn

Bael tree armed with straight, sharp, axillary thorns, 2-5 cm long. Considerable variation in thorn, its number, size, shape is found in different different genotypes (Fig. 7). In some of the genotypes, thorn is small and stout, whereas in few genotypes, three thorns can be joined together and spread outward. In some others, thorn is large and slender, whereas in a few genotypes, the thorn is distinctly smaller and shorter. A few genotypes were observed to be thornless, whereas in the others, thorns are absent only at the terminal end of the shoot.

Fig. 5. Transverse section showing viviparous seed, b: vivipery in extracted seed and c. vivipary in individual seed

Fig. 6. Variations in leaf morphology

Fig. 7. Variations in thorn.
seen at a node. It can also be observed that the leaf convert into spine in pair in very few genotypes. Generally, two thorns at a node are common. Goma Yashi is thornless under rainfed dryland conditions of western India (Singh et al., 2012). In some of the genotypes, thorn may be seen in primary branches, but not at secondary or tertiary branches under dry land condition. However, it may vary in different agro-climatic conditions (Nicotra et al., 2011).

**Variation in flower organs**

Bisexual flowers are born in clusters and they are greenish white, axillary or terminal cymes. The calyx is shallow with 4 or 5 short sepals (tetrameros and pentameros), broad teeth, pubescent outside. Petals are oblong oval, 4 or 5 are common (Fig. 9) and 6 or 7 rarely observed in flower (Fig. 8) and pale greenish white in colour. Stamens are numerous, hypogynous with short filaments. Flower bud emergence, flowering duration, time of anthesis, dehiscence of anther, stigma receptivity and pollen viability vary according to variety and locality (Singhal et al., 2011 and Singh et al. 2014 a

**REFERENCES**


Majumdar C P. 1935. Upvana-Vinoda (A sanskrit literature on arbore-horticulture) Published by The Indian Research Institute, Calcutta.


Swingle W T. 1928. Metaxenia in the date palm, possibly a hormone action by the embryo or endosperm. *Journal of Heredity* 19: 257-68.
