

New bael varieties for dryland

Three new abiotic stress tolerant varieties (Thar Srishti, Thar Prakriti and Thar Shivangi) of bael have been developed by Central Horticultural Experiment Station (ICAR-CIAH), Godhra, Gujarat. These varieties perform well in abiotic stress conditions, and have been identified at institute level for specific traits like Thar Srishti for highly centric locule arrangement, Thar Prakriti for high fibre and papery shell (1.4 cm) and Thar Shivangi for high antioxidant activity having drooping branches. Economic yield from full grown tree can be obtained up to 400 mm rainfall under rainfed hot semi-arid conditions of western India. These varieties were evaluated purely under hot rainfed semi-arid conditions and have been recommended for commercial cultivation under dryland areas of country.

BAEL (*Aegle marmelos* Correa) is an important indigenous medicinal fruit of India and known since ancient times. In India, bael is being grown throughout the country and is known by other vernacular names like *bael*, *bela*, *bili*, *bilva*, *belo*, *maredu*, *vikram*, *sripthal*, golden apple, Indian quince and Bengal quince. It is found growing in sub-tropical, tropical, arid and semi-arid regions of the country. It is a nutritious and medicinal fruit plant, which is most suitable to grow in water scarce areas of the country. All parts of the tree, whether stem, bark, root, leaves, flower and fruit at different maturity stages has some use or the other. It is used in the preparation of several, *Ayurvedic* medicines since ancient times. Keeping above facts in view, a large number of genotypes (215) have been collected and established through *in-situ* patch budding in the field gene bank of station. After thorough evaluation, these varieties were developed for specific traits.

STRIKING FEATURES

Thar Srishti

Bael variety 'Thar Srishti' was identified and released in 2020 by ICAR-CIAH, Regional Satation, CHES, Godhra, Gujarat. It is first variety with highly centric seed cavity (locule arrangement) with attractive pulp and appealing ripened fruit colour having no off flavour. Its average yield/tree during 9th year (91.50 kg), fruit weight (1.55 kg), fruit size (21.00 × 14.00 cm), fruit girth (43.53 cm), shell thickness (0.20 cm), number of locules in cross section (14.00), peel weight (200.00 g), pulp weight (1.20 kg), fibre weight (62.32 g), total seed weight (19.00 g), total number of seed/fruit (98.15), TSS of pulp (36.75°brix), TSS of mucilage (51.50°brix), total sugar (21.40%), acidity (0.35%) and TSS/acidity ratio(128.33) were recorded under rainfed semi-arid conditions of western India. It belongs to mid maturity group (April),

its fruit attain maximum size up to 20th October. Its fruits are comparatively less affected (18.13%) by sunscald due to dense canopy, and lustrous and luxuriant growth with peculiar leaves. Colour of pulp is deep yellow after ripening and emits very less aroma. Fully mature fruits can be kept for 12-18 days and ripened ones for 7-9 days under ambient condition.

The locules embedded with seeds and mucilage, adhere in centre, rich in fine fibres and sacs along with seeds and mucilage can easily scooped out by spoon and can be consumed fresh. It can be used as desert as well as for processing purpose.

Thar Prakriti

Based on desirable horticultural traits, it has been identified promising genotype, collected from Anand, Gujarat in 2010. Average yield/plant is 115.75 kg in 12th year, fruit weight 1.40 kg, fruit size 14.05 cm × 15.10 cm, fruit girth 44.10 cm, shell thickness 0.14 cm, total number of seed 60.23, seed weight 0.20 g, total seed weight 17.40 g, fibre weight 28.42 g, shell weight 190.60 g, locules in cross section 14-17, TSS (pulp) 38.00°B, TSS (mucilage) 51.00°B, acidity (0.33%) and vitamin C 22.50 mg/100 g pulp were recorded. The fruits of this variety are having good flavour and aroma, and rich in antioxidants. It is highly suitable for sharbat, *murabba* and powder making and various ayurvedic medicines. Time taken from fruit setting to ripening is 315 days; fruits are round in shape with peculiar styler end cavity. It belongs to late maturity group (1st week of May) having uniform and peculiar roundish fruit shape and size. Distinct character of the variety is papery shell, very less seed, rich in fibre content and peculiar styler end cavity.

Thar Shivangi

Average yield/plant is 109.15 kg in 11th year, fruit weight 1.35 kg, fruit size 15.50 cm × 12.87 cm, fruit girth

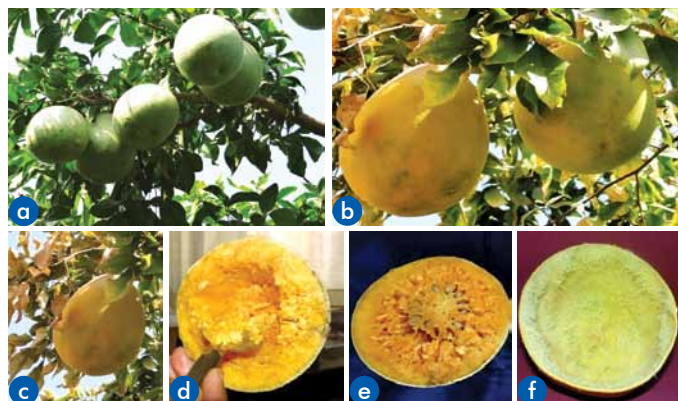


Figure 1: Different views of Thar Srishti (a) branches laden with uniform fruit shape and size, (b&c) ripened fruit colour, (d) section of scoped mucilage and seed, (e) Transverse section of fruit showing highly centric locule arrangement and (f) section of fruit exhibiting fine fibre content

44.80 cm, shell thickness 1.9 mm, total number of seed 75.32, total seed weight 32.00 g, fibre weight 35.00 g, shell weight 190.21 g, locules in cross section 15.50, pulp 70.50%, TSS (pulp) 37.10°B, TSS (mucilage) 50.50°B, acidity (0.35%) and vitamin C 20.40 mg/100 g pulp were recorded. Luxuriant growth, peculiar leaf shape, drooping branches, curved petals and high phenolic content are the distinct traits of this variety. Being small in stature, it is highly suitable for high density planting (5m×5m).

PRODUCTION TECHNOLOGY

Propagation

Usually, seedlings of 1 year old are used as rootstocks for budding. *In-situ* patch budding by using 1 month's old scion during May and June before onset of monsoon gives >95% success while softwood grafting provides >85% success, whereas for softwood patch budding >85% success seeds sown in polythene bags in the first week of March can be used as rootstock for budding at the end of May-June before onset of rain, gives more than 75% success under rainfed conditions of semi-arid ecosystem.

Planting

Under rainfed hot semi-arid conditions, planting

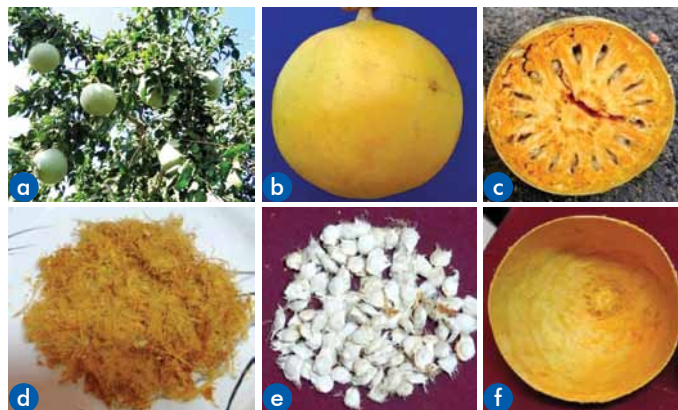


Figure 2: Thar Prakriti (a) Branches laden with uniform fruit shape and size, (b) ripened fruit colour, (c) transverse section of fruit, (d) fibre content, (e) very less seeds in fruit and (f) empty papery shell

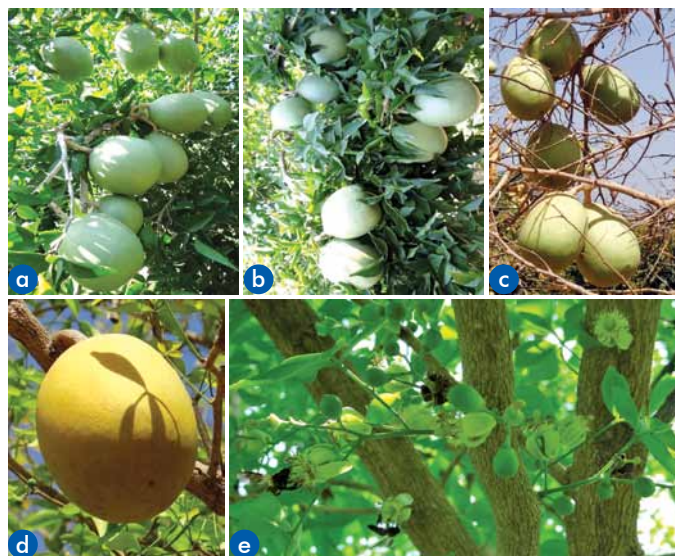


Figure 3: Thar Shivangi (a,b & c) drooping branches laden with fruits, (d) ripened fruit on tree and (e) cauliflorous flowering behaviour with curved petals

should be done just after first rain so that plant could establish during rainy season for better survival during stress condition. The planting distance for Thar Srishti, Thar Prakriti and Thar Shivangi should be maintained at distance of 7 m × 7 m, 8 m × 6 m and 6 m × 6 m respectively under dryland conditions. The pits of 1m × 1m × 1m are dug and are filled with 50:50 FYM and top soil mixture and it is also advisable to mix 125 g SSP and 150 g neem cake. Drenching of pit with Tafaban (chlorpyrifos) @1-2ml/l is effective to avoid the termite attack during initial years.

Nutrient management

Farm yard manure (10 kg) and fertilizers (50 g nitrogen, 25 g phosphorus and 50 g potassium) are applied in two split doses/year/plant, and this dose should be increased in same proportion up to the 10 years age for its better growth and development of plant. FYM plus half dose of nitrogen and potassium and full dose of phosphorus should be applied just after first rain while remaining doses should be applied in the last week of August under rainfed conditions. Micronutrients should be applied after 3rd year of planting.

Canopy architecture

Canopy architecture is an essential aspect for moderating the canopy temperature and aeration and also protects fruits from sun scald, a burning problem in hot semi-arid region of the country. Desired shape and size of the plants can be managed through skilful canopy architecture. It is better to train the plant in modified



Figure 4: Softwood patch budding

Figure 4: Scion shoots (20-25 days old)

leader system and it should be completed in initial 3-4 years followed by the shoots are further pruned at 25% of its annual growth alternate year during leafless condition of the plant for better flowering and fruiting.

Mulching

Under dryland conditions, application of organic mulch in tree basin imparts manifold beneficial effects for successful cultivation of bael particularly in dryland conditions. Mulching can be done with any suitable locally available organic material like paddy straw, maize straw, grasses, husk etc. to develop congenial micro-climate for proper growth and development of plant. Leaf litter management of bael under the canopy is not only an effective mulch to retain soil moisture during summer but also improve the soil health.

Diseases management

Bael tree is not affected by serious diseases. However, leaf spots, powdery mildew, shot hole and fruit canker, fruit rot, *Fusarium* rot and stalk end rot have been reported from different parts of country.

Canker is caused by *Xanthomonas bilvae* and the pathogen causes infection on fruits, twigs and thorns. Spraying once or twice with streptomycin sulphate 250 ppm or Bordeaux mixture 1% at 12-15 days interval effectively control the disease.

During summer months i.e. May-June, a severe post-harvest rot caused by *Aspergillus awamori* Nakazawa is also observed. The disease is somewhat serious during storage period of fruits. Pre harvest spray of Carbendazim (0.05%) and avoiding bruises to the pericarp during picking, storage and transport are suggested to manage the disease.

Stalk end rot of *bael* is caused by *Fusarium solani* (Mart.) Sacc. Dropping of immature young fruits is the main symptom of this disease. For effective control of the disease, two sprays of Thiophanate methyl Benomyl (0.1%) at fortnightly interval are recommended to manage the disease.

Shell soft rot caused by *Syncephalastrum racemosum* is observed on mature, harvested fruits. The fruits may be dipped after harvest in hot water at $52\pm1^{\circ}\text{C}$ and then shade dried or dipped into 0.05% Thiophanate Methyl for 2 minutes and dried in shade. Tender shoots are also found infected with the powdery mildew. The disease is caused by *Oidium* sp. Spray with Carbendazim 50 w p (Bavistin 0.1%) or wettable sulphur (0.2%) is found to be useful.

Gummosis is common in bael orchards. To manage the disease, it is suggested to scrap off the infected portion

of bark with the help of a sharp knife, which should be followed by application of Bordeaux paste. Spray with copper fungicides (Bordeaux mixture 1% or copper oxychloride (0.3%)) is also suggested at monthly intervals during and after the rainy season. Removal of highly infected twigs and incorporation of *Trichoderma viridae* propagules in the soil of rhizosphere of bael were found helpful to control the disease.



Gummosis in branches

Pest management

Lemon butterflies, the caterpillars feed on foliage and cause economic loss. Other insect-pests like *Citrus* leaf miner (*Phyllocnistis citrella* Stainton), Spiralling Whitefly (*Aleurodicus dispersus* Russel) and brown scale are of minor importance, as these are either sporadic in occurrence or confined to certain pockets. In case of severe infestation, spray with Quinalphos or 0.05% Chlorpyrifos or Phosalone is recommended. Spraying the entomogenous fungus, *Bacillus thuringiensis* Berliner or nematode DD-136 strain also gives very high mortality of the caterpillars. Installation of yellow sticky traps @ 20/ha to attract adults and fish oil resin soap 40 ml/lit in the early morning hours. Predators *Axinoschymnus puttardria* and Parasites, *Encarsia haitensis* proved highly effective against spiraling white fly. Scale insect can be controlled by spraying of Diomethoate (0.05%) or Imidachlorpid (0.5 ml/l) at fortnightly interval. It is first report of infestation on bael by scale insect under dryland condition.



Lemon butterfly

Physiological disorders

Fruit drop is a natural phenomenon, but the extent of damage is a matter of concern. Immature fruit drop (marble size) has also been observed. Sometimes cricket ball sized fruits also fall down during August and mature fruits in January-February in northern India. The extent of fruit drop in bael can be reduced effectively by adopting better orchard practices which include mulching with organic materials and proper soil nutrient management (macro-micro) and application of growth hormones like NAA (15-20 ppm/litre) at pea size stage during August-September. Fruit drop and fruit cracking can be minimized by spraying borax 0.1% or by soil application of 100 kg Farm Yard Manure/tree as the basal dose in monsoon.

Sun scald is manifested by turning of normal green shell into dark brown at the fruit surface where it is exposed to the hot sun for maximum period during day hours. Sometimes, the pulps of fruit beneath the shell also get affected due to moisture loss and irradiation.



Microscopic view of fruit rot by *Aspergillus nidulans*



Powdery mildew affected leaves



Packaging in gunny bags



Packaging in CFB boxes

The main reasons of sun scald may be ascribed to intense solar radiation affecting the shell for long time during the day coupled with unavailability of sufficient soil moisture and the temperature of sun scalded portion is increased by 8-10°C as compare to unexposed portion of the fruit. Mulching along with fruit covering with foam net followed by cotton cloth bags and canopy management are useful in reducing this disorder up to some extent.

Harvesting and post-harvest management

Mature bael fruits are harvested individually from the tree along with the portion of fruit stalk (2-3 cm) to avoid infection and it also helps to judge the ripening. The stalk is easily separated while pressing the fully ripened fruit which is indication of ripening. Proper care is required for harvesting of bael fruits. Harvesting by shaking of trees should be discouraged, as the fruits are likely to develop cracks on impact as the peel of fruit is highly brittle which invites infection and can cause heavy loss during storage. To prevent fruit from falling on ground, fruit picker can be used for harvesting.

Grading is very important to avoid spoilage loss during storage and also to fetch better price in the market. Bael fruits are likely to get damaged during harvesting due to improper care at the time of harvesting. Injured fruits are sorted out and healthy one are graded. Bael fruits have different shape and size; hence, they should be graded accordingly. At present, the fruits are packed in gunny bags, baskets or wooden crates and sometimes they are transported without any packing. It is highly essential that some cushioning material namely, straw paper, saw dust, news paper liner etc. should be used while packing bael fruits. The fruit should not develop any crack or damage during packing, transportation, marketing and storage; otherwise, it may cause spoilage by fungal infection.

Value added products

Bael fruit is not popular as dessert fruit due to its hard shell, mucilaginous texture and numerous seed and fibre content. However, in recent time, it is becoming popular due to its medicinal value and refreshing nature. The preserve made from mature fruits is a most common

processed bael product, while from the ripe fruit a popular drink *Sharbat* during summer. Besides these, a number of value added products such as squash, pickle, RTS, syrup, jam, jelly fruit slab, toffee, powder *etc.* are prepared from bael fruit. Possibility of blending bael with other fruit for making beverages.

Economics

Bael is a highly suitable crop for irrigated arid and semi-arid regions. From the plantation of these varieties, 200 to 240 q fruits/ha can be harvested. Net income of ₹ 1.40-2.00 lakhs by selling @ Rs 15/kg can be earned under semi-arid conditions. However, under high density planting, 5 m x 5 m, accommodating 400 plants/ha approximately ₹ 2.00 to 2.50 lakhs can be earned from full grown tree under rainfed semi-arid conditions of western India.

SUMMARY

Thar Srishti can be used as table purpose owing to highly centric locule (seed cavity) arrangement and ideally suitable for powder making owing to richness in fibre content whereas, Thar Prakriti and Thar Shivangi can be used for various processed products and ayurvedic formulations owing to high antioxidant values and richness in bioactive compounds. We are recommending to the farmers to grow all the varieties developed by the Station, viz. Goma Yashi, Thar Divya, Thar Neelkanth and newly released Thar Srishti, Thar Prakrati and Thar Shivangi, so that fruits can be made available in the market right from January to July. These varieties are gaining popularity among the farmers of country in general and fruit growers of dryland areas in particular, because of higher yield with quality fruits having specific traits, and better adaptability under aberrant agro-climatic conditions of the country. Planting materials of these varieties are available at Station during monsoon.

For further interaction, please write to:

Dr A. K. Singh (Principal Scientist & I/c Head), Central Horticultural Experiment Station (ICAR-CIAH), Vejalpur-389340, Panchmahals, Gujarat. Email: aksbicar@gmail.com