

Shrinking in bael: A new malady in subtropical region of India

Bael (*Aegle marmelos* Correa), a wonder tree, is one of the important lesser utilized fruit crops grown mainly in semi-arid region. Being hardy in nature, it looks immune to insect, pests/or diseases but in reality suffered with various diseases, viz. gummosis, fruit rot, anthracnose, leaf spots and pests like lemon butterfly, leaf miner and termites. Further, physiological disorder also came into picture like fruit cracking, fruit drop and sun scalding. Physiological disorder negatively influenced the fruit texture and a significant yield loss was also reported. For managing them, some simple management tactics that keep away the pests/pathogens and alleviate the non-parasitic disorders, are recommended.

RECENTLY, a new emerging disorder, i.e. shrinking of bael (particularly in Narendra Bael-5) fruits have been recorded in subtropical regions of India which might be due to physiological imbalances viz., a combination of dry soil, poor supply of water and assimilates to the developing fruits via adjoining branch/dried twigs. Moreover, sunny days during February-March months may cause loss of water from the fruits. Shrinkage was much more closely related to leaf water potential and mostly it is reported in the drying twigs of the canopy as drying of twigs occurs after senescence of photosynthetically active leaves and simultaneously clogging of the xylem occurs which hinders water and mineral supply to the sink, i.e. developing fruits.

Bael, a tree with magnificent potential is a deciduous tree, having 6.0 to 10 m height with axillary thorns and trifoliate aromatic leaves. Further, the shape of the fruit is oblong and pyriform. Bael is native of India and its existence ranges from Indian Peninsula, in dry hilly places ascending (1,200 m) in the western Himalaya. Bael is found growing along the foothills of the Himalayas, Uttar Pradesh, Bihar, Chhattisgarh, Uttarakhand, Jharkhand, Madhya Pradesh, etc. Good sandy loam soil, sunny situation, and warm humid climate are suitable for the cultivation of this plant. At initial stages, the fruits are deep green in colour and gradually converted to light yellowish in colour at ripening. The fruits are harvested along with a portion of the fruiting stalk as it serves as a signal of ripening as it is easily detachable only in the ripe fruits. The fruits require about a year to ripen. Moreover, the average yield is 300-400 fruits/tree. Further, it was observed that larger and heavier the seed sacs, the greater the amount of mucilage and the poor fruit quality was observed. At maturity, the fruits should be harvested along with 1.0 cm stalk (stem end). Generally, bael fruits mature and ready for harvest from mid-April to May. It is well known fact that the bael is known for its nutritional and

nutraceutical value and due to anticancerous, antidiabetic, antimicrobial, anti-inflammatory, antipyretic, analgesic, cardioprotective, anti-spermatogenic, and radio-protective properties, it is also considered as medicinal plant.

Physiological condition of tree affected with shrinking

Large diversity exists among bael trees in India having higher yield potential and high nutritional value. The Narendra Bael (NB-5) is the most popular one as it is adorned with low mucilage, soft flesh with excellent taste. In recent years, ICAR-Central Institute for Subtropical



Normal/healthy twigs (left) and clogging of xylem in twigs of shrink fruits (right)

Table 1. Attributes of bael fruits in normal vs. shrunked fruits

Attribute	Shrunked fruits	Normal fruits
Appearance	Just like punctured football	Spherical/round in shape without any sunken surface
Segments after cut	Looks like star in shape with many grooves	Completely round with any ups and down in circle
Moisture percentage	Very low	Normal
Fruit yield (kg per tree)	40-50	50-60
Fruit weight (g)	620 g (smaller)	1230 g
TSS	Higher (35°B)	Low (18°B).
Mucilage content	Completely dry having zero stickiness in shrinks pulp	High mucilage content
Fruit maturity and development	Completely brittle and dropped from tree without attaining final maturity	Brittle free
No. of seed per fruit	10-12	12-15
Pulp weight (g)	312 (90.41)	764 g (130.8)
Peel weight (g)	241 (92.20)	386 (114.90)
Fruit drop (%)	80-90	20-25

Horticulture, Lucknow has developed CISH B-1 (mid-season maturity, weight up to 1.0 kg), and CISH B-2 (a dwarf variety with moderate spread and having 1.80-2.70 kg fruit weight, low fibre and seed content). The Central Horticultural Experiment Station, Godhra, Gujarat has developed the Goma Yashi (dwarf, spineless, prolific bearer with early maturity) and G B Pant University of Agriculture and Technology, Pantnagar, Uttarakhand has developed Pant Aparna (dwarf with drooping flowers, almost thornless, precocious, and heavy bearer), Pant Shivani (early bearer), Pant Sujata (medium dwarf with drooping and spreading foliage), and Pant Urvashi (mid-season precocious and heavy bearer).

While assessing the physiological parameters, branches affected with shrinking had low photosynthetic rate ($4.8 \mu \text{mol m}^{-2} \text{s}^{-1}$) and stomatal conductance ($214 \text{ m mol m}^{-2} \text{s}^{-1}$) than the healthy branches ($6.5 \mu \text{mol m}^{-2} \text{s}^{-1}$, $371 \text{ m mol m}^{-2} \text{s}^{-1}$). The water use efficiency (WUE: A/E) of affected twigs reduced by half, i.e. 0.7 against 1.50 in healthy branches. There might be high abscisic acid in the peduncle as it was observed that once the shrunked fruit is touched, it falls down.

Physiological disorders of bael

There are many physiological disorders (caused

by high or low temperature, poor moisture regime, unbalanced soil nutrients, inadequate or excess of certain soil minerals, extremes of soil pH, and poor drainage), viz. fruit cracking (occurs twice in a year; during December-January, when developing fruits are immature and during March-April when fruits are mature and in ripening phase, can be managed by maintaining optimum soil moisture regime through mulching and by creating wind breaks in the orchard); fruit drop (of course a natural phenomenon, but by using organic mulching and use of NAA (15-20 ppm/litre) at pea size stage during August-September, it can be reduced), sun scald (manifested by turning of normal green shell into dark brown which may be ascribed to intense solar radiation affecting the shell for long time during the day coupled with unavailability of sufficient soil moisture). The temperature of sun scalded portion is increased by $8-10^{\circ}\text{C}$ as compare to unexposed portion. This malady reduces the market price of the fruit even though the pulp of fruit is not much affected below the scorched shell. Mulching and canopy management are useful to reduce down this disorder up to some extent. These disorders in bael are now creating havoc for quality fruit production in the current era of climate change. However, these are being managed by application of borax @ 0.1% twice, i.e. at full bloom and after fruit



Shrink fruit vs. normal fruit on same tree
(Bael cv. NB-5)



Shape of shrunked fruits in bael cv. NB-5

Table 2. Eight weeks weather data during shrinkage of fruits of bael cv. NB-5

Weeks during January-February	Temperature (°C)		Humidity (%)		Sunshine (hour/day)	Wind speed (km/hr)	Evaporation in 24 hr (mm)
	Max.	Min.	Max.	Min.			
1	15.42	5.92	84.71	62.14	2.57	1.77	4.62
2	15.25	4.33	83.50	63.00	2.96	1.26	4.78
3	20.78	3.92	82.28	63.00	6.56	1.96	4.94
4	24.04	9.36	81.71	64.14	5.10	1.84	5.30
5	24.75	7.31	82.75	64.25	7.76	2.55	5.33
6	27.31	7.75	82.00	65.87	8.94	2.97	6.26
7	29.71	10.15	84.43	64.57	7.33	1.46	6.25
8	30.38	9.52	83.17	63.95	8.15	2.03	5.88

set or spray of NAA (20-30 ppm in subtropical region) besides maintenance of proper soil moisture regime near rhizosphere.

One more physiological disorder that recently appeared on bael fruit is its ‘Shrinking’ at the full developmental stage. The shrinking of bael is more severe in the case of the NB-5 variety in the Lucknow region, which is severely affecting the crop yield and appearance of the tree.

When shrinking of bael fruits appear?

The shrinking is observed in January-February months on fully mature fruits when the night temperature is low, i.e. < 11°C (Table 2.). In variety NB-5 (Narendra Bael-5), it was reported in more than 30% of trees. The incidence was also observed in some other varieties but its intensity is <10% of trees planted. Sometimes diseased fruits shrink due to late infection, become black, light in weight, mummified, and remain hanging with stalks for

a longer period.

Possible reasons of shrinkage of fruits

The possible reason for this new emerging problem is the non-availability of assimilated supply, and water shortage to the fruit-bearing branch which may be attributed to clogging of xylem, as this problem was emerged mainly in that branch which faced cold stress or frost affected twigs. The leaves and twigs become dry and show senescence completely after cessation of winter. The expansion and contraction of fruits appeared to be a function of the degree of water deficit in the fruits in different atmospheric conditions. The night temperature was hovering around 3.92-10.15°C with clear sky during January-February could be another reason for frost damage in the tree and shrinkage of fruits (Table 2).

Thus, this malady needs to be addressed as NB-5 is the most popular variety of bael in northern India and orchardists are losing considerable price, they could fetch. A breeding program could be initiated for this variety to improve Narendra Bael-5 having high yield potential and better qualitative characters and free from this disorders. The development of integrated crop management strategies for sustainable fruit production of bael and bael-based cropping systems/cropping models should be developed to provide income stability to the farmers who grow NB-5.



Normal vs. shrunk fruit after cut

For further interaction, please write to:

Dr Sanjay Kumar Singh, ICAR-Central Institute for Subtropical Horticulture, Rehmankhara, Lucknow, Uttar Pradesh 226 101.

*Corresponding author: sanjay.singh3@icar.gov.in

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Krishi Anusandhan Bhavan-I, Pusa, New Delhi 110 012

Telefax: 011-2584 3657; E-mail: bmicar@gmail.com