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Performance of bael (*Aegle marmelos* Corr.) cultivars under arid condition of Haryana

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Abstract

The study was conducted in the experimental orchard, Regional Research Station, Bawal. Bael varieties *viz.*, NB 5, NB 9, NB 17, CISH 1, CISH 2, NB 16, Pant Aparna and Pant Sujata were evaluated for growth, yield, pulp/seed characteristics and quality parameters and recorded significant variation. Among the growth parameters CISH 2 showed dwarfing plant as compared to other cultivars. Fruit drop, fruit cracking and fruit weight were observed less in NB 5, however, number of fruits and yield were recorded highest in NB 17. Number of seed sacks and seeds per fruit were lowest in NB 16. Test weight and seed weight per fruit were highest in NB 5. TSS was recorded highest in NB 1, ascorbic acid and chlorophyll content was recorded highest in CISH 2, but acidity in Pant Sujata.

Key words: Arid conditions, *Aegle marmelos*, quality parameters, seed, yield attributes

Introduction

Bael *(Aegle marmelos* Corr.) is an indigenous fruit of India belongs to family Rutaceae. Plant of bael held sacred by Hindus and offered in prayers of deities Lord Shiva and Parvati and thus the tree is also known by the name Shivaduma (The Tree of Shiva). The bael plant has found mention in mythological treatise and Indian pharmacopoeia (Singh *et al.*, 2016). All the plant parts of bael like leaves, roots, barks, seeds and fruits are important ingredients of several traditional formulations against various diseases and many bioactive compounds have also been isolated from it (Badam *et al.*, 2002; Gupta and Tondon, 2004). Bael plants have wide range of adaptability to adverse soil and climate. The bael is found as a wild plant, in lower ranges of Himalayas up to an elevation of 500 meters. It is also found growing along foothills of Himalayas, Uttaranchal, Jharkhand, Madhya Pradesh and the Deccan Plateau and along the eastern coast (Sharma *et al.*, 2007). Bael is also cultivated in Nepal, Myanmar, Tibet, Vietnam, Laos, Cambodia, Sri Lanka, Bangladesh, Thailand, Indonesia, Malaysia, Java, Fiji, Surinam and Trinidad; some gardens of Egypt and to a limited extent on Northern Luzon of Philippine Islands. Under hot arid ecosystem the extent of hardiness has been observed and the plants are giving good yield in rainfed conditions (Singh *et al.*, 2017). Owing to its hardy nature, bael plant has a wide range of habitat flexibility to undesirable soil and climatic state even where other crops cannot endure well. However, well drained, sandy loam soils are found suitable for its growth, yield and better quality fruits.

A full grown budded bael tree of about 10-12 years old produces 100-150 fruits under good management practices, though the seedling trees produce 300-400 fruits of smaller size (Saroj *et al.*, 2004). However, fruit yield depends on age of the tree; cultivar besides management practices. Bael gene pool is stretch over different parts of the country and has colossal inconsistency with respect to qualitative as well as quantitative characters. Apart from the tree morphological characters, ample variability exists in fruit size and shape, bearing habit, flesh colour, texture, sugar content, mucilage content, number of seeds per fruit, gum locules and pericarp thickness (Misra *et al.*, 2000); ascorbic acid content, fruit weight, fruit length, number of seeds and their weight per fruit, fibre content, petiole length (Rai *et al.*, 2002); bark, leaves and fruits (Sharma and Dubey, 2013). Recently, few land races have been developed for commercial cultivation from NDUA&T, Faizabad; GBPUAT, Pantnagar; CIAH, Bikaner and CISH, Lucknow. In order to identify distinctive characters of various bael cultivars, the morphological characters are equally important to the fruit characters. In the absence of suitable genotype, desirable growth, flowering and fruit set has not been observed. Characterization and suitability genotypes for the region are necessary for promoting its productivity, production and quality of the fruits under arid conditions of Haryana. It will also help the orchardist in selection of appropriate cultivar(s) of this neglected crop for large scale cultivation to get high yield with good quality fruits. Unproductive/ barren land of this region could be utilized properly by growing such a hardy fruit crop, which holds promise for nutritional security and also helpful in curing the various ailments. The evaluation of cultivars is helpful for researcher to plan their experiment on the basis of

performance of different cultivars under these conditions.

Materials and Methods

The present study was conducted on uniformly grown bael plants in experimental orchard of Regional Research Station, Bawal. Experimental location has typical arid climate with hot dry summer and extremely cold winter. These plants were maintained under same agronomic/cultural operations. The growth parameters were observed at active growth stage of the plant. Plant height was measured from ground level to the tip of the highest shoot with the help of graduated measuring bar. Plant spread was measured as canopy width (average of east-west and north-south dimensions) during active growth period. Stem girth was measured at 15 cm above the graft union in grafted/budded plants. Chlorophyll content was analyzed from the fully grown leaf with the help of chlorophyll meter. The fruit set was calculated on the basis of total number of flowers on tagged branches. Dropped and cracked fruits were counted to calculate per cent drop/crack fruit on the basis fruits set on the tree. Fruits for yield and qualitative characters were collected at harvest maturity after complete litter fall. Randomly selected fruits from different direction of the tree were plucked and weighed on digital electric balance and these fruits were further used for qualitative analysis. The total soluble solids of fruit pulp was determined at room temperature with the help of Abbe's refractometer and the reading was expressed in °Brix. Ascorbic acid and acidity were analyzed by the method prescribed by A.O.A.C. (2000). Seed sacks were counted from horizontally broken fruit; thereafter number of seeds per sack was also counted. These collected seeds were dried in shade and weighed on digital electric balance for seed weight per fruit and test weight (ISTA, 2010). The pulp of horizontally broken fruit was scooped and shell thickness was measured with the help of digital vernier calliper, which was expressed in millimeters (mm). The statistical method described by Panse and Sukhatme (1985) was followed for analysis and interpretation of the experimental results.

Results and Discussion

Growth parameters

The results pertaining to variation in growth parameters such as plant height, stem girth and plant spread (NS & EW) in respect of various cultivars showed significant difference. Results revealed that the highest plant height (6.50 m) was recorded in NB 17; followed by NB 16 (5.83 m), whereas lowest plant height (3.80 m) was recorded in cv. CISH 2. Maximum trunk girth (63.90 cm) was recorded in cv. Pant Sujata; followed by NB 5 and NB 16 (62.90 cm), whereas minimum plant girth (32.50 cm) was recorded in CISH 2. Plant spread (EW) was highest in NB 17 (6.50 m). However, lowest plant spread EW (4.16 m) was recorded in CISH 2. Plant spread NS was highest in NB 17 (6.40 m). However, lowest plant spread NS (3.90 m) was observed in CISH 2 (Table 1). On the basis of the data, CISH 2 showed dwarfing. Jaiswal *et al.,* (1999) reported that Pant Sujata and Pant Aparna showed dwarf trees, while Pant Bael 3 and Pant Bael 1 showed tall and vigorous growth of trees. Singh *et al.* (2014) reported that variation in vegetative growth among the varieties may be due to inherent characters of individual varieties and their acclimatization to varied agro-climatic conditions. Bael gene pool is operated over different parts of the country and has enormous variability with respect to qualitative as well as quantitative characters (Nagar *et al.,* 2018). The dwarfing is the desirable characters for the high density planting by accommodating more plants per unit area and harvest more sunlight to enhance the productivity. Mishra *et al.* (1999) also reported that the different bael genotypes exhibited variations in their growth behaviour under moist conditions of eastern India. Pandey *et al.* (2013) carried a survey of bael germplasm in different areas of UP and reported variation in fruit circumference from 29.00 cm to 61.00 cm.

Yield attributes

The results pertaining to variation per cent fruit set, fruit drop, fruit cracking, number of fruits, fruit weight and fruit yield in respect of various cultivar varied significantly among different cultivars. The range of fruit set varied from 10.91 to 17.44 per cent. Fruit set per cent was recorded maximum (17.44%) in NB 17 which was statistically at par with CISH 1 (16.71%), while minimum fruit set per cent (10.91%) was observed in Pant Sujata (Table 2). Uniyal and Misra (2013) reported maximum fruit set in Pant Aparna and

Table 1. Growth parameters of bael cultivars under arid conditions of Haryana

Cultivars	Fruit set (%)	Fruit drop (%)	Fruit cracking (%)	Number of fruits/ plant	Fruit weight (g)	Fruit yield/ plant (kg)
NB 5	13.68	89.2	11.2	80	810	64.80
NB 9	15.55	90.2	15.2	56	850	47.60
NB 17	17.44	91.3	20. 5	41	1060	43.46
CISH 1	16.71	90.9	42. 9	40	1520	60.80
CISH 2	15.62	91.9	35.8	43	1340	57.62
NB 16	14.43	92.5	56.2	53	900	47.70
Pant Aparna	14.89	93.5	17. 3	40	972	38.88
Pant Sujata	10.91	91.2	15.5	35	1210	42.35
Range	10.91 - 17.44	89.2 -93.5	11.2 -56.2	35 -80	810 -1520	64.80 -38.88
CD at 5%	1.3	2.2	5.9	3.9	44	6.5

minimum fruit set in Pant Shivani. This variation in fruit set per cent among the various varieties of bael might be due to their inherent characters. Sometimes fruit set per cent may vary due to agronomic practices and local environmental conditions.

Fruit drop per cent in different genotypes varied from 89.20 to 93.5 per cent. Fruit drop per cent was maximum (92.5%) in Pant Aparna (93.5%) and NB 16, these values were statistically at par with CISH 2 (91.9 %), NB 17 (91.3%), however, minimum fruit drop per cent (89.2%) was recorded in NB 5 succeeded by NB-9 (90.2%). Fruit set per cent may directly affect the yield of the plant. Uniyal and Misra (2013) reported fruit drop may be due to embryo abortion. Maximum fruit drop recorded in Pant Sujata followed by Pant Uravshi, while minimum in Pant Shivani. Dropping of fruits due to embryo abortion after fertilization was also reported in litchi by Ray *et al.* (2002). One of the reasons might be due to deficiency of micronutrient especially zinc and boron. This disorder may be due to competition among fruit lets for carbohydrates, water, nutrients, hormones and other metabolites (Uniyal and Misra, 2013).

Fruit cracking in all the genotypes showed significant variation. Fruit cracking per cent was maximum (56.20%) in NB 16, however, minimum fruit cracking (11.20%) was observed in NB 5. Uniyal and Misra (2013) reported maximum fruit cracking in Pant Sujata followed by Pant Urvashi, while minimum fruit cracking was in Pant Aparna. Boron was helpful in improving the appropriate growth of bael tree and it is constituent of cell membrane and essential for cell division, which reduces disorders like cracking in fruits. Numbers of fruits were recorded highest (80) in NB 5; followed by NB 9 (56). Lowest numbers of fruits (35) were found in Pant Sujata. Similar results have been reported in annual report of AICRP of Arid Zone fruits (Anonymous, 2014). In a different study, Kumar and Nath (2010) reported maximum number of fruits in CHBI 21 genotype followed by CHBI 20 and CHBI 19 under Orissa conditions.

Fruit weight recorded maximum (1520 g) in CISH 1; followed by CISH 2 (1340 g), whereas minimum (810 g) fruit weight was observed in NB 5. Patel *et al.* (1977) reported that increase in fruit weight of some germplasm might be due to more uptake of water, nutrients and also due to the accumulation of photosynthetic assimilates from source to

Table 2. Yield attributes of fruits of bael cultivars under arid conditions of Haryana

Cultivars	Fruit set (%)	Fruit drop (%)	Fruit cracking (%)	Number of fruits/ plant	Fruit weight (g)	Fruit yield/ plant (kg)
NB 5	13.68	89.2	11.2	80	810	64.80
NB 9	15.55	90.2	15.2	56	850	47.60
NB 17	17.44	91.3	20. 5	41	1060	43.46
CISH 1	16.71	90.9	42. 9	40	1520	60.80
CISH 2	15.62	91.9	35.8	43	1340	57.62
NB 16	14.43	92.5	56.2	53	900	47.70
Pant Aparna	14.89	93.5	17. 3	40	972	38.88
Pant Sujata	10.91	91.2	15.5	35	1210	42.35
Range	10.91-17.44	89.2 -93.5	11.2 -56.2	35 -80	810 -1520	64.80 -38.88
CD at 5%	1.3	2.2	5.9	3.9	44	6.5

Table 3. Seed variability in different bael cultivars under arid condition of Haryana

Cultivars	Number of seed sacks/ fruit	Number of seeds /sack	Number of seeds/ fruit	Seed weight / fruit (g)	Test weight of seed (g)	Shell thickness (mm)
NB 5	14.4	7.6	110.8	19.42	15.66	3.99
NB 9	15.8	7.4	116.0	10.91	9.49	2.29
NB 17	11.6	8.6	102.2	10.04	9.93	2.66
CISH 1	14.8	5.0	74.0	5.93	8.09	3.94
CISH 2	13.4	5.6	76.4	5.71	7.55	3.06
NB 16	13.4	5.4	71.8	5.50	7.74	3.10
Pant Aparna	14.8	7.2	108.6	7.78	7.23	2.15
Pant Sujata	14.4	6.0	86.8	6.41	7.46	3.03
Range	13.4 -15.8	5.0 -8.6	71.8 -116.0	5.50 -19.42	7.23 -15.66	2.15 -3.99
CD at 5%	1.1	0.9	9.70	2.3	1.36	0.56

sink. The other probable reason may be due to fertility states of soil, micro-climate and inherent characters of germplasm. Pandey *et al.* (2005) collected the existing diversity and exploration in parts of Bihar and UP conditions and observed range of fruit weight from 1.75 kg per fruit in genotype VN/DP-6/5 to 0.64 kg per fruit in VN/DP-6/8.

Maximum yield per tree (64.80 kg) was recorded in NB 5 and minimum (38.88 kg) in Pant Aparna. A significant difference was also reported in yield per plant among various clones of bael by Jaiswal and Misra (1996). However, Bhawana and Misra (2011) reported maximum yield per plant in Pant Shivani followed by Pant Bael 17, Pant Sujata, Pant Aparna and Pant Urvashi. The variation in yields of different germplasm is more or less in accordance with the findings of Kumar and Nath (2010) and Pandey *et al.* (2013). Fruit yield varied due to variation in fruit weight, number of fruits per plant, fruit drop, fruit cracking and genetic characteristics of germplasm.

Quality parameter

The results pertaining to variation in biochemical characteristics such as TSS, acidity, ascorbic acid, and chlorophyll content in respect of various cultivars varied significantly. Chlorophyll content of the genotypes evaluated under this study ranged from 22.37 spad unit to 39.19 spad unit (Table 4). It was recorded maximum in CISH 2 (39.19 spad unit), while the minimum in NB 9 (22.37 spad unit), which was at par with NB 5 (23.61 spad unit). Singh and Mishra (2007) reported that chlorophyll-a, chlorophyll-b and total chlorophyll contents were found higher in genotypes PB-3, PB-10, PB-22 and PB-24. TSS values of all the genotypes ranged from 29.00 °B to 40.67 °B. Maximum TSS (40.67 °B) was recorded in NB 17, followed by NB 9 (40.33 °B) and Pant Aparna (40.00 °B), whereas minimum TSS were recorded in Pant Sujata (29.00 °B). Rai *et al.* (2002) reported that TSS ranged from 32.6 °B to 36.20 °B in bael germplasm. Further, Jana *et al.* (2014) recorded variation in TSS of genotype; HABL 1 recorded maximum TSS as 37.00 °B and 39.00 °B in 2008 and 2009, respectively under Ranchi condition. More TSS in a fruit is more useful in medicinal as well as processing industry.

Acidity was noticed minimum (0.29%) in NB 9, which was at par with NB 17 (0.31%), however, maximum (0.39%) value of acidity was recorded in Pant Sujata, which was at par with Pant Aparna and NB 5(0.40 %). Similar range of acidity was also observed by Pandey *et al.* (2013), who observed minimum acidity (0.30 %) in T_{16} genotype and maximum (0.56 %) in T_{46} genotype. The variation in acidity among different bael germplasm was also reported by Kumar *et al.* (2008) and Raju *et al.* (2014). Variation in qualitative attributes of different germplasm at different locations might be due to adaptability to varied agro-climatic conditions, root distribution pattern of the crop and genetic make-up of the germplasm (Nagar *et al.*, 2017).

Table 4. Chlorophyll content and quality parameters of bael cultivars under arid conditions

Cultivars	Chlorophyll content (Spad Unit)	TSS (°Brix)	Acidity (%)	Ascorbic acid (mg/100g)
NB 5	23.61	39.33	0.36	11.12
NB 9	22.37	40.33	0.29	9.87
NB 17	32.10	40.67	0.31	8.82
CISH 1	30.85	34.67	0.33	10.92
CISH 2	39.19	31.67	0.34	10.51
NB 16	33.56	39.00	0.33	11.96
Pant Aparna	31.66	40.00	0.38	13.01
Pant Sujata	28.29	29.00	0.39	12.35
Range	22.37 -39.19	29.00 -40.67	0.29 -0.39	8.82 -13.01
CD at 5%	1.50	1.50	0.03	0.80

Ascorbic acid was found maximum (13.01 mg/100g) in Pant Aparna, being at par with Pant Sujata (12.35 mg/100g) and minimum ascorbic acid was recorded in NB 17 (8.82mg/100g). The results regarding variation in ascorbic acid among different germplasm are in line with the findings of Pandey *et al.* (2006) and Pandey *et al.* (2013). Singh *et al.* (2014) studied ascorbic acid content in different bael genotypes and reported maximum ascorbic acid in Goma Yashi followed by NB 5 and NB 7 and minimum in Pant Sujata.

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