Indian Journal of Agricultural Sciences **84** (10): 1236–42, October 2014/Article

Characterization of bael (*Aegle marmelos*) varieties under rainfed hot semi-arid environment of western India

A K SINGH[1], SANJAY SINGH[2], R S SINGH[3], H K JOSHI[4] and S K SHARMA[5]

Central Horticultural Experiment Station (CIAH), Vejalpur, Panchmahals (Godhra), Gujarat

Received: 6 November 2013; Revised accepted: 8 September 2014

ABSTRACT

The present study was undertaken to evaluate the performance of different varieties of bael (*Aegle marmelos* Correa.), established through *in-situ* patch budding during the year 2003, at Experimental Farm of Central Horticultural Experiment Station (CIAH), Vejalpur, Panchmahals (Godhra), Gujarat under rainfed hot semi-arid ecosystem of western India during the years 2010-12. The results of study revealed that the different varieties of bael exhibited considerable variation for vegetative, floral, yield and physico-chemical attributes of bael fruits. The vegetative growth in terms of plant height, stem girth, plant spread (E-W) and plant spread (N-S) varied between 3.38-5.85m, 28.95-88.39 cm and 3.74-7.68 m and 3.40-7.52 m, respectively, while the terminal leaf length, breadth, lateral leaf length and breadth ranged between 10.72-15.02 cm, 5.85-9.38 cm, 7.45-11.38cm and 4.13-6.57cm, respectively. Different varieties of bael exhibited wide variations with respect to morphometrics of vegetative characters under rainfed conditions of western India. Varieties also showed wide differences for floral traits with regards to bud size, flower size and other floral organs. The morphological features of fruit of different varieties, viz. fruit yield (40.50-69.29 kg), fruit weight (0.43-4.25 kg), length (10.61-19.59 cm), width (9.40-22.00 cm) and fruit girth (29.10-70.00 cm) also showed variations. Physical composition of bael fruit exhibited wide variation in their shell weight (115.25-560.05g), shell thickness (0.16-0.31cm), number of seed/fruit (90.34-212.25), total fresh seed weight (17.34-43.41 g), number of seed sacs (10.23-19.17), fibre weight (15.91-106.50g) and pulp weight/fruit (0.27-3.67 kg). The qualitative characters of fruit in terms of TSS mucilage, TSS pulp, total sugar, reducing sugar, non reducing sugar, vitamin C, total phenols, acidity and TSS to acid ratio ranged between 37.00-49.50° brix, 30.57-37.45° brix, 16.15-19.98%, 3.30-4.95%, 12.85-15.13%, 17.13-21.03 mg/100g, 2.34-2.75%, 0.30-0.49% and 68.88-124.83, respectively**.** All the varieties of bael showed significant diffferences for qualitative and quantitative morphological characters under rainfed hot semi arid environment.

Key words: Bael, Evaluation, Morphology, Quantitative characters, Qualitative characters, Rainfed

Bael (*Aegle marmelos* Correa.) is one of the important indigenous medicinal fruit tree of India. It belongs to family Rutaceae and various species of the genus persist naturally throughout the India, but it is found growing frequently in Uttar Pradesh, Bihar, Madhya Pradesh, West Bengal and Rajasthan, which typically represents varied agro-climatic conditions of India. Hot semi-arid zone is characterised by the low rainfall and the rainy spells are confined to 2 to 4½ wet months (June to September) and the remaining parts of the year are dry months. The rains are also erratic and often come in a few storms of short duration which results in great runoff without charging the soil moisture profile resulting into water stress in soil as well as atmosphere during major parts of the year. Arid and semi-arid regions have peculiar eco-climatological features in which several major agronomical crops fail to sustain. As one of the hardy underutilised fruit crop, bael has capability to adapt the varied agro-climatic conditions. It is well known that the level of variation in reproductive traits of its constituents influence fruit production. Hence, any detectable variation in these traits may be attributed to genetic causes and can be effectively used as markers to characterise the varieties. Owing to highly nutraceutical, therapeutical, and post harvest values, and its usages in *Ayurvedic* system of medicines, the demand of this fruit is increasing day-by-day. It has higher content of riboflavin (Mukharjee and Ahmed 1957) and has great potential to become a new export commodity for the country, because each part of the tree such as root, bark, leaf flower and fruit are the important ingredients of indigenous traditional formulations. Studies on physico–chemical attributes of some varieties of bael (Ram and Singh 2003), floral traits and yield in some bael cultivars (Singh and Mishra 2004) have been reported by earlier workers, but systematic work on characterization of bael vrieties has not been still reported especially under rainfed

[1] Senior Scientist, [2] Principal Scientist & Head (e mail: sanjaysingh@gmail.com), [3] Principal Scientist (e mail: rssinghl@yahoo.com), [4]Scientist (e mial: chesvejalpur@gmail.com), [5] Director, CIAH, Bikaner, Rajasthan

conditions. Keeping above points in view and unavailability of scientific information on its adaptability and performance under dry land conditions, and also for visualising the prospect of bael fruit, research work on characterization of bael varieties was attempted to assess the performance and find out the suitable variety for hot semi-arid region, so that unproductive land of such region could be made productive by growing such a hardy fruit tree like bael, which holds promise for nutritional security and also helpful in curing the various ailments.

MATERIALS AND METHODS

The location of the experiment is 113 m above msl on latitude 22° 41' 38" N and longitude 73° 33' 22" E and is characterised by hot semi-arid climate. The annual rainfall is mainly confined to three months (July-September) and actual mean precipitation is about 750 mm, and the total number of rainy days average to about 31.The mean summer temperature is 33.4° C while the mean winter temperature is 20.3° C indicating that the area falls under hyperthermic soil regime. The mean annual maximum and minimum temperatures vary from 42-44° C in May and 6-9° C in January, respectively. The soil depth of experimental field ranged from 0.65 to 1.0 m derived from mixed alluvial basalt, quartzite, granite and layers of limestone and falls under semi-arid hot climate. A total of twelve varieties, viz. Goma Yashi, CISH-B-1, CISH-B-2, NB-16, NB-17, NB-5, NB-7, NB-9, Pant Aparna, Pant Shivani, Pant Sujata and Pant Urvashi were established through *in-situ* patch budding during the year 2003. The experiment was laid out in randomized block design with four replications considering two plants as unit of each treatment (variety).

The soil was analysed for organic carbon, EC, pH, N, P and K (Bhargava and Raghupati 1993) and soil bulk density and hydraulic conductivity (Page *et al.* 1982) before the initiation of the experiment. The experimental soil type was characterised with available N (150.25 kg/ha), P (8.23 kg/ha) and K (145.50 kg/ha) and organic carbon (0.31%), while EC and *p*H, bulk density and hydraulic conductivity of soil were 0.14 dS/m, 8.35, 1.43g/cc and 0.27 cm/hr, respectively. The observations on vegetative growth included plant height, stem girth, plant spread, leaf size (Central and lateral leaflet) were taken during month of October, 2010 and 2011. Twenty shoots spread over four directions on each selected trees were tagged and detail observations of morphometrics of floral organs like bud size, flower size, petal size, pedicel size, stamen size, pollen diameter, ovary size, style size, stigma and pollen viability were recorded in May during both the years. Fruits were randomly selected from all the directions of the plant for quantitative and qualitative attributes of fruit like fruit weight, length, width, girth, shell weight, shell thickness, total number of seed, total seed sacs, fresh seed weight, total fresh seed weight and fresh fibre weight/fruit were recorded by following standard procedure and methods. Pollen viability percentage was carried out using 1% acetocarmine stain test (Johansen 1940). Chemical attributes of fruit like acidity, total soluble solids of pulp as well as mucilage were determined by standard methods, and for vitamin C, phenols, total sugar, reducing as well as non = reducing sugar were determined by the methods outlined in AOAC (1980). The pooled data were statistically analysed as per method advocated by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The results of study on morphological characters and qulity attributes of fruit revealed that the various varieties of bael exhibited wide range of variation for all the characters studied under rainfed conditions of western India.

Vegetative characters

Results of study on the vegetative characters of different bael varieties revealed that the growth in terms of plant height, stem girth, plant spread, leaf and flower characters showed significant variations under rainfed hot-semi-arid environment.

Growth

The data on vegetative growth of different varieties depicted in Table 1 exhibited significant differences. The differences in plant height, stem girth, plant spread ranged between 3.38-5.85 m, 28.95-88.39 cm and 3.74-7.68 m, respectively. The plant height (5.85 m), stem girth (88.39 cm), plant spread (E-W-7.68 m and N-S-7.52m) were recorded the maximum in Pant Shivani, CISH-B-2 and NB-7, respectively, while the vegetative characters in terms of plant height (3.38 m), stem girth (30.38 cm) and plant spread (E-W-3.74 m and N-S-3.40m) were measured the minimum in Goma Yashi and Pant Aparna, respectively among the varieties.

The difference in vegetative growth among the varieties may be due to inherent characters of individual varieties and their acclimatization to varied agro-climatic conditions. The dwarfness is the desirable characters for the high density planting by accommodating more number of plants per unit area which ultimately enhance the productivity. Mishra *et al.* (1999) also reported that the different bael genotypes exhibited variations in their growth beahaviour under moist conditions of eastern India.

Leaf

It is evident from the data that the varieties showed wide differences in their leaf characters under dry land conditions of western India (Table 1). It was noticed that the terminal leaflet size in terms of length (15.02) and breadth (9.38 cm) was found maximum in NB-7 followed by CISH-B-2, Pant Shivani and NB-16 for length and CISH-B-2 and Pant Sujata with respect to leaflet width, while the minimum length (10.72 cm) and breadth (6.15 cm) was recorded in NB-9 followed by Pant Urvashi. The lateral leaflet length (11.38 cm) and breadth (6.57 cm) was observed the maximum in CISH-B-2 and NB-7, respectively, whereas the minimum lateral leaflet length (7.45 cm) and breadth (3.65cm) was observed in NB-9 and NB-16,

Table 1 Morphomatrics of vegetative characters of bael varieties under rainfed conditions of western India.

Varieties	Vegetative growth				Terminal leaf size (cm)		Lateral leaf size (cm)	
	Plant height (m)	Stem girth (cm)	Plant spread (m)		Length	Breadth	Length	Breadth
			E-W	N-S				
CISH-B-1	4.57	28.95	4.51	4.10	12. 40	6.19	09.17	4.50
CISH-B-2	5.28	88.39	6.12	7.25	14.54	8.49	11.38	6.35
Goma Yashi	3.38	30.38	3.90	3.47	11.57	6.19	07.95	4.65
NB-16	4.93	67.05	4.81	5.02	13.18	5.85	08.01	3.65
NB-17	5.57	60.96	5.82	6.52	12.75	7.80	07.83	4.13
NB-5	3.68	33.52	4.90	4.35	12.84	7.29	09.93	6.44
NB-7	4.51	85.34	7.68	7.52	15.02	9.38	10.12	6.57
NB-9	3.84	82.29	5.21	5.85	10.72	6.15	07.45	4.43
Pant Aparna	3.90	47.20	3.74	3.40	12.45	7.30	09.57	6.52
Pant Shivani	5.85	64.31	6.79	7.22	13.58	7.58	09.42	5.30
Pant Sujata	4.02	76.20	5.24	5.42	11.93	8.45	09.63	6.41
Pant Urvashi	4.60	82.29	6.49	6.18	11.45	7.27	08.41	4.87
CD (P = 0.05)	0.42	6.12	0.59	0.64	1.29	0.86	0.93	0.62

respectively followed by Goma Yashi and NB-16 for leaf length and varieties NB-17 and NB-9 with respect to lateral leaflet breadth in all varieties studied for the leaf morphological characters. Differences in the leaf morphology in different varieties are variety specific characters and adaptability to different agro-climatic conditions. More or less similar variations with respect to leaf characters in various bael genotypes have beeen reported by Mishra *et al.* (1999) and Singh (2000) in bael under different agro-climatic conditions.

Flower

The data on the morphometrics of flower of bael varieties depicted in Table 2 and 3 showed considerable differences for all the floral characters studied. Flower characters with respect to bud size in terms of bud length (10.00-13 mm), bud width (7.00-9.70 mm), flower length (12-19 mm), flower width (22-35 mm), pedicel length (4.50-10.50 mm), pedicel width (2.00-2.50 mm), petal length (11-19 mm), petal width (7-10 mm), stamen length (6.75-9.00 mm), filament length (2.75-5.00 mm), width (0.40-0.80mm), anther length (3.50-4.50mm), width (0.50-0.80mm), pollen diameter (41.25-45.00 micron), ovary length (4.00-8.00 mm), diameter (2.50-5.00), style length (1.00-1.50 mm), width (1.50-2.50 mm), stigma length (2.00-3.50 mm) and width (2.00-3.00 mm) exhibited wide variations in their floral organs. Pollen viability was found to be significantly highest 98% in NB-7 and NB-9, whereas rest of the varieties have 95% pollen viability or more than it. Bud length (13.00 mm) and width (9.70 cm) were found maximum in NB 17 and CISH-B 2, whereas bud length was the minimum in Pant Aparna followed by NB 9 and NB 16, however bud width was measured the minimum in CISH-B 1 (7.00 mm) followed by Pant Shivani and Pant Sujata. Flower size with respect to length and width was measured maximum in CISH-B-2 (19.00 mm) and NB 7 (35.00 mm), respectively

Table 2 Floral biology of different bael varieties under rain fed conditions of western India

Varieties	Flower size (mm)		Bud size (mm)		Petal size (mm)		Pedicel size (mm)	
	Length	Width	Length	Width	Length	Width	Length	Width
CISH-B-1	14.00	35.00	11.00	7.00	15.00	7.00	07.50	2.00
CISH-B-2	19.00	26.00	13.00	9.70	13.00	8.00	06.50	2.00
NB-5	14.15	29.00	11.50	8.00	18.00	7.50	10.50	2.50
NB-7	18.50	35.00	13.00	9.50	19.00	9.00	05.50	2.50
NB-9	12.00	26.00	10.25	8.00	11.00	7.00	04.50	2.00
NB-16	14.00	28.00	10.50	8.00	12.00	7.00	04.50	2.00
NB-17	18.00	34.00	13.00	9.70	18.00	9.00	05.00	2.50
Pant Aparna	16.00	30.00	10.00	9.00	18.00	10.00	10.00	2.50
Pant Sujata	15.15	29.00	12.50	8.00	17.00	7.50	09.50	2.50
Pant Shivani	15.00	30.00	11.50	7.50	18.50	8.00	09.50	2.00
Pant Urvashi	15.00	26.00	11.50	8.50	16.00	9.00	7.00	2.50
Goma Yashi	12.00	22.00	12.00	9.00	15.00	9.50	6.50	2.00
CD (P = 0.05)	1.74	3.28	1.17	0.83	1.76	0.92	0.88	0.21

Table 3 Floral biology of bael varieties under rainfed conditions of western India

Varieties	Stamen size (mm)	Filament size (mm)		Anther size (mm)		Pollen size (micron)	Ovary size (mm)		Style size (mm)		Stigma size (mm)		Pollen viability
	Length	Length	Width	Length	Width	Diameter	Length	Width	Length	Width	Length	Width	(%)
CISH-B-1	8.50	5.00	0.70	3.50	0.80	41.25	6.00	3.00	1.50	2.00	2.50	2.00	96.00
CISH-B-2	9.00	5.00	0.80	3.50	0.70	41.25	6.00	4.00	1.00	1.50	3.50	2.50	95.00
Goma Yashi	8.00	4.00	0.40	4.00	0.80	45.00	5.50	3.00	1.00	2.00	2.00	2.50	95.00
NB-16	8.00	4.00	0.70	3.50	0.60	44.00	6.00	3.00	1.00	2.50	3.50	2.00	95.00
NB-17	8.50	4.50	0.80	4.50	0.80	45.00	6.00	3.50	1.50	2.50	3.00	2.00	97.00
NB-5	7.50	4.00	0.80	3.50	0.80	45.00	5.00	3.50	1.50	2.00	2.50	2.50	95.00
NB-7	6.75	2.75	0.60	4.00	0.70	41.25	6.50	3.00	1.00	2.50	3.50	2.50	98.00
NB-9	7.00	3.50	0.40	3.50	0.50	41.25	4.00	2.50	1.00	2.00	2.00	2.50	98.00
Pant Aparna	7.75	3.75	0.80	4.00	0.70	42.50	8.00	5.00	1.00	1.50	3.50	3.00	95.00
Pant Shivani	7.50	4.00	0.70	3.50	0.70	43.50	6.50	4.50	1.00	2.00	2.50	3.00	96.00
Pant Sujata	8.00	3.50	0.80	4.00	0.60	42.00	5.50	3.50	1.50	2.00	3.00	2.50	94.00
Pant Urvashi	7.50	4.00	0.50	3.50	0.70	44.00	6.50	3.00	1.00	2.50	2.50	2.00	95.00
CD (P=0.05)	0.42	0.17	0.04	0.08	0.21	2.05	0.41	0.32	0.05	0.14	0.12	0.13	3.29

and same was recorded minimum in GomaYashi followed by NB 9 and NB 16. Pedicel length (10.50 mm) and pedicel width (2.50 mm) were observed the maximum in NB 5 followed by Pant Aparna and Pant Sujata, whereas the same was measured minimum in NB 9 and NB 16 among the varieties of bael tested under rainfed conditions. Flower petal length (19.00 mm) and petal width (10.00 mm) were the maximum in NB 7 and Pant Aparna, respectively, whereas minimum petal length (11.00 mm) and width (7.00 mm) were recorded in NB 9 followed by NB 16 and CISH-B 2. Floral traits are inherent features of individual varieties, and such differences in flower traits may be used as morphological marker which is essential step in breeding. It was observed that the most of floral organs are bigger in size in NB-7 than rest of the varieties. Floral traits are believed to be the most conserved traits and affected the least by the environment. Variations in floral traits in different bael genotypes have been reported by Singh (1989), Srivastava and Singh (2000), Lal (2002) and Singh and Mishra (2004) under different climatic conditions of India.

Fruit characters

Results of study on the quantitative and qualitative characters of fruits of different bael varieties showed significant differences for the physico-chemical parameters studied under rainfed conditions of western India.

Quantitative

It is evident from the data (Table 4) that the values of quantitative characters also varied significantly in different varieties. The maximum yield per plant was recorded in NB-9 (69.29 kg) followed by CISH-B 1 (67.00 kg), Pant Sujata (65.57 kg), Goma Yashi (65.45 kg) and Pant Urvashi (60.150 kg) and they were found at par for fruit yield, whereas fruit yield was recorded minimum in NB 16 (40.50 kg) followed by NB 17 (45.39 kg), NB 7 (48.34 kg) and Pant Shivani (49.12 kg) in the varieties studied for yield. Fruit weight was recorded the highest in NB-7(4.25

Table 4 Physical attributes of fruits of bael varieties under rainfed conditions of western India

Variety	Fruit yield/ tree (kg)	Fruit weight (kg)	Fruit length (cm)	Fruit length (cm)	Fruit girth (cm)	Shell weight (g)	Shell thickness (cm)	Pulp weight (kg)
CISH-B-1	67.00	0.96	17.15	10.30	34.53	141.69	0.18	0.73
CISH-B-2	56.78	2.58	19.59	17.50	54.12	465.00	0.27	2.00
Goma Yashi	65.45	1.32	15.28	13.50	44.20	146.09	0.16	1.14
NB-16	40.50	0.43	10.61	9.40	29.10	115.25	0.26	0.27
NB-17	45.39	1.92	16.50	14.90	48.62	412.92	0.22	1.29
NB-5	54.00	1.20	15.03	13.50	43.20	146.47	0.17	1.00
NB-7	48.34	4.25	16.54	22.00	70.00	560.05	0.31	3.67
NB-9	69.29	1.75	18.50	16.10	49.30	227.31	0.27	1.42
Pant Aparna	61.06	1.10	13.15	11.80	43.30	240.22	0.22	0.80
Pant Shivani	49.12	2.45	19.05	16.30	52.24	374.74	0.23	1.92
Pant Sujata	65.57	1.22	14.12	13.20	41.25	190.63	0.30	0.97
Pant Urvashi	60.15	2.90	18.20	19.40	61.70	610.75	0.23	2.16
CD (P=0.05)	10.21	0.25	1.46	1.82	05.34	30.16	0.28	0.12

kg) followed by Pant Urvashi (2.90 kg), CISH-B 2 (2.58 kg) and Pant Shivani (2.45 kg), whereas the lowest fruit weight was recorded in NB 16 (0.43 kg) followed by CISH-B 1 (0.96 kg). Fruit length (19.59 cm) was found to be highest in CISH-B 2 and Pant Shivani followed by NB 9 and Pant Urvashi, whereas the same was recorded the lowest in NB-16 (10.61) followed by Pant Aparna and Pant Sujata. Fruit width (22.00 cm) was measured the maximum in NB-7 followed by Pant Urvashi (19.40 cm),

CISH-B 2 (17.50 cm) and Pant Shivani (16.30 cm) and it was the minimum in NB 16 (9.40cm) followed by CISH-B 1, Pant Aparna and Pant Sujata. The maximum fruit girth (70.00 cm) was exhibited by NB 7 followed by Pant Urvashi (61.70 cm) and CISH-B 2 (54.12 cm), while the minimum fruit girth was observed in NB 16 (29.10 cm) followed by CISH-B-1 (34.53 cm), Pant Sujata (41.25 cm), Pant Aparna (43.30 cm), NB 5 (43.20 cm) and Goma Yashi (44.20 cm). Variations in the physical parameters among the varieties may be owing to individual varietal characters. However, differencec in floral traits in various genotypes of bael are as just reported by earlier workers (Mazumdar 1975, Rai *et al.* 1991, Pathak *et al.* 2002, Ram and Singh 2003 and Pandey *et al.* 2005) under different agro-climatic conditions.

Physical composition

It is evident from the data that the fruit attributes vary greatly in different varieties (Table 4 and 5). Shell weight (610.75 g) was measured conspicuously very high in Pant Urvashi and the lowest in NB 16 (115.25 g) followed by Goma Yashi (146.09 g) and NB 5 (146.47g).

Shell thickness (0.31 cm) was recorded maximum in NB 7 (0.31 cm) and the least thickness was observed in Goma Yashi (0.16 cm) followed by NB 5 (0.17 cm) and CISH-B 1 (0.18 cm). The pulp content was maximum in NB 7 (3.67 kg) followed by Pant Urvashi (2.16 kg), CISH-B 2 (2.00 kg) and the minimum pulp content was obtained from the variety NB 16 (0.27 kg) followed by CISH-B 1 (0.73 kg) and Pant Aparna (0.80 kg). Total number of seed per fruit was counted the maximum in NB 17 (212.25) followed by CISH-B 1 (191.12), Pant Shivani (171.00), NB 16 (162.50), NB 7 (160.14) and CISH-B 2 (140.29) while the number of seeds/fruit were recorded minimum in Goma Yashi (90.34) followed by Pant Urvashi (103.25) and NB 5 (114.43). Total seed sacs per fruit were recorded highest in NB 9 (19.17) and it was lowest in CISH-B 1 (10.23) followed by Pant Sujata (13.13). Fresh seed weight/fruit was recorded the maximum in Pant Urvashi (0.22g) and minimum in NB 16 as well as NB 9 (0.15g). Total fresh seed weight/fruit was recorded the highest in NB 17 (43.41g) followed by CISH-B 1 (38.44 g) and same was observed the lowest in Goma Yashi (17.34 g) followed by Pant Urvashi (18.18g). Fresh fibre weight was obtained highest in NB 17 (106.50g) followed by Pant Shivani (101.50 g) and it was lowest in NB 16 (15.91 g) followed by CISH-B 1 (22.70g), NB-5 (25.24 g) and GomaYashi (28.50 g).

Table 5 Physical composition of fruits of bael varieties under rainfed conditions of western India

Varieties	Total seed sacs/ fruit	Total number of seed/ fruit	Seed weight (g)	Total seed weight/ fruit (g)	Fibre weight/ fruit (g)
CISH-B-1	10.23	191.12	0.20	38.44	22.70
CISH-B-2	15.42	140.29	0.20	23.05	67.00
Goma Yashi	14.18	090.34	0.18	17.34	28.50
NB-16	13.19	162.50	0.15	21.89	15.91
NB-17	18.20	212.25	0.17	43.41	106.50
NB-5	15.05	114.43	0.21	27.30	25.24
NB-7	17 .60	160.14	0.17	31.50	49.30
NB-9	19.17	114.78	0.15	23.04	63.80
Pant Aparna	14.50	110.30	0.18	18.18	35.60
Pant Shivani	14.17	171.00	0.19	34.47	101.50
Pant Sujata	13.13	121.89	0.21	25.75	30.77
Pant Urvashi	17.84	103.25	0.22	28.86	92.46
CD (P=0.05)	1.42	13.80	0.02	2.76	3.84

The physical composition of bael fruit consisted of shell, seed, fibre and pulp percentage varied between 11.76-26.80, 0.80-5.05, 2.23-4.14 and 63.45-85.14, respectively in different varieties of bael. The highest percentage of shell and total seed were computed 26.80 and 5.05 in NB 16, whereas the shell and seed percentage was minimum in Goma Yashi (11.76) and CISH-B 2 (0.80), respectively. The minimum fibre (2.23) and maximum pulp (85.14) percentage were obtained in the Goma Yashi, while the maximum fibre (4.14%) and minimum pulp (63.45%) were recorded in NB 17 and NB 16, respectively in all the varieties studied for physical composition (Fig 1). Differences in the various quantitative characters of fruits of varieties are genetic in nature rather than due to edaphic or other environmental factors. Such kinds of differences in quantitative constituents seems to be associated with the results as reported by Singh *et al.* (2000), Pathak *et al.* (2002) and Pandey *et al.* (2013) in bael.

Qualitative

It is quite obvious from the data (Table 6) that the different varieties manifested considerable variation in qualitative attributes. Fruit acidity was estimated highest in Pant Urvashi (0.49%) followed by NB 16, Pant Shivani and CISH-B 2 and it was lowest in Goma Yashi (0.30%) followed by NB 17 and NB 9, however the maximum Vitamin 'C' content was found in Goma Yashi (21.03 mg/100 g) followed by NB 5 (20.63 mg/100 g) and NB 7 (19.78 mg/100 g) and the same was observed the minimum in Pant Sujata (17.13 mg/100 g) followed by Pant Aparna (17.15 mg /100 g). Total phenol was estimated highest in CISH-B 1 (2.75%) followed by CISH-B 2 (2.65%) and the lowest in Pant Urvashi (2.34%). The total soluble solids in pulp were recorded highest in Goma Yashi (37.45° brix) followed by Pant Urvashi (36.44° brix), NB 5 (36.21° brix) and NB 16 (35.90° brix) and the lowest TSS of pulp was recorded in NB 7 (30.57° brix) followed by CISH-B 2 (31.00° brix) and CISH-B 1 (31.20° brix). The total soluble solids in mucilage

Table 6 Chemical attributes of bael varieties under rainfed conditions of western India

Varieties	Acidity (%)	Vitamin (mg/100g)	Total phenol (%)	T.S.S pulp (Brix)	T.S.S. mucilage (Brix)	Total suger (%)	Reducing suger (%)	Non reducing suger (%)	TSS: Acid ratio
CISH-B-1	0.33	19.75	2.75	31.20	46.29	18.00	4.87	13.13	94.54
CISH-B-2	0.45	17.37	2.65	31.00	42.25	17.34	4.25	13.09	68.88
Goma Yashi	0.30	21.03	2.35	37.45	43.43	18.75	4.12	15.00	124.83
NB-16	0.48	18.19	2.54	35.90	45.60	18.00	4.00	14.50	74.79
NB-17	0.31	18.28	2.43	34.88	48.52	16.60	4.50	13.00	112.51
NB-5	0.32	20.63	2.38	36.21	46.15	18.50	4.75	13.75	113.15
NB-7	0.35	19.78	2.47	30.57	49.00	16.15	3.30	12.85	87.34
NB-9	0.32	19.20	2.47	35.29	46.83	19.98	4.85	15.13	110.28
Pant Aparna	0.34	17.15	2.63	34.23	37.00	19.93	4.95	14.98	104.11
Pant Shivani	0.47	19.55	2.54	35.40	48.65	17.77	3.54	14.23	75.31
Pant Sujata	0.44	17.13	2.41	33.25	44.47	18.00	3.35	14.65	75.56
Pant Urvashi	0.49	17.49	2.34	36.44	49.50	16.15	4.00	14.00	74.36
C D at 5%	0.043	1.78	0.23	3.45	4.32	1.77	0.39	1.34	10.21

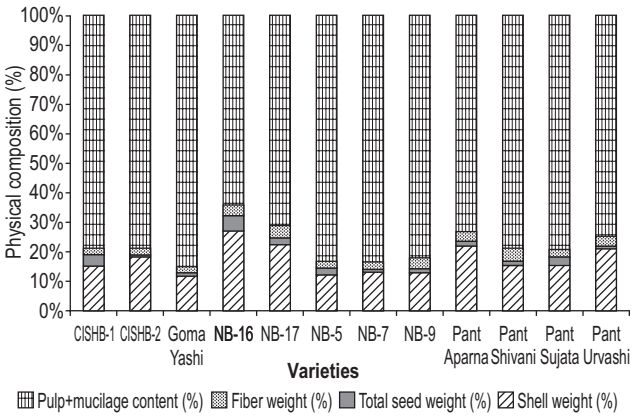

Fig 1 Physical composition (%) of fruits of bael varieties under rainfed conditions of western India

were recorded highest in Pant Urvashi (49.50° Brix) followed by NB 7 (49.00° brix), Pant Shivani (48.65° brix) and NB 17 (48.52° brix) and similar was the minimum in Pant Aparna (37.00° brix). Total sugar was found maximum in NB 9 (19.98%) followed by Pant Aparna (19.93%), whereas the same was recorded the minimum in Pant Urvashi, NB 7 (16.15%) and NB 17 (16.60%). Reducing sugar was estimated the highest in Pant Aparna (4.95%) followed by CISH-B 1, NB 9 and NB 5 and the same was the lowest in NB 7 (3.30%) followed by Pant Sujata, Pant Shivani. Non=reducing sugar was recorded maximum in NB 9 (15.13%) followed by Goma Yashi and it was the minimum in NB 7 (12.85%). TSS/Acid ratio was computed the maximum in Goma Yashi (124.83) followed by NB 5 (113.15) and NB 17 (112.51), whereas it was minimum in Pant Urvashi (74.36) followed by NB 16 (74.79), Pant Shivani (75.31) and Pant Sujata (75.56). Variations in the qualitative attributes of the varieties might be due to the root distribution pattern of individual variety, adaptability to varied agro-climatic conditions, availability of nutrient to individual variety and genetic make up of the varieties. Mazumdar (1975), Singh *et al.* (2000), Nath (2003) and Pandey *et al.* (2008) reported differences in chemical composition in fruits of bael genotypes from West Bengal, Uttar Pradesh, Bihar and Jharkhand and east central India.

Based on the observations, it may be inferred from the study that the bael can successfully be grown commercially without irrigation under rainfed conditions of western India. Among the varieties, the varieties namely NB 7, CISHB 2 and NB 17 for growth, Pant Sujata, CISH-B 1, NB 9, Goma Yashi for yield, Goma Yashi, NB 5 and CISH-B 1 for both yield and quality were found superior under rainfed hot semi arid environment of western India, besides these characters, Goma Yashi being dwarf in nature owing to slow annual growth resulting the minimum plant height, stem girth and plant spread, may be recommended for high density planting to increase the productivity and economy per unit area under dryland condition. Based on the overall performance on various aspects, varieties, viz. Goma Yashi, NB 5, CISH-B 1 and Pant Sujata were found to be better under rainfed hot semi-arid environment of western India.

REFERENCES

AOAC. 1980. *Official Methods of Analysis*. Association of Official Agricultural Chemists, Benjamin Franklin Station, Washington, DC.

Bhargava B S and Raghupati H B. 1993. Analysis of plant material for macro and micro nutrients. *Methods of Analysis of Soil Plant Water and Fertilizer*, pp 49–82. Tondon (Ed) Fertilizer Development and Consultation Organization, New Delhi.

Gomez K A and Gomez A A. 1984. *Statistical Procedure for Agricultural Research,* 2nd Edn. John Wiley and Sos Inc., New York.

Johansen D A. 1940. *Plant Micro-technique*. Mc Graw Hill Company, New York.

Lal G. 2002. Evaluation of bael (*Aegle marmelos*) germplasm in semi aid regions of Rajasthan. *Current Agriculture* **26**(1-2): 127–9.

Mazumdar B C. 1975. Physico-chemical analysis of some types of bael (*Aegle marmelos* Correa). I. Fruits growing in West Bengal. *Indian Agriculture* **19**(3): 295–8.

Misra K K, Singh R and Jaiswal H R. 1999. Studies on leaf characters, development pattern and shoot growth in bael genotypes. *Progressive Horticulture* **31**(3-4): 144–50.

Mukharjee B and Ahmed K. 1957. Riboflavin. *Pakistan Journal Biology and Agriculture Science* **1**: 47–51.

Nath V, Pandey D and Das B. 2003. Diversity of bael (*Aegle marmelos* Correa) in east central India. *Indian Journal of Plant Genetic Resources* **16**: 222–5.

Page A L, Miller R H and Keeney D R. 1982. *Method of Soil Analysis* Part 1 & 2, *Chemical and microbial properties*. American Society of Agronomy, Madison, Wiscosin, USA.

Pandey D, Shukla S K and Nath V. 2005. Diversity of bael (*Aegle marmelos* Correa) in Bihar and Uttar Pradesh. *Progressive Horticulture* **31:** 359–62.

Pandey D, Shukla S K, Nagar A K and Yadav R C. 2008. Variability in bael accessions from Bihar and Jharkhand. *Indian Journal of Horticulture* **65**(2): 226–9.

Pandey D, Tandon D K, Hudedamani Umesh and Tripathi M. 2013. Variability in *bael* (*Aegle marmelos* Corr.) genotypes from eastern Uttar Pradesh. *Indian Journal of Horticulture* **70**(2): 170–8.

Pathak R K, Pandey D and Pramanik P K. 2002. Diversity in bael (*Aegle marmelos* Correa)-An underutilized fruits of India. *IPGRI Newsletter* **37**: 22–37.

Rai M, Dwivedi R and Gupta P N. 1991. Variability and potentials of identified germplasm of bael (*Aegle marmelos* Correa.). *Indian Journal of Plant Genetic Resources* **4**(2): 86–92.

Ram D and Singh I S. 2003. Physico-chemical studies on bael (*Aegle marmelos* Correa) fruits. *Progressive Horticulture* **35**(2): 199–201.

Singh V P and Mishra K. 2004. Estimation of variability parameters for floral traits and yield in Bael (*Aegle marmelos* Correa). *Progressive Horticulture* **36**(2): 253–8.

Singh R D. 1989. Studies on bael (*Aegle marmelos* Correa) morphology of flower, anthesis, dehiscence and receptivity of stigma. *Progressive Horticulture* **32**: 15–24.

Singh R, Mishra K K and Jaiswal H R. 2000. Studies on physico-chemical characters of fruits of bael genotypes. *Indian Journal of Horticulture* **57**(4): 314–7.

Srivastava K K and Singh H K. 2000. Floral biology of bael (*Aegle marmelos*) cultivars. *Indian Journal of Agricultural Sciences* **70**: 797–8.