VARIABILITY STUDIES IN BAEL (*Aegle marmelos* L. correa)

Lokesh Ramdas Raut[1], Dr.N.H. Ramteke[2], Dr.D.M. Panchbhai[3], Dr.S.G.Bharad[4] ,Dr.S.R.Patil[5]
1.-M.Sc. Student, Department of Fruit Science, Dr. PDKV, Akola, Maharashtra, India
2.-Assistant Professor, Department of Fruit Science, Dr. PDKV, Akola, Maharashtra, India
3. - Dean, Faculty of Horticulture, Dr. PDKV, Akola, Maharashtra, India
4. - Head, Department of Fruit Science, Dr. PDKV, Akola, Maharashtra, India
5. - Professor, Department of Fruit Science, Dr. PDKV, Akola, Maharashtra, India
lraut855@gmail.com

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Abstract

The experiment was conducted in the Sewagram, Wardha district of Maharashtra during the year 2023-2024. A total of 22 genotypes having desirable traits were collected and analysis of fruits was done. Genotypes showed considerable variation for fruit morphological traits. The observations of existing trees showed rich genetic variations regarding their fruit characteristics, tree height (4.36 to 9.75 m), east-west direction (4.50 to 8.64 m), north-south direction (3.34 to 7.34 m), leaf area (58.16 to 63.98 cm^2) fascicle length (54.83 to 67.93 cm), number of flower per fascicle (15.49 to 25.20), number of fruit per fascicle (1.57 to 3.52), fruit weight (331.67 to 2347.82 g), fruit length (8.80 to 17.02 cm), fruit diameter (8.60 to 16.90 cm), fruit pulp weight (204.62 to 1398.52 g), pulp percentage (45.02 to 75.16), pulp: seed ratio (14.06 to 42.54), skull weight (93.87 to 904.82 g), skull thickness (2.85 to 5.57 mm), skull percentage (22.40 to 53.57), number of fruits per plant (50 to 350), volume of fruit (309 to 1888 CC), fruit yield per plant (32.85 to 238.75 kg), number of seeds per fruit (43.75 to 113), weight of seeds per fruit (7.77 to 44.47 g) and seed percentage (1.38 to 4.42) among the different genotypes. On the basis of overall assessment, four genotypes, viz., AKLB-3, AKLB-8, AKLB-11, AKLB-21 and AKLB-22 were found most promising. The objective of that experiment is to find out superior genotypes for their better yield and quality.

***Key words**: Bael, variability, genotype.*

Introduction

Bael (*Aegle marmelos*) is important underutilized indigenous fruit crop of India, belongs to family Rutaceae. It is a subtropical and deciduous tree, which is very hardy and can thrive well under diverse agro-climatic conditions. The tree generally reaches a height of 6 to 8 metres with trifoliate, aromatic leaves, while the terminal leaflet is 5.7 cm long and 2.8 cm broad with a long petiole. Moreover, two lateral leaflets are 4.1 cm long and 2.2 cm wide, almost sessile (Allen, 1969). It can easily be grown on eroded soil and adverse climatic conditions where most of the other fruits cannot be grown. Bael fruits are popular due to its medicinal and nutritional properties and regarded as 'Amrit Phal' in cure of diarrhoea and dysentery. All part of tree (stem, bark, root, leaves and fruits) at different maturity stages has one or the other use. It is also used in the preparation of Ayurvedic medicines since ancient times (Rai *et al*., 1991). In India, it is found in wild form in sub-Himalayan tract and in dry deciduous forest of central and southern Indian region (Pandey *et al*., 2005) since pre-historic times and, therefore, a large number of landraces are available in the different diversity regions. A wide range of diversity of bael tree has been noticed in dry subtropical belt of north India. Bael (*Aegle marmelos*) is important underutilized indigenous fruit crop of India, belongs to family Rutaceae. It is a subtropical and deciduous tree, which is very hardy and can thrive well under diverse agro-climatic conditions. The tree generally reaches a height of 6 to 8 metres with trifoliate, aromatic leaves, while the terminal leaflet is 5.7 cm long and 2.8 cm broad with a long petiole. Moreover, two lateral leaflets are 4.1 cm long and 2.2 cm wide, almost sessile (Allen, 1969). Some leaf abnormalities of A. marmelos have been noticed (Rao, 1951). Abnormalities of lobation have also been reported by Dutta and Mitra (1960). The leaf characters, development pattern and shoot growth of eight selected genotypes of bael were studied by Misra *et al*. (1999). The fruit has been known in India since the pre historic era. Bael fruit grows throughout the Indian Peninsula as well as in Sri Lanka, Nepal, Pakistan, Bangladesh, Burma, Thailand and most Southeast Asian countries. Bael is a valuable tree species and its fruits are recognized for their medicinal and nutritive properties. It is traditionally used in curing several diseases and as ingredients of nutritive foods. The livelihoods of some ethnic groups depend on bael fruit collection, processing and marketing (Roy and Singh, 1979). It can easily be grown on eroded soil and adverse climatic conditions where most of the other fruits cannot be grown.

Bael fruits are apopular due to its medicinal and nutritional properties and regarded as 'Amrit Phal' in cure of diarrhoea and dysentery. All part of tree (stem, bark, root, leaves and fruits) at different maturity stages has one or the other use. It is also used in the preparation of Ayurvedic medicines since ancient times (Rai *et al*., 1991). Bael cultivars have been identified and found useful for commercial cultivation i.e., Narendra Bael-5, NB-7 and NB-9 from Narendra Dev University of Agriculture and Technology, Kumarganj, Faizabad (Pareek and Nath, 1996); Pant Aparna, Pant Sujata, Pant Shivani and Pant Urvashi from GB Pant University of Agriculture & Technology Pant Nagar, Nainital (Singh *et al*., 2000) and CISH-B1 and CISH-B2 from Central Institute for Sub-tropical Horticulture, Lucknow (Pathak *et al*., 2002). The location specific genotypes of bael need to be identified and evaluated in iso-climatic regions to develop good cultivars on one hand and known by local people for high degree of variability with regards to qualitative characters are on the verge of extinction due to urbanization and industrialization. Therefore, there is an immediate need to conserve them for the use of posterity (Rai *et al*., 1991).

Materials and Methods

The present study of bael trees was conducted in the Wardha districts of Maharashtra in the years 2023 and 2024. Efforts were taken to identify only regular, prolific bearer, dwarf type with thin skull, having less seed, fibre and mucilage contents, pleasant aroma and disease and pest-free healthy trees bearing fruits of uniform shape and size. A total of 22 genotypes having good fruit and tree characters were identified. The method of random sampling from a population and biased sampling after gathering information about a particular genotype was followed. Four fruits were randomly collected from all the directions from each genotype to record the morphological and qualitative characters. The extent of variation in morphological and qualitative traits of fruits from different locations was recorded. The physical attributes, viz., fruit weight, length, diameter, number of seeds, seed weight, skull weight, skull thickness and pulp weight were calculated following standard procedures. Fruit yield per tree was calculated by counting the number of fruits per tree and multiplying by the average fruit weight.

The fruits of uniform size free from injury, disease or bruising were harvested randomly from tagged branches of each germplasm for fruits characteristics. The pulp was scooped from selected fruits, thereafter, pulp as well as shell weighed separately for weight and their ratio. The thickness of pulp detached shell was expressed in millimeters (mm). The data was analysed using statistical method described by Panse and Sukatme (1967).

Results and Discussion

The data on morphological attributes of bael genotypes depicted in the table showed considerable variability for all the characters studied.

Plant height recorded varied from 4.36 m to 9.55 m. The highest tree height (9.55 m) was recorded by the genotype AKLB-2. The minimum tree height (4.36 m) was recorded by AKLB-8. 7.02 m was the mean tree height of twenty-two genotypes. The maximum tree spread (8.74 m) was found in the genotype AKLB-21, which was found superior over all the genotypes. While the minimum tree spread (4.50 m) was found in the genotype AKLB-11. The average tree spread for twenty-two genotypes was 6.70 m. The maximum tree spread (7.34 m) was found in the genotype AKLB-2. While the minimum tree spread (3.34 m) was found in the genotype AKLB-3. The average tree spread for twenty-two genotypes was 5.30 m .The highest leaf area (63.98 cm^2) was recorded in genotype AKLB-21. Genotype AKLB-10 has recorded the least leaf area (58.16 cm^2). The mean leaf area of twenty-two genotypes was found to be 61.7 cm^2. A maximum fascicle length (67.93 cm) was observed in genotype AKLB-16 followed by genotypes AKLB-19 (56.44 cm) and AKLB-18 (57.30 cm). The genotype AKLB-11 had a minimum flower pedicel length of (54.83 cm). The mean flower pedicel length of twenty-two genotypes was 62.97 cm. The genotype AKLB-14 has recorded higher number of flowers per fascicle (25.20). The genotype AKLB-12 recorded the minimum number of flowers per fascicle (15.49). The mean number of flowers per fascicle was 20.85. Variations in different growth parameters might be due to the different genetic constituent of cultivars of bael. Singh *et al*., 2014; Jana *et al*., 2014 also depicted the considerable variation in different bael cultivars.

There was huge variation observed AKLB-10,AKLB-11,AKLB-13,AKLB-15,AKLB-17,AKLB-18,AKLB-19 produced flowers early during the first week of July and genotype AKLB-2,AKLB-3,AKLB-5,AKLB-6,AKLB-7,AKLB-21,AKLB-22 produced flowers late during the fourth week of July. The highest number of fruits per fascicle (3.52) was found in the genotype AKLB-4. The minimum number of fruits per fascicle (1.57) was found in the genotype AKLB-12. The mean number of fruits per fascicle was found to be 2.6.Variation was found with respect to fruit weight among different genotypes, where the mean fruit weight reported among bael genotypes was 688.87 g. The maximum fruit weight was observed in genotype AKLB-3 (2347.82 g). Whereas genotype AKLB-16 reported a minimum fruit weight of 331.67 g. A maximum length of fruit (17.02 cm) was observed in genotype AKLB-3 followed by genotypes AKLB-21(13.57). The genotype AKLB-17 had a minimum fruit length of (8.80 cm). The mean fruit length of the twenty-two genotypes was 10.96 cm. The maximum fruit diameter (16.9 cm) was observed in AKLB-3. The minimum fruit diameter (8.6 cm) was observed in genotype AKLB-17. The mean fruit diameter of twenty-two genotypes was 10.42 cm. Generally shape of the total twenty- two bael genotypes are round and oval shape.The highest weight of pulp 1398.52 g was found in the genotype AKLB-3. Minimum weight of pulp 204.62 g. was found in the genotype AKLB-17. The mean weight of pulp was 425.87 g. The difference in fruit weight might be attributed to an increase in pulp weight, seed weight and skull weight of trees. The findings are in agreement with the results of earlier researches (Pandey *et al*., 2008, Pandey *et al*., 2013 and Mitra *et al*., 2010).

The genotype AKLB-13 had highest pulp percent (75.16 %). The genotype AKLB-21 had minimum pulp percent (45.02%). The mean pulp percent of twenty –two genotypes was found 64.27 %. The genotype AKLB-6 recorded a higher pulp: seed ratio (42.54 %). The genotype AKLB-16 was recorded with a minimum pulp: seed ratio of 14.06 per cent. The mean pulp: seed ratio was found to be 25.38 percent. Where, maximum skull weight (904.82 g) was recorded in AKLB-3. AKLB-1 has recorded minimum skull weight (93.87 g). The mean skull weight of twenty-two genotypes was found 245.87 g. The highest skull thickness (5.57 mm) was recorded by the genotype AKLB-12. The minimum skull thickness (2.87 mm) was recorded by AKLB-19. 4.58 mm was the mean skull thickness of twenty-two genotypes. The highest skull % (53.57 %) was of genotype AKLB-21. Lowest skull % is 22.40% had genotype AKLB-13.The mean skull percent of twenty-two genotypes was 33.04%.The highest yield per plant was (238.75 kg) in genotype AKLB-21 and the lowest yield per plant (32.85 kg) was in AKLB-12. The mean of yield per plant was 120.39 kg. Increase in yield might be due to the specific climatic requirement of the variety and the genetic makeup of the cultivar (Kumar *et al*., 2021).

Maximum number of fruits (350) was counted in AKLB-21 .The minimum number of fruits per plant (50) was counted in AKLB-12. The mean number of fruit per plant of twenty-two genotype was 208.84. The highest volume 1888 was of genotype AKLB-3. Lowest volume of fruit is 309 had genotype AKLB-17. The mean volume of twenty-two genotypes was 591.21 CC. The genotype AKLB-3 was observed with maximum number of seeds per fruit (113). The genotype AKLB-7 was recorded with minimum number of seeds per fruit (43.75). The average number of seeds per fruit was recorded 55.8. The highest weight of seed per fruit (44.47 g) was recorded in genotype AKLB-3. The minimum weight of seed per fruit (7.77 g) was recorded in AKLB-1. The mean weight of seed per fruit was recorded 17.13 gm. The highest seed percentage (4.42%) was recorded in AKLB-16 and the minimum seed percentage (1.38%) was observed in genotype AKLB-21. The mean of seed percentage was 2.69%.The difference in seed weight may be attributed to differences in the number and size of seeds among the trees. The results are in conformity with the earlier findings (Pandey *et al*., 2008, Pandey *et al*., 2013; Singh and Misra, 2010)

Table 1: Mean performance of bael genotypes based on tree, flower and fruit character.

Name of genotype	Tree height (m)	Tree Spread (m)		Flowering time	Fruit Shape	No. of fruits per plant
		E-W Direction	N-S Direction			
AKLB-1	5.22	8.62	6.84	1st week of July	Oval	164
AKLB-2	9.55	7.52	7.34	4th week of July	Round	237
AKLB-3	5.73	7.42	6.63	4th week of July	Round	154
AKLB-4	6.58	6.68	5.45	3rd week of July	Oval	327
AKLB-5	5.52	6.62	4.35	4th week of July	Oval	205
AKLB-6	6.58	5.35	3.34	4th week of July	Oval	100
AKLB-7	5.54	7.57	6.30	4th week of July	Oval	155
AKLB-8	4.36	8.44	6.36	2nd week of July	Round	349
AKLB-9	8.32	8.64	6.62	1st week of July	Oval	299
AKLB-10	8.54	8.51	6.77	1st week of July	Oval	192
AKLB-11	9.75	4.50	3.93	1st week of July	Round	63
AKLB-12	9.68	4.62	3.55	4th week of July	Oval	50
AKLB-13	6.61	6.55	4.37	1st week of July	Round	199

AKLB-14	6.62	6.59	5.46	3rd week of July	Oval	216
AKLB-15	6.76	5.58	4.50	1st week of July	Oval	211
AKLB-16	6.60	5.67	4.62	4th week of July	Oval	204
AKLB-17	5.76	5.82	3.61	1st week of July	Oval	192
AKLB-18	6.98	5.60	4.40	1st week of July	Oval	104
AKLB-19	5.69	5.56	4.52	1st week of July	Oval	200
AKLB-20	6.51	4.55	4.33	3rd week of July	Oval	304
AKLB-21	6.03	8.74	6.68	4rd week of July	Round	310
AKLB-22	6.40	8.27	6.56	4rd week of July	Oval	350
Range	4.36-9.75	4.50-8.64	3.34-7.34			50-350
Mean	7.02	6.70	5.30			208.84

Table 2: Mean performance of bael genotypes based on fascicle and fruit character.

Sr. No.	Genotype	Fascicle length (cm)	No. of flower /fascicle	No. of fruit /fascicle	Fruit weight (g)
1	AKLB-1	58.63	18.89	2.42	349.35
2	AKLB-2	63.31	18.85	2.35	469.72
3	AKLB-3	66.57	24.58	2.92	2347.82
4	AKLB-4	65.78	25.83	3.52	684.55
5	AKLB-5	65.36	21.22	3.17	631.25
6	AKLB-6	59.58	17.77	2.50	462.95
7	AKLB-7	60.20	19.77	2.92	465.15
8	AKLB-8	62.62	24.74	2.60	651.80
9	AKLB-9	67.27	17.98	2.90	511.22
10	AKLB-10	63.79	18.28	2.77	545.12
11	AKLB-11	67.93	22.56	2.72	1195.30
12	AKLB-12	59.10	15.49	1.57	626.00
13	AKLB-13	63.15	20.64	3.17	667.85
14	AKLB-14	65.89	25.20	3.25	586.55
15	AKLB-15	65.49	21.81	2.40	424.70
16	AKLB-16	54.83	17.84	1.97	331.67
17	AKLB-17	67.07	17.97	2.00	331.97
18	AKLB-18	57.30	19.98	1.62	547.82
19	AKLB-19	56.44	23.33	2.55	632.55
20	AKLB-20	66.11	20.78	2.05	534.40
21	AKLB-21	67.12	26.03	3.35	1476.07
22	AKLB-22	61.83	19.82	2.45	681.45
	Range	54.83-67.93	15.49-25.20	1.57-3.52	331.67-2347.82
	Mean	62.97	20.85	2.6	688.87
	SE(m)±	2.29	1.9	0.13	14.1
	CV	7.29	18.31	10.28	4.09
	CD at 5%	6.49	5.39	0.37	39.86

Table 3: Mean performance of bael genotypes based on fruit character.

Sr. No.	Genotype	Fruit length (cm)	Fruit diameter (cm)	Fruit pulp weight (g)	Pulp (%)
1	AKLB-1	10.47	9.15	247.70	70.95
2	AKLB-2	10.75	9.37	350.75	74.71
3	AKLB-3	17.02	16.90	1398.52	59.61
4	AKLB-4	9.87	10.75	479.72	70.08
5	AKLB-5	11.22	9.80	394.37	62.50
6	AKLB-6	9.67	9.55	337.00	72.89
7	AKLB-7	9.60	9.55	263.80	56.77
8	AKLB-8	10.60	10.47	448.37	68.81
9	AKLB-9	10.47	9.80	319.32	62.45
10	AKLB-10	10.77	9.85	346.20	63.56
11	AKLB-11	13.15	12.55	602.35	50.60
12	AKLB-12	11.37	10.35	422.57	67.50
13	AKLB-13	10.60	11.40	501.75	75.16
14	AKLB-14	10.80	10.00	387.25	66.78
15	AKLB-15	10.27	8.60	304.17	71.76
16	AKLB-16	9.65	8.80	205.97	62.23

17	AKLB-17	8.80	8.60	204.62	61.69
18	AKLB-18	10.75	9.75	369.85	67.53
19	AKLB-19	10.82	11.02	430.02	68.01
20	AKLB-20	10.60	10.30	346.95	64.98
21	AKLB-21	13.57	12.50	664.65	45.02
22	AKLB-22	10.25	10.22	343.27	50.44
	Range	8.80-17.02	8.60-16.90	204.62-1398.52	45.02-75.16
	Mean	10.96	10.42	425.87	64.27
	SE(m)±	0.31	0.24	13.02	1.78
	CV	5.68	4.63	6.11	5.56
	CD at 5%	0.88	0.68	36.81	5.05

Table 4: Mean performance of bael genotypes based on seed and leaf character.

Sr. No.	Genotype	No .of seed /fruit	Seed weight/fruit (g)	Seed (%)	Leaf area (cm²)
1	AKLB-1	48.00	7.77	2.22	62.95
2	AKLB-2	47.50	9.97	2.12	61.98
3	AKLB-3	113.00	44.47	1.89	61.87
4	AKLB-4	54.50	23.47	3.42	63.54
5	AKLB-5	51.25	14.30	2.26	62.07
6	AKLB-6	50.00	7.97	1.71	61.01
7	AKLB-7	43.75	11.32	2.42	62.99
8	AKLB-8	44.25	24.20	3.70	60.28
9	AKLB-9	45.50	17.75	3.47	58.16
10	AKLB-10	50.25	15.02	2.75	58.90
11	AKLB-11	59.25	23.90	2.00	63.67
12	AKLB-12	50.25	18.02	2.87	59.90
13	AKLB-13	62.50	16.17	2.42	60.74
14	AKLB-14	50.75	18.02	3.07	63.62
15	AKLB-15	83.00	13.12	3.09	62.07
16	AKLB-16	47.75	14.67	4.42	60.73
17	AKLB-17	64.25	10.87	3.27	61.61
18	AKLB-18	45.75	15.07	2.75	60.13
19	AKLB-19	53.25	20.62	3.26	62.75
20	AKLB-20	60.75	11.77	2.20	62.39
21	AKLB-21	44.50	20.55	1.38	63.98
22	AKLB-22	57.75	17.82	2.61	62.02
	Range	43.75-113.00	7.77-44.47	1.38-4.42	58.16-63.98
	Mean	55.8	17.13	2.69	61.7
	SE(m)±	2.27	0.55	0.11	1.37
	CV	8.15	6.43	8.16	4.46
	CD at 5%	6.43	1.55	0.31	3.88

Table 5: Mean performance of bael genotypes based on fruit character.

Sr. No.	Genotype	Pulp: seed ratio	Skull weight (g)	Skull thickness (mm)	Skull (%)	Fruit yield/plant (kg)	Volume of fruit (CC)
1	AKLB-1	31.96	93.87	4.72	26.80	64.50	318.00
2	AKLB-2	35.26	109.00	5.05	23.15	131.70	445.00
3	AKLB-3	31.49	904.82	4.65	38.48	215.20	1888.00
4	AKLB-4	20.47	181.35	4.50	26.47	207.50	537.50

5	AKLB-5	27.67	222.57	5.15	35.22	128.30	565.75
6	AKLB-6	42.54	117.97	4.12	25.37	42.32	458.00
7	AKLB-7	23.41	190.02	5.50	40.78	71.00	378.25
8	AKLB-8	18.56	179.22	3.67	27.46	201.80	500.50
9	AKLB-9	18.01	173.97	5.50	34.06	173.70	446.25
10	AKLB-10	23.07	183.90	5.05	33.67	96.00	465.50
11	AKLB-11	24.98	569.22	5.50	47.38	79.37	1238.25
12	AKLB-12	23.50	185.40	5.57	29.60	32.85	524.25
13	AKLB-13	31.45	149.92	5.02	22.40	143.92	640.50
14	AKLB-14	22.91	181.27	3.45	30.88	142.42	533.25
15	AKLB-15	23.26	107.40	3.35	25.12	84.67	528.00
16	AKLB-16	14.06	111.02	3.40	33.32	64.97	336.25
17	AKLB-17	18.85	116.47	4.77	35.01	65.17	309.00
18	AKLB-18	24.56	162.90	3.62	29.70	64.50	533.50
19	AKLB-19	20.87	181.90	2.85	28.71	122.55	559.75
20	AKLB-20	29.59	175.67	5.42	32.80	102.77	470.25
21	AKLB-21	32.54	790.87	4.95	53.57	238.75	884.50
22	AKLB-22	19.28	320.35	5.05	46.92	174.72	446.50
	Range	14.06-42.54	93.87-904.82	2.85-5.57	22.40-53.57	32.85-238.75	309.00-1888.00
	Mean	25.38	245.87	4.58	33.04	120.39	591.21
	SE(m)±	1.26	20.32	0.18	1.83	1.34	10.99
	CV	10	16.53	7.97	11.09	2.23	3.72
	CD at 5%	3.58	57.44	0.51	5.18	3.8	31.07



Variability In Bael Fruit Genotypes




Conclusion:

In the present investigation efforts were made for analysis of physical and morphological characteristics of bael fruit. On the basic of yield and contributing characteristics of bael the genotype AKLB -3 were found promising for improvement programme. Hence, these genotypes may be given consideration for improvement of yield and sensory qualities in bael. The genotype AKLB -3 is 2347.82 g of edible bael fruit pulp contain 1398.52 g, height of tree 5.73 m, total number of fruits per plant is 154, number of flower fascicle per is 24.58, number of fruits per fascicle is 2.92, fruit length 17.02 cm, fruit diameter 16.90 cm, pulp percent is 59.61 %, pulp: seed ratio 31.49, skull thickness is 4.65 mm and fruit yield per plant is 215.20 kg. The physical characteristics of fruit play a very important role in development of processing technology and on the quality of final products which assess the nutritional value.

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