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RESEARCH ARTICLE

Studies on Variability and Correlation in Bael (*Aegle marmelos* (L.) Correa)

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Bael is an underutilized, indigenous and designated as vulnerable species. The pilgrimage centre Shri Kalmurudeshwaraswamy matha of Sakharayapattana in Chikkamagaluru district in Karnataka, India has a sacred groove of bael trees. Due to natural sexual propagation they have acquired a high level of variability. Hence, the documentation and conservation of this groove is essential. A total of 356 trees of bael were evaluated for growth, fruit characters and showed considerable variations. Among 356 trees, SB-353 was found superior with respect to fruit characters *viz*., length (13 cm), volume (310 cm^3), weight (68.03 g), pulp weigh (202.40 g) and higher pupl:seed (10.22). For stability, the plus tree has to be evaluated for future usage in bael improvement.

Key Words: Bael, Correlation studies, Fruit morphological parameters, Tree morphological parameters

Introduction

Bael (*Aegle marmelos* (L) Correa) is one of the important underutilized, indigenous fruit crops of India, known for its high medicinal and nutritional values. It was found wild in the Sub-Himalayan tract and dry deciduous forests of Central and Southern India. Therefore, a large number of landraces are available in different diversity regions. Each tree is genetically diverse from others as most of them are of seedling origin. Individual tree varies greatly in their morphology; variation may be due to genetical or environmental or both. This heterozygous nature gives scope for further selection and the establishment of desirable trees. Information on magnitude of variation and association of characters is useful as a basis for the selection of desirable types. Hence, identification of elite trees for the region is necessary for promoting its production, productivity and quality of the fruits under the Southern Transitional Zone of Karnataka, India. Keeping in view the above facts investigation was conducted to characterize the bael trees for morphological, yield and yield attributing traits.

Material and Methods

The survey was conducted during 2018-19 in the Sakharayapattana, Chikkamagaluru district of Karnataka which is located between 13.431757° N latitude and 75.924549° E longitude with an elevation of 763 m above mean sea level. The experimental site is located in Central Dry Agro-climatic Zone of Karnataka with red sandy loam soils. The observations were recorded based on guidelines by PPV and FR. The colour of leaves was distinguished using colour chart of Royal Horticulture Society. The age of the trees were ranged between 20-40 years and grown widely. The height of trees was measured using Ravi altimeter. The data recorded during the investigation of morphological variations among 356 trees were analyzed using frequency distribution. Among 356 trees, 76 fruit bearing trees were subjected to fruit yield and quality parameters. These were grouped into 18 clusters based on cluster analysis (using SPSS software). Using cluster membership, superior 12 trees were selected and subjected to one way ANOVA (Gomez and Gomez, 1984). The correlation co efficient analysis was done using standard formulae described by Gomez and Gomez, 1984.

Results and Discussion

For selection of a superior tree it's important to study the vigour nature of tree. Tree height also represents the vigour nature of the trees. Maximum height (9 m) of the tree was observed in three trees SB-8, SB-9, SB-354 and it was minimum (4 m) in ten trees (SB-33, SB-35,

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SB-38, SB-39, SB-40, SB-41, SB-42, SB-44, SB-146 and SB-351).

Upright growth and spreading growth habit were observed in 274 trees 82 trees respectively. The variation in tree height and plant growth habit might be due to its inherent genetic character and existing climatic condition. These lines are under conformity with the results of Gupta and Mishra (2002), Rai *et al*. (2002) and Bhawna and Mishra (2011). Grey bark colour was observed in maximum trees (171). However, Greyish black colour was observed in a minimum number of trees (25) and other bark colours *viz*., greyish brown (97), brown (35), black (28) was also observed among the trees. Such variations in bark colour among the trees may be governed by it's a varietal expression and existing favourable environmental condition. Among the trees surveyed, a higher number of trees (275) showed irregular bark splitting habit and a lesser number (81) of trees showed rectangular bark splitting habit. It's directly influences the easy flow of phloem transportation of tree. The variation in bark splitting nature might be due to genotypic and phenotypic character associated with the trees. The observations are in agreement with the result of Parihar and Pandey (2019). Regarding leaf base cunate, round and tapering leaf base were observed in 217,7 and 132 trees respectively. With respect to leaf shape lanceolate (345 trees), broadly ovate shape (1 tree), ovate (8 trees) and lanceolate to ovate (2 trees) were recorded. The maximum number of trees (252) showed the crenulated type of leaf margin whereas; the minimum number of trees (104) recorded the crenate type of leaf margin. A greater variation in leaf base, leaf shape and leaf margin among the trees might be due to the presence of abundant genetic variability associated with their trees. Such variation may be due to its better photosynthetic activity and their utilization for building up of new cells and also might be due to the genomic constitution of individual tree. Such variation in leaf shape was previously reported by Saroj *et al.* (2008).

Bael trees observed significant differences in leaf colour Yellow-green leaves were observed in 185 trees whereas, green leaves were observed in 171 trees. The difference in leaf colour may be due to it's inherent genetic character and also due to physiological and metabolic changes in chlorophyll and photosynthetic activity involved in the colour variation of the leaf. No variability was observed for thorniness. Thorn length had a significant variation which was ranged from 3.2 to 6 cm. The variation in thorn length might be due to genotypic and phenotypic character associated with the trees. The result was in agreement with the previous author Parihar and Pandey (2019).

Variation in pomological characters is furnished in Table. 1. The length of fruit showed a significant variation on bael trees which was ranged from 6.50 cm to 13 cm. The longest length of fruit (13 cm) was observed in tree SB-353 which was statistically on par with SB-73 (12 cm) and a shorter length of fruit was recorded in tree SB-305 (6.50 cm). The variation in fruit length might be governed by genomic character associated with the trees and also favourable climatic condition. The results are in agreement with the findings of Kaushik *et al.* (2000), Nath *et al*. (2003) and Pandey *et al*. (2013). Maximum fruit volume was observed in tree SB-353 (310 cm^3) followed by trees SB-253 and SB-209 (160 cm^3 respectively) however, minimum was observed in tree SB-305. The variation in fruit volume due to positive interrelationship with fruit weight and also governed by its varietal expression of individual tree. The findings are in agreement by previous authors Lal (2002), Rai *et al.* (2002) and Singh and Mishra (2010). Fruit weight was ranged from 68.30g to 320g. Maximum weight (320 g) of fruit was registered in SB-353 tree followed by SB-209 and SB-187 (169 g) whereas, minimum fruit weight was observed in SB-305 (68.30 g). The difference in fruit weight attributed to an increase in fruit length, fruit volume, pulp weight, seed weight, skull weight of the fruits of the trees. The findings are also in agreement with the results of Ram and Singh (2003), Srivastava and Singh (2004) and Mitra *et al* (2010). Significantly maximum pulp weight was observed in tree SB-353 (202.40 g) and minimum was observed in tree SB-80 (27.70 g). An increase in pulp weight could have positively associated with higher fruit weight and it's negatively associated with seed weight. A variation in pulp content could be due to inheriting genetic makeup of the trees. The results are in agreement with the findings of Nidhi and Gehlot (2007). The highest number of locules per fruit was observed in SB-187 (10.67) whereas; the lowest was recorded in SB-73 (7.67). The difference in a number of locules per fruit might be due to varietal character associated with the trees. Similar results have been reported by Misra *et al* (2000) and Pandey *et al* (2008). Maximum skull thickness (6.76 mm) in SB-203 tree followed by SB-305 (6.50 mm) however, minimum skull thickness was

Table 1. Variability in pomological characters of bael tree

Tree	Fruit length (cm)	Fruit volume (cm^3)	Fruit weight (g)	Pulp weight per fruit (g)	No. locules per fruit	No. of seeds per locule	Skull thickness (mm)	No. of seeds per fruit	Seed weight per fruit (g)	Seed : Pulp	Pulp : Seed
SB-353	13.00 a	310.00 a	320.00 a	202.40 a	10.66 a	3.75 bc	4.95 c	40.00 b	19.80 b	0.10 h	10.22 a
SB-323	9.00 bc	130.00 c	138.50 d	70.50 c	8.33 c	3.96 b	4.29 d	33.00 cd	15.20 c	0.22 f	4.62 g
SB-305	6.50 d	60.00 f	68.30 g	51.50 g	8.67 c	2.54 cd	6.50 a	22.00 f	10.10 g	0.20 f	5.10 e
SB-275	7.50 cd	110.00 d	119.00 e	58.10 f	8.00 c	3.88 b	3.20 e	31.00 d	15.50 c	0.27 d	3.75 i
SB-297	7.20 d	110.00 d	122.00 e	60.98 e	9.00 b	2.11 d	4.50 cd	19.00 f	9.50 g	0.16 g	6.42 c
SB-253	10.00 b	160.00 b	155.70 c	75.59 b	8.00 c	3.13 c	5.67 b	25.00 ef	12.50 f	0.17 g	6.05 d
SB-209	8.50 c	160.00 b	169.00 b	74.30 b	9.67 b	6.93 a	3.89 d	67.00 a	39.57 a	0.53 a	1.88 l
SB-203	7.30 d	140.00 c	151.50 c	57.69 f	10.00 a	3.50 b	6.76 a	35.00 c	17.88 c	0.31 c	3.23 j
SB-187	7.30 d	160.00 b	169.00 b	57.69 f	10.67 a	2.72 c	5.91 b	29.00 de	14.50 d	0.25 e	3.98 h
SB-80	9.00 bc	80.00 e	85.90 f	27.70 i	9.00 b	2.89 c	5.50 b	26.00 e	13.22 ef	0.48 b	2.10 k
SB-123	9.00 bc	90.00 e	96.20 f	30.31 h	9.00 b	0.89 e	6.30 ab	8.00 g	3.07 h	0.10 h	9.87 b
SB-73	12.00 a	140.00 c	158.60 b	65.50 d	7.67 d	3.39 bc	4.89 c	26.00 e	13.50 e	0.21 f	4.85 f
F value	**	**	**	**	**	**	**	**	**	**	**
S.Em ±	0.35	5.77	4.31	0.82	0.32	0.17	0.17	1.05	0.27	0.01	0.08
CD @ 5%	1.01	16.85	12.58	2.38	0.93	0.51	0.50	3.08	0.79	0.02	0.22

** Significant at 5% and 1

observed in tree SB-275 (3.20 mm). Variation in skull thickness was noticed due to the distinct nature of the tree. The findings are also in agreement with the results of Mitra *et al.* (2010). Significantly minimum number of seeds per locule was observed in the SB-123 tree (0.89) and maximum number of seeds per locule was observed in the SB-209 tree (6.93). The decrease in seed number per locule has a positive correlation with higher pulp content. A similar variation in seed number per locule could be attributed to the inherited genetic makeup of the trees. Findings are in agreement with the results of Singh and Mishra (2010). Significantly maximum seed weight per fruit was observed in SB-209 (39.57 g) followed by SB-353 (19.80 g) and minimum seed weight per fruit was observed in SB-123 (3.07 g). The difference in seed weight was attributed to difference in the number and size of seeds among the trees. It was observed that the ratio of seed to pulp was maximum in SB-209 (0.53) followed by tree SB-80 (0.48) and it was found minimum in SB-353 and SB-123 (0.10 respectively). Pulp to seed ratio was found maximum in tree SB-353 (10.22) which was followed by SB-123 (9.87) and the minimum was observed in SB-209 (1.88) tree. These observations are in agreement with similar results have been reported by Nidhi and Gehlot (2007). An increase in pulp weight could have positively associated with higher fruit weight and it's negatively associated with seed weight.

Correlation studies

Correlation coefficient analysis measures the mutual relationship between various plant characters and determines the component characters on which, selection can be based. Correlation provides information on the nature and extent of relationship between all pairs of characters. Fruit length showed positively significant association with fruit volume, fruit weight and pulp weight. while with number of seeds per locule, number of seeds per fruit, seed weight per fruit showed positive non-significant association. Number of locules per fruit and skull thickness showed negative non-significant association. Fruit volume showed highly significant positive association with the characters like fruit weight and pulp weight per fruit. Whereas, characters like number of locules per fruit, number of locules per fruit, number of seeds per fruit and seed weight per fruit showed non-significant positive association with fruit volume. Skull thickness showed a negative non-significant association with fruit volume. Fruit weight

showed highly significant positive relation with pulp weight per fruit whereas for other parameters it showed a non significant relation. Number of locules per fruit showed non-significant association with all characters. It was observed highly significant positive association between number of seeds per locule and number of seeds per fruit, seed weight per fruit. Skull thickness showed a non significant negative association with for all characters except for number of locules per fruit it showed positive non significant association. Number of seeds per fruit showed highly significant positive association with seed weight per fruit. The results are also in-line with Divakara (2008).

Conclusion

Variations are recorded for all the 356 trees of bael for growth and fruit characters. It is concluded that among the 356 trees the tree SB-353 was found superior with respect to fruit characters (fruit weight, fruit length, fruit volume, pulp weight). Therefore, tree SB-353 to be evaluated further for stability and if found consistent can be used in the bael improvement programme.

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References

Bhawna and KK Misra (2011) Evaluation of bael trees for variation in yield, chlorophyll content and photosynthetic potential. *Mysore J. Agric. Sci.* **45**(2): 442-444.

Divakara BN (2008) Variation and character association for various pod traits in *Tamarindus indica* L. *Indian Forester*. **134**(5): 687-696.

Gomez KA and AA Gomez (1984) *Statistical procedures for agricultural research*. A Wiley-Inter Sci., John Wiley and Sons, New York.

Gupta NK and KK Misra (2002) Growth, yield and photosynthetic efficiency of bael (*Aegle marmelos*) trees in foot-hills region of Uttaranchal. *Indian J. Agric. Sci*. **72**(4): 220-222.

Kaushik RA, R Yamdagni and SS Dhawan (2000) Physico-chemical characteristics of bael fruit at green and ripe stage of maturity. *Haryana J. Hort. Sci.* **29**(1): 44-45.

Kaushik RA, R Yamdagni and SS Dhawan (2002) Seasonal changes during growth and developmant of bael (*Aegle marmelos* Correa.) fruit. *Haryana J. Hort. Sci*. **31**(1): 32-34.

Lal G (2002) Evaluation of bael (*Aegle marmelos* Correa) germplasm in semi-arid regions of Rajasthan. *Curr. Agric*. **26**(1): 127-129.

Misra KK, R Singh and HR Jaiswal (2000) Performance of bael (*Aegle marmelos*) trees under foot-hills region of Uttar Pradesh. *Indian J. Agric. Sci.* **70**(10): 682-683.

Mitra SK, CS Maity, D Mani and B Ghosh (2010) Genetic resources of bael (*Aegle marmelos* Correa) – a potential underutilized fruit. *Acta Hort*. **864**: 49-52.

Nath V, D Pandey and B Das (2003) Diversity of bael in East Central India. *Indian J. Pl. Genet. Resour.* **16**: 222-224.

Nidhi and Gehlot (2007) Studies on physico-chemical characteristics of fresh bael and guava fruits. *Resea. Crops.* **8(1):** 189-190.

Pandey D, SK Shukla and A Kumar (2008) Variability in bael accessions from Bihar and Jharkhand. *Indian J. Hort*. **65**: 226-229.

Pandey D, DK Tandon, U Hudedamani and M Tripathi (2013) Variability in bael (*Aegle marmelos* Corr.) trees from eastern Uttar Pradesh. *Indian J. Hort.* **70**(2): 170-178.

Parihar N and CS Pandey (2019) Studies on morphological variability in bael (*Aegle marmelos* Correa) gene pool of kymore plateau and satpura hill region. *Int. J. Agric. Sci.* **11**(6): 8078-8081.

Prasad Y and RP Singh (2001) Evaluation of bael (*Aegle marmelos* Correa) in Uttar Pradesh and Bihar areas. *Haryana J. Hort. Sci.* **30**(1): 70-71.

Rai D and Misra KK (2005) Studies on genetic divergence in bael (*Aegle marmelos* Correa.). *Indian J. Hort*. **62(2):** 152-154.

Rai D, KK Misra and VP Singh (2002) Analysis of genetic divergence in bael (*Aegle marmelos* Correa.) germplasm. *Prog. Agric.* **34**(1): 35-38.

Ram D and IS Singh (2003) Physico-chemical studies on bael (*Aegle marmelos* Correa.) fruits. *Prog. Hort*. **35**(2): 199-201.

Saroj PL, TA More and UV Singh (2008) Performance of bael (*Aegle marmelos*) cultivars under hot arid ecosystem of Rajasthan. *Indian J. Agric. Sci.* **78**(12): 1071-1074.

Singh VP and KK Misra (2010) Analysis of genetic variability and heritability in bael (*Aegle marmelos* Correa) germplasm. *Prog. Agric.* **10**(1): 132-134.

Srivastava KK and HK Singh (2004) Physico-chemical quality of bael (*Aegle marmelos* Correa) cultivars. *Agric. Sci. Digest*. **24**(1): 65-66.