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VARIABILITY STUDY IN BAEL (*Aegle marmelos Correa.*) GENOTYPES

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ABSTRACT : Genetic variability and correlation coefficient were studied in fifty genotypes of bael fruit at Horticulture Reasearch Centre and laboratory of the Department of Horticulture, SVPUA&T, Meerut in two consecutive years *i.e.,* 2013-14 and 2014-15. Data were recorded on 16 morphological and qualitative traits. Invariably commercially released cultivars *viz.,* Pant Shivani, Pant Aparna, Pant Sujata along with genotypes VB-28 and VB-23 exhibited higher yield and yield contributing traits. High values of GCV and PCV were observed for yield per tree, fruit pulp weight, fruit weight, seed weight, number of fruits per tree, ascorbic acid, skull weight, and reducing sugar. High heritability (in broad sense) along with high estimates of genetic advance (% of mean) was observed for almost all the characters viz. yield per tree, fruit weight, fruit pulp weight, skull weight, seed weight per fruit, T.S.S., ascorbic acid and total sugar. The present study also revealed the presence of great amount of genetic variability which offers bright prospects for its improvement in near future.

Keywords : *Bael, variability, heritability, genetic advance.*

Bael (*Aegle marmelos* Correa.) is an important deciduous aromatic fruit tree. It is widely grown and distributed throughout the country. It is an ancient fruit which is quoted in various famous religious holy books like *Ramayan, Mahabharat.* etc. It is also known as Shree Phal, Bengal quince, Bael fruit, Golden apple, Holy fruit, Indian quince, Stone apple, etc. Its leaves are used to worship "Lord Shiva", It belongs to family Rutaceae. Bael fruit is the important fruit in terms of medicinal value (Rai and Dwivedi, 15). All the parts of bael tree (roots, bark, leaves, branches, fruits) are consumed in the form of 'Panchang' for curing various diseases like ulcer, dysentery and diarrhoea, etc. It has 'marmelosin' constituent in fruits which protects our stomach from various stomach diseases.

Bael tree has gaining popularity in terms of socio-economic impact in large part of the country. It has significant contribution to improvement of economic status of orchardist through orcharding of bael nursery and processing of herbal product. Due to predominance of seedling propagation, India holds rich genetic diversity in cultivated and their wild relatives of bael. Genetic erosion of these resources is constantly high due to severe deforestation, natural calamities and mismanagement of genetic resources of bael. Only few promising cultivars are gaining popularity for commercial cultivation in selected pockets of Uttar Pradesh and neighbouring states of country. However, enormous variability in bael still remains unexploited and awaited proper attention on exploration, collection and maintenance of germplasms for conserving them from available genetic diversity of bael in the nature. Besides cultivated species of *Aegle marmelos*, some other available species can be utilized in bael improvement programme through defined breeding procedures.

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Knowledge of variability only does not give clear understanding for the improvement in promising cultivars through selection. Selection of promising cultivars are depends on the heritability and genetic advance. The high heritability coupled with high genetic advance would help in selection of promising types of plants for the further improvement. Genetic advance is directly related with heritability as it gives an idea about the expected genetic changes on account of selection applied for a particular trait. Genetic gain is the product of heritability and selection differential expressed in terms of phenotypic standard deviation. Heritability often fails to provide the estimate of absolute variability. It is, thus, important to use heritability value in conjunction with selection differential which will give

expected gain based on selection. Therefore, the present investigation was carried out to study the variability, heritability and genetic advance for sixteen morphological and quality characters in bael under Western Uttar Pradesh condition.

MATERIALS AND METHODS

The experiment was conducted at Horticultural Research Centre, Department of Horticulture, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (UP) during 2013-14 and 2014-15 with 50 genotypes of bael fruit. A total of 50 genotypes were selected from 20 years old orchard of bael. A total of 150 fruits for 50 treatments were used with Randomized Block Design consisted three replication and one unit per treatment for the study. Observations were recorded on morphological and qualitative characters and calculated the average pool data for various statistical analysis.

Number of fruits per tree was calculated by counting the number of fruits per tree. Fruit yield per tree was calculated by counting the number of fruits per tree and multiplying by the average fruit weight. Average fruit weight was recorded on the basis of cumulative weight of three fruits selected randomly on each marked tree and their values calculated by dividing the weight of fruits by the total number of fruits. Fruit length was measured with the help of scale meter. Fruit diameter was measured at the widest point of the fruit with the help of digital vernier calipers. Firstly, three fruits per sample were crushed to removing the pulp from the fruits, after removing the fruit skull and seeds separately rest of pulp was weighed and average value was find out. The skull weight was obtained after breaking the fruit and separated from pulp, with the help of weighing balance. After breaking the fruit, the thickness of skull was recorded with the help of digital vernier calipers. After separating the seeds thoroughly from pulp and washed, the number of seeds per fruit was calculated by counting the number of seeds per fruit. After washing the seeds thoroughly, weight of seeds per fruit was taken with the help of weighing balance. The quality parameters such as, TSS of pulp was determined with the help of refractometer. Acidity was estimated by simple acid-alkali titration method suggested by AOAC (1). Ascorbic acid content of fruit was estimated using standardized 2,6-dichloro- phenol indophenol dye and expressed as mg per 100 g pulp. Reducing sugar, non-reducing sugar, total sugars and ascorbic acid contents were analyzed by using standard methods suggested by AOAC (1). The statistical analysis was done according to methods given by Johnson *et al.* (4) and Allard (2).

RESULTS AND DISCUSSION

Analysis of variance revealed that all the parameters were found significant (Table 1). It is revealed from the data that all the genotypes varied for number of fruits per tree. Genotypes VB-1 had maximum number of fruits (101.67) followed by VB-36 (81.00). On the other hand genotypes VB-44 had minimum number of fruits (26.16) followed by VB-35 (26.83). The grand mean of character was 44.96. The yield per tree ranged from 6.38 in genotype VB-26 to 94.12 in cv. Pant Shivani to with a grand mean of 30.36. The highest fruit weight was recorded in cv. Pant Sujata (1831.33g) followed by Pant Shivani (1660.93g), whereas lowest fruit weight was found in genotype VB-26 (233.20) followed by VB-36 (244.97g). The grand mean was 638.45g for the trait. All genotypes showed wide range of variation with respect to fruit length. It was maximum in cv. Pant Sujata (17.20 cm) followed by VB-14 (16.34 cm), while, the minimum fruit length was found in genotype VB-36 (8.09) followed by VB-19 (8.26). The grand mean was 11.11 cm for the trait. Wide range in fruit diameter was observed in all the genotypes under studied. Cultivar Pant Sujata showed maximum fruit diameter (16.79 cm) followed by Pant Shivani (16.02 cm). On the other hand, VB-18 showed minimum fruit diameter (7.73 cm) followed by VB-26 (7.82 cm). the grand mean for fruit diameter was 10.38 cm. The maximum fruit pulp weight was recorded in cv. Pant Sujata (1650.85 g) followed by Pant Shivani (1495.79 g). Minimum fruit pulp weight was found in genotype VB-26 (123.32 g) followed by VB-19 (162.81 g). The grand mean was 480.49 g for the trait. Singh *et al.* (12) and Pandey *et al.* (11) have also reported similar findings. The minimum skull weight was recorded in genotype VB-36 (59.43 g) followed by VB-19 (84.56 g), whereas maximum skull weight was found in genotype VB-45 (211.66 g) followed by VB-37 (211.01 g). The grand mean for character was 150.17 g.

The minimum skull thickness was found in genotype VB-2 (2.02 mm) followed by VB-36 (2.03 mm), while maximum skull thickness was recorded in genotype VB-8 (3.76 mm) followed by VB-45 (3.72 mm). The grand mean was 2.76 mm for the trait. It is revealed from the Table that all the genotypes varied for number of seeds per fruit. It was lowest in VB-16 (51.50) followed by VB-23 (58.50) and highest in VB-2 (129.00) followed by VB-10 (126.17 g). The grand mean was 96.57 for the character. The seed weight per fruit was minimum in VB-14 (2.22 g) followed by VB-16 (2.23 g), whereas it was maximum in genotype VB-2 (14.68 g) followed by VB-33 (13.61 g). The grand mean

was 7.11g for the trait. This finding is also closely related with Kumar *et al.* (5 and 6).

The maximum total soluble solids were found in genotype VB-14 (48.45 °Brix) followed by VB-12 (47.36 °Brix) and it was minimum in VB-4 (24.29 °Brix)

Table 1 : Mean performance of 50 genotypes of bael for different morphological and qualitative characters based on pool data of 2013-14 and 2014-15.

Characters/ Genotypes	No. of fruits/ tree	Yield /tree (kg)	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Fruit pulp weight (g)	Skull weight (g)	Skull thickness (mm)	No. of seeds/ fruit	Seed weight /fruit (g)	TSS (°B)	Acidity (%)	Ascorbic acid (mg/ 100g)	Total sugar (%)	Reducing sugar (%)	Non reducing sugar (%)
VB-1	101.67	54.38	534.88	8.99	10.22	410.27	119.37	2.38	73.67	5.25	40.13	0.34	12.55	18.42	8.45	9.97
VB-2	52.33	21.95	419.31	9.13	9.78	320.09	84.58	2.02	129.00	14.68	36.36	0.28	10.07	15.23	6.28	8.95
VB-3	27.17	18.87	694.43	10.93	10.52	509.79	179.16	2.52	78.83	5.33	25.42	0.35	12.05	18.45	8.53	9.92
VB-4	76.00	32.51	427.75	10.81	8.89	198.64	189.49	3.19	89.00	6.28	24.29	0.29	12.06	18.47	8.57	9.89
VB-5	39.17	22.36	570.92	11.59	10.36	410.82	152.22	3.17	111.17	7.88	26.49	0.33	10.04	14.26	6.24	8.02
VB-6	43.00	23.07	536.45	10.87	10.65	322.81	209.33	3.63	78.17	4.28	29.37	0.28	9.55	19.35	9.24	10.11
VB-7	28.17	20.84	739.82	11.89	9.32	531.35	200.19	3.34	109.50	8.28	35.32	0.35	13.55	20.21	9.23	10.99
VB-8	26.50	15.65	590.47	11.85	9.63	372.47	209.64	3.77	110.67	8.37	28.41	0.33	10.04	19.65	9.70	9.95
VB-9	46.50	15.37	330.58	10.07	9.98	221.59	104.64	2.57	88.33	4.36	34.31	0.33	11.20	12.00	5.98	6.01
VB-10	33.33	29.57	887.14	11.80	11.36	673.38	200.46	2.84	126.17	13.30	32.53	0.37	15.54	20.67	9.67	10.99
VB-11	76.50	32.64	426.70	9.32	9.79	255.82	164.49	2.49	100.67	6.38	33.35	0.28	8.53	11.98	5.49	6.49
VB-12	52.17	58.11	1114.00	15.58	14.37	971.87	139.64	2.39	61.00	2.33	47.36	0.43	20.04	25.69	12.25	13.44
VB-13	26.67	8.21	308.00	8.30	8.53	183.12	120.51	2.34	108.67	4.36	38.26	0.28	9.05	14.65	6.30	8.35
VB-14	72.17	88.80	1230.47	16.35	15.00	1048.91	179.34	3.27	78.33	2.22	48.44	0.47	21.54	25.31	12.13	13.18
VB-15	28.17	14.83	526.29	10.67	10.73	408.16	109.74	2.23	116.67	8.39	25.37	0.39	17.03	21.55	9.59	11.97
VB-16	52.17	56.34	1080.00	14.37	11.86	927.30	150.47	2.51	51.50	2.23	45.35	0.43	19.04	24.20	11.72	12.48
VB-17	29.67	20.73	698.59	12.27	8.25	563.29	124.97	2.46	121.83	10.33	38.37	0.38	16.54	22.04	10.54	11.51
VB-18	32.17	9.23	286.82	9.33	7.73	168.93	114.51	2.37	90.50	3.37	28.31	0.27	8.53	13.64	6.68	6.95
VB-19	41.67	10.49	251.69	8.26	9.83	162.82	84.56	2.16	86.00	4.31	27.36	0.35	13.03	18.55	8.54	10.01
VB-20	37.00	17.35	468.93	9.25	9.39	312.30	149.33	3.14	99.17	7.31	35.49	0.38	15.53	20.27	9.53	10.74
VB-21	29.83	13.65	457.71	9.47	9.99	305.92	144.89	2.99	87.83	6.90	29.61	0.28	9.54	14.41	6.46	7.95
VB-22	28.50	13.07	458.39	9.81	9.60	311.68	139.79	2.89	81.50	6.93	39.48	0.26	8.87	13.50	6.49	7.01
VB-23	71.50	93.87	1312.89	14.39	13.26	1175.17	135.20	2.83	58.50	2.53	45.69	0.47	22.20	26.29	12.60	13.76
VB-24	26.83	14.00	521.54	9.55	9.25	311.52	200.70	3.34	120.00	9.32	35.65	0.37	14.53	15.16	6.29	8.87
VB-25	30.50	19.46	638.03	11.85	10.37	419.12	210.14	3.59	117.50	8.77	36.69	0.37	15.05	18.17	8.19	9.98
VB-26	27.33	6.38	233.21	8.28	7.82	123.32	104.56	2.38	91.83	5.33	31.97	0.27	10.03	16.55	7.53	9.02
VB-27	61.17	32.44	530.36	10.61	9.77	422.73	101.09	2.24	94.17	6.55	33.19	0.28	9.55	13.63	5.98	7.64
VB-28	66.50	89.56	1346.68	13.48	13.59	1244.95	99.43	2.09	72.33	2.30	37.49	0.37	20.54	24.01	11.49	12.52
VB-29	26.67	10.10	378.48	10.68	8.98	250.43	119.60	2.43	93.83	8.45	44.43	0.47	17.54	21.60	10.30	11.30
VB-30	61.83	22.80	368.65	9.03	8.89	241.03	120.24	2.44	96.17	7.38	40.21	0.41	17.04	20.59	9.60	10.99
VB-31	41.17	13.33	323.75	8.34	8.30	214.85	99.49	2.16	100.33	9.40	35.53	0.34	13.53	18.58	9.00	9.59
VB-32	28.17	9.14	324.31	8.89	8.39	215.20	100.43	2.20	117.33	8.68	25.41	0.29	11.53	16.19	7.26	8.93
VB-33	51.50	29.91	580.71	10.14	10.19	415.45	151.65	3.19	121.50	13.61	27.49	0.35	14.54	18.67	8.69	9.98
VB-34	29.50	15.85	537.08	10.49	9.97	402.39	124.32	2.47	112.00	10.38	26.62	0.33	12.54	16.92	7.29	9.62
VB-35	26.83	8.27	307.94	10.39	8.57	205.52	94.25	2.30	111.83	8.17	29.36	0.33	13.04	16.19	7.26	8.94
VB-36	81.00	19.85	244.99	8.09	8.18	173.17	59.43	2.03	121.17	12.38	34.87	0.34	12.54	16.66	7.71	8.95
VB-37	34.50	23.23	673.29	11.93	11.38	453.44	211.02	3.51	119.50	8.83	29.32	0.30	11.21	16.18	7.20	8.98
VB-38	55.83	45.99	823.65	12.67	12.16	701.74	119.50	2.45	72.17	2.41	41.72	0.50	22.54	25.86	12.47	13.40
VB-39	61.33	21.33	347.73	12.20	9.17	235.92	104.41	2.59	95.33	7.40	35.32	0.35	13.03	16.35	7.29	9.06
VB-40	37.00	16.21	437.94	9.88	9.03	230.37	201.17	3.34	91.17	6.40	26.24	0.28	10.04	13.33	6.25	7.08
VB-41	28.00	17.41	621.69	11.21	10.00	402.18	210.36	3.61	95.83	9.15	38.13	0.34	12.55	15.39	7.40	7.99
VB-42	31.50	12.27	389.41	8.38	9.29	225.32	159.77	2.53	82.00	4.32	28.45	0.34	13.04	16.87	7.90	8.97
VB-43	31.00	18.24	588.30	11.28	10.13	390.67	191.56	3.17	82.00	6.07	36.29	0.26	9.04	11.59	5.49	6.10
VB-44	26.17	22.11	845.04	11.93	10.60	624.02	208.68	3.40	119.17	12.34	31.46	0.31	9.54	12.89	6.50	6.39
VB-45	72.17	44.21	612.57	12.26	10.03	390.16	211.66	3.73	111.50	10.75	31.52	0.33	11.54	13.52	5.80	7.72
VB-46	41.67	23.86	572.58	10.56	9.51	355.33	207.93	3.22	107.00	9.33	28.55	0.7	14.04	15.31	7.67	7.64
VB-47	51.17	21.77	425.43	10.24	9.36	210.75	205.18	3.27	95.67	9.49	32.57	0.32	13.03	14.41	7.32	7.09
Pant Shivani	56.67	94.12	1660.93	16.18	16.03	1495.79	160.37	2.26	83.67	4.78	45.49	0.47	20.52	25.92	12.20	13.72
Pant Aparna	63.17	88.72	1404.45	14.54	13.98	1251.60	150.20	2.21	77.00	2.65	42.37	0.39	19.59	24.67	12.04	12.64
Pant Sujata	46.83	85.77	1831.33	17.20	16.79	1650.85	174.94	2.49	89.67	5.50	46.31	0.44	20.67	25.54	12.14	13.40
Mean	**44.96**	**30.36**	**638.45**	**11.11**	**10.38**	**180.49**	**150.17**	**2.76**	**96.57**	**7.11**	**34.56**	**0.35**	**13.77**	**18.19**	**8.49**	**9.70**
C.V.	3.40	4.48	1.94	3.74	1.49	2.72	1.67	3.03	2.42	2.78	1.05	5.56	1.49	0.96	2.25	2.77
C.D. (P = 0.05)	1.74	1.55	14.07	0.47	0.18	14.84	2.85	0.10	2.66	0.22	0.41	0.02	0.23	0.20	0.22	0.31

Table 2 : Mean, range, PCV, GCV, Heritability and genetic advance for different characters in bael based on pool data of 2013-14 and 2014-15.

Characters	Mean	Range	PCV	GCV	Heritability	GA	GA as % of mean
Number of fruits per tree	44.96	26.17–101.67	41.20	41.06	0.98	37.90	84.29
Yield per tree (kg)	30.36	6.38–94.12	83.43	83.31	0.99	52.04	161.37
Fruit weight (g)	638.45	233.21–1831.34	58.09	58.06	0.99	763.20	119.54
Fruit length (cm)	11.11	8.90–17.20	20.54	20.19	0.98	4.54	40.90
Fruit diameter (cm)	10.38	7.73–16.79	19.84	19.78	0.96	4.22	40.63
Fruit pulp weight (g)	480.49	123.32–1650.85	75.76	75.71	0.99	748.86	155.86
Skull weight (g)	150.17	59.44–211.66	29.08	29.03	0.99	89.67	59.71
Skull thickness (mm)	2.76	2.02–3.77	19.04	18.79	0.96	1.06	38.22
Number of seeds per fruit	96.57	51.50–129.00	19.60	19.45	0.97	38.39	39.75
Seeds weight per fruit (g)	7.11	2.22–14.68	44.93	44.85	0.99	6.56	92.21
T.S.S. (°B)	34.56	24.29–4.45	19.26	19.23	0.99	13.67	39.56
Acidity (%)	0.35	2.26–0.49	18.60	17.75	0.90	0.12	34.90
Ascorbic acid (mg per 100 g)	13.77	8.53–22.54	29.43	29.39	0.99	8.33	60.47
Total sugar (%)	18.19	11.59–26.29	23.47	23.45	0.99	8.78	48.26
Reducing sugar (%)	8.49	5.49–12.60	25.33	25.23	0.98	4.40	51.77
Non reducing sugar (%)	9.70	6.02–13.76	22.58	22.41	0.97	4.44	45.81

followed by VB-15 (25.37 °Brix). The grand mean was 34.56 for the trait. The maximum acidity was observed in genotype VB-38 (0.50%) followed by VB-14 (0.47%) and it was minimum in VB-22 and VB-43 (0.26%) followed by VB-21(0.27%). The grand mean was 0.35% for acidity. The highest ascorbic acid was recorded in genotype VB-38 (22.54 mg) followed by VB-23 (22.20 mg). Lowest ascorbic acid was found in VB-18 (8.53 mg) followed by VB-10 (8.54 mg). The grand mean was 13.77 mg for the trait. The highest total sugar was obtained from genotype VB-23 (26.29 mg) followed by Pant Shivani (25.92%), while genotype VB-43 produced lowest total sugar (11.59%) followed by VB-11 (11.99%). The grand mean was 18.19% for the trait. The highest reducing sugar was obtained from genotype VB-23 (12.60%) followed by VB-38 (12.47%), while genotypes VB-11 and VB-43 produced lowest reducing sugar (5.49%) followed by VB-45 (5.80%). The grand mean was 8.49 for the trait. The highest non reducing sugar was obtained from genotype VB-23 (13.75%) followed by Pant Shivani (13.72%), while genotype VB-9 produced lowest non reducing sugar (6.01%) followed by VB-43 (6.10%). The grand mean was 9.70% for the trait. Findings for nature and magnitude of variation for quality characters were also reported earlier by Pandey *et al.* (10) in aonla, Navprem *et al.* (8) in mango and Pandey *et al.* (11) in bael..

Analysis of variance revealed significant differences among the genotypes used in the present investigation for all the studied characters and indicated wide spectrum of variation among the genotypes (Table 2). The estimates of parameters of variability viz. grand mean, range of variation, phenotypic coefficient of variation, genotypic coefficient of variation, heritability in broad sense and expected genetic advance expressed as percentage of mean for different morphological and qualitative traits studied.High PCV and GCV (>25 %) was observed for yield per tree, fruit pulp weight, fruit weight, seed weight, number of fruits per tree, ascorbic acid, skull weight and reducing sugar, whereas moderate (10-25%) PCV and GCV values were recorded for total sugar, non reducing sugar, fruit length, fruit diameter, number of seeds per fruit, T.S.S., acidity and skull thickness. The results are also closely related with findings of Dalal and Beniwal (3) and Nayak *et al.* (9) and Srivastava *et al.* (14). Values of heritability in broad sense for all the characters were studied and very high heritability (> 60%) was observed for most of the characters viz. yield per tree (99%), fruit weight (99%), fruit pulp weight (99%), skull weight (99%), seed weight per fruit (99%), T.S.S. (99%), ascorbic acid (99%) and total sugar (99%) followed by number of fruits per tree (98%), fruit length (98%), reducing sugar (98%), number of seeds per fruit (97%), non reducing sugar(97%). fruit diameter (96%), skull thickness (96%) and acidity (90%). Genetic advance at 5% selection intensity and percentage of mean for various characters expressed as percentage of mean was observed high (> 20%) for almost all the characters i.e. number of fruits per tree, yield per tree, fruit weight, fruit length, fruit diameter, fruit pulp weight, skull weight, skull thickness, number of seeds per fruit, seed weight per fruit, T.S.S., acidity, ascorbic acid, total sugar, reducing sugar and non reducing sugar in both the individual environments and combined over

environments. Present findings are in erose line of Nayak *et al.* (9), Singh and Mishra (13) and Mir *et al.* (7).

CONCLUSION

Parent inbred line, *i.e.* VB-28, Pant Aparna, VB-23, Pant Shivani and Pant Sujata was found most superior genotypes as for as fruit yield is concerned for the Western Uttar Pradesh conditions. High values of GCV and PCV were observed for the was observed for yield per tree, fruit pulp weight, fruit weight, seed weight, number of fruits per tree, ascorbic acid, skull weight, and reducing sugar. High heritability (in broad sense) along with high estimates of genetic advance (% of mean) was observed with was observed for almost all the characters viz. yield per tree, fruit weight, fruit pulp weight, skull weight, seed weight per fruit, T.S.S., ascorbic acid and total sugar. The present study also revealed the presence of great amount of genetic variability which offers bright prospects for its improvement in near future.

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