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Variability and character association analysis in bael germplasm

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ABSTRACT

Genetic variability and correlation coefficient were studied in eighteen Bael genotypes. Data were recorded on 24 morphological and yield contributing traits. Invariably commercially released cultivars viz., Pant Shivani, Pant Urvashi, Pant Aparna, Pant Sujata, NB-1 along with one genotype PB-1 exhibited larger and broader leaflets with large sized flowers and floral organs. Leaf area and leaf fresh weight were also higher in these genotypes. High values of GCV and PCV were observed for the shoot length, leaf area, fruit yield and fruit weight. High heritability (in broad sense) along with high estimates of genetic advance (% of mean) was observed with fruit weight, leaf fresh weight and fruit yield. Keeping in view the estimates of correlation coefficients, selection for improvement in important fruit traits as weight, diameter, and length could be practiced on the basis of leaf length, leaf fresh weight and shoot length during the juvenile phases of plant growth. The present study also revealed the presence of great amount of genetic variability which offers bright prospects for its improvement in near future.

Key words: Bael, *Aegle marmelos*, genetic variability, heritability, correlation.

INTRODUCTION

Bael (*Aegle marmelos* Correa) occupies an important place among indigenous fruits of India due to its nutritional, medicinal and pesticidal values. In the absence of suitable cultivars, expected growth in production of this crop has not been accomplished till date. Identification of suitable genotypes, therefore, becomes imperative for promoting its production, productivity and quality of the produce. A wide range of variation is encountered in Bael (Rai *et al.*, 6) as it was largely propagated through seeds until recently. However, very little efforts have been made to quantify the genetic variability present in it and its utilization in crop improvement. As with any crop, plant breeding programme with fruit crops depends on knowledge of key traits, genetic system controlling their inheritance and genetic and environmental factors that influence their expression. The information about the nature and magnitude of genetic variability as well as associationship among key traits would be helpful in formulating an effective breeding programme for its genetic improvement. Therefore, the present investigation was undertaken to gather information on nature and magnitude variability, heritability, expected genetic gain and trait association in this crop. The information on such aspects would be of great significance in formulating appropriate breeding strategy for genetic upgradation of this valuable crop.

MATERIALS AND METHODS

The investigation was carried out at Horticultural Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar on Fifteen-year-old grafted trees of Bael planted at a distance of 5.0 metres in square system and maintained under uniform cultural practices. The experimental material consisted of eighteen selected Bael genotypes and the experiment was laid out in randomized block design with three replications and each treatment had one tree per replication. Twenty shoots spread over four directions were tagged and data were recorded during 2004-06 on twenty four traits viz., tree height, tree spread, stem girth, leaf length, petiole length, leaf fresh weight, shoot length, leaf area, flower length, flower breadth, petal length, petal breadth, ovary length, ovary diameter, bud length at flower opening, bud breadth at flower opening, fruit yield/ tree, fruit length, fruit diameter, fruit weight, fibre content, T.S.S., acidity and ascorbic acid content. The genotypic and phenotypic coefficients of variation, heritability (in broad sense) and expected genetic advance (% of mean) were calculated as per standard statistical procedure (Burton and DeVane, 2; Johnson *et al.*, 3). The correlation coefficients were estimated as suggested by Al Jibouri *et al.* (1).

RESULTS AND DISCUSSION

Highly significant differences among genotypes were

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observed for all twenty four traits under investigation (Table 1). A perusal of the data revealed that the genotypes which were released for commercial cultivation i.e. Pant Shivani, Pant Urvashi, Pant Sujata, Pant Aparna and NB-1 along with one genotype PB-1 invariably showed larger and broader leaflets with large sized flowers and floral organs. Leaf area and leaf fresh weight were also higher in these genotypes. These traits might have

Table 1. Mean performance of different genotypes for various traits in Bael (Pooled means).

Genotypes	Tree height (m)	Tree spread (m)	Stem girth (cm)	Leaf length (cm)	Petiole length (cm)	Leaf fresh wt. (g)	Shoot length (cm)	Leaf area (cm^2)	Flower length (cm)	Flower breadth (cm)	Petal length (cm)	Petal breadth (cm)
PB-1	6.86	7.40	77.50	18.48	4.32	3.85	43.33	120.67	1.47	3.80	1.87	0.93
PB-2	6.81	6.43	73.93	14.61	3.82	2.54	58.33	65.18	1.29	3.32	1.57	0.73
PB-3	7.43	7.05	89.00	14.48	4.12	2.59	28.00	75.11	1.26	3.23	1.56	0.72
PB-4	6.40	6.18	71.90	16.01	3.75	2.62	35.67	78.19	1.34	3.61	1.79	0.75
Pant Shivani	6.68	7.13	82.73	19.93	4.60	4.71	70.67	143.25	1.51	3.98	1.92	0.83
Pant Urvashi	6.43	5.69	76.35	19.69	4.63	4.69	92.33	145.17	1.50	4.00	1.98	0.85
PB-7	6.23	6.03	63.93	14.13	4.00	2.30	61.33	62.76	1.43	3.63	1.76	0.76
NB-1	6.85	5.97	73.21	18.99	4.53	4.25	70.00	137.44	1.45	3.96	1.86	0.87
Pant Aparna	5.98	5.58	74.10	18.37	4.53	4.35	61.66	135.86	1.38	3.17	1.52	0.77
PB-10	6.80	5.06	72.06	13.93	3.72	2.44	63.66	60.11	1.12	3.02	1.50	0.68
PB-11	6.76	5.48	78.60	16.60	4.09	4.49	56.66	112.30	1.34	3.54	1.75	0.80
Pant Sujata	6.78	6.45	72.70	17.91	4.35	3.92	98.00	125.50	1.48	3.93	1.89	0.93
PB-13	7.38	6.45	88.50	14.40	3.78	2.43	96.66	64.13	1.10	2.73	1.39	0.69
PB-14	6.65	5.65	78.86	16.08	4.12	2.86	81.33	105.38	1.25	3.06	1.43	0.70
PB-15	5.86	6.87	79.86	15.91	4.19	2.60	97.33	88.82	1.30	3.40	1.63	0.74
PB-16	5.81	6.04	73.13	16.34	4.65	2.52	55.00	84.17	1.24	3.63	1.61	0.70
PB-7B	5.56	4.93	74.36	16.00	4.72	3.28	63.00	107.53	1.33	3.58	1.73	0.72
PB-8B	6.50	5.40	94.73	10.33	3.19	1.23	56.33	87.00	1.05	2.56	1.28	0.61
C.D.(p=0.05)	0.817	0.972	7.315	1.658	0.197	0.295	26.170	5.860	0.078	0.161	0.091	0.047

Contd.

Genotypes	Ovary length (cm)	Ovary diameter (cm)	Bud length at flower opening (cm)	Bud breadth at flower opening (cm)	Fruit yield/ tree (no.)	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (kg)	Fibre content (%)	T.S.S. (%)	Acidity (%)	Ascorbic acid (mg/100 g)
PB-1	0.41	0.42	1.30	0.99	35.00	12.37	12.22	2.09	3.15	38.18	0.78	21.78
PB-2	0.36	0.37	1.26	0.81	40.33	11.60	10.50	0.57	3.04	40.72	0.85	15.83
PB-3	0.24	0.31	1.13	0.82	34.67	12.78	12.34	0.75	3.02	35.80	0.72	24.56
PB-4	0.32	0.36	1.30	0.91	29.33	11.90	11.18	1.20	3.04	39.12	0.81	16.97
Pant Shivani	0.40	0.43	1.38	1.10	38.67	16.94	16.03	1.99	3.43	34.18	1.31	15.70
Pant Urvashi	0.42	0.43	1.39	1.14	37.67	15.72	15.35	2.06	3.15	35.15	1.09	17.76
PB-7	0.31	0.33	1.30	0.81	32.67	15.18	14.45	1.90	3.16	31.95	0.75	16.30
NB-1	0.28	0.40	1.25	0.90	33.00	15.22	13.84	2.10	3.25	31.38	0.70	18.40
Pant Aparna	0.34	0.39	1.31	0.87	36.67	14.28	13.41	1.03	3.06	30.90	0.81	15.46
PB-10	0.31	0.29	1.10	0.74	40.00	11.85	10.88	1.13	2.58	31.70	0.80	12.50
PB-11	0.28	0.35	1.25	0.83	46.00	13.00	11.78	1.06	4.03	32.20	0.97	12.93
Pant Sujata	0.41	0.42	1.32	1.00	36.00	16.02	15.01	1.80	2.95	26.93	0.75	15.10
PB-13	0.28	0.29	1.07	0.75	36.33	15.08	12.84	1.10	3.18	31.08	0.98	12.56
PB-14	0.30	0.36	1.24	0.80	30.67	12.53	11.75	1.07	2.24	33.90	0.80	15.53
PB-15	0.39	0.35	1.30	0.90	34.67	12.24	11.15	1.10	2.92	31.47	0.71	16.36
PB-16	0.33	0.35	1.18	0.85	34.00	13.30	12.15	1.65	3.11	32.45	0.82	16.66
PB-7B	0.33	0.37	1.35	0.88	36.33	16.54	15.63	1.09	2.63	30.53	0.84	17.20
PB-8B	0.24	0.25	1.04	0.72	48.00	10.93	10.00	1.65	3.16	31.36	0.71	18.10
C.D. (p=0.05)	0.030	0.037	0.061	0.040	5.381	0.465	0.562	0.113	0.176	1.236	0.247	0.551

improved the photosynthetic efficiency and thus ultimate growth potential of the plant. Individual fruit weight was also found to be higher in these genotypes expect Pant Aparna which had lower fruit weight.

Coefficient of variation is a good indicator of the extent of variation and high magnitudes of genotypic and phenotypic coefficients of variation (GCV and PCV) were observed for the shoot length, leaf area, fruit yield and fruit weight. These values suggest a scope for improvement of these traits through selection. In general, the PCV was higher in magnitude than their corresponding GCV for all the traits. Closeness between GCV and PCV for most of the traits under investigation indicates that the phenotypic expression of all the genotypes is under genetic control and environment has slight influence. This also suggests that phenotypic variability is a reliable measure of genotypic variability.

Broad sense heritability has a primary use when both the additive and non-additive genetic variation can be transferred from parents to off-springs such as when vegetative propagation is used. Therefore, estimation of broad sense heritability is valuable in vegetatively propagated crops. However, for more reliable conclusions, Johnson *et al.* (3) suggested that heritability estimates coupled with genetic gain would be more meaningful. In present investigation, high heritability along with high estimates of genetic advance (% of mean) was observed with fruit weight, leaf fresh weight and fruit yield/ tree. These characters also exhibited high GCV, therefore, selection based on phenotypic performance for these traits would be effective in improving these characters directly in the population. Panse (5) suggested that if the heritability is mainly due to additive gene effects, it would be associated with high genetic advance and if it is due to non-additive effects the genetic gain would be low. High values of GCV and heritability estimates supplemented with greater genetic gains are also indicative of such traits (Narayan *et al.*, 4), therefore, these traits reflect greater selective values and offer ample scope for efficient selection. High heritability coupled with moderate genetic advance for leaf length, leaf area, ovary length, ascorbic acid, acidity, fruit length and fruit diameter might also be attributed to additive gene action controlling their expression and phenotypic selection for

Table 2. Estimates of variance components and related genetic parameters for various traits in Bael.

Sl. No.	Character	Mean	Range	GCV (%)	PCV (%)	Heritability (%)	Genetic advance (% of mean)
1.	Tree height	6.54	5.56-7.43	7.26	10.40	48.29	10.39
2.	Tree spread	6.10	4.93-7.40	11.96	15.13	62.46	19.46
3.	Stem girth	77.53	63.93-94.73	10.45	11.92	76.82	18.87
4.	Leaf length	16.23	10.33-19.93	13.63	16.52	92.74	36.52
5.	Petiole length	4.23	3.19-4.63	3.27	9.34	48.39	10.67
6.	Leaf fresh weight	3.20	1.23-4.71	36.85	39.30	91.25	64.12
7.	Shoot length	66.07	28.00-98.00	27.71	37.60	78.13	24.56
8.	Leaf area	99.92	60.11-145.17	19.36	23.83	65.99	32.39
9.	Flower length	1.32	1.05-1.51	9.87	11.13	87.13	17.96
10.	Flower breadth	3.45	2.56-4.00	10.13	10.75	92.16	21.15
11.	Petal length	1.67	1.28-1.98	13.28	14.93	85.67	25.11
12.	Petal breadth	0.77	0.61-0.92	12.77	13.98	86.85	23.54
13.	Ovary length	0.33	0.24-0.42	14.84	17.15	81.06	32.60
14.	Ovary diameter	0.36	0.25-0.43	13.28	17.19	69.48	17.94
15.	Bud length at flower opening	1.25	1.04-1.39	5.77	7.20	87.75	13.40
16.	Bud breadth at flower opening	0.90	0.72-1.14	14.27	15.41	90.05	18.67
17.	Fruit yield/ tree	36.67	29.33-48.00	30.59	33.17	87.24	57.36
18.	Fruit length	13.75	10.93-16.94	13.88	13.97	98.81	28.43
19.	Fruit diameter	12.81	10.00-16.03	14.75	14.87	98.45	30.16
20.	Fruit weight	1.41	0.57-2.10	34.67	35.18	98.30	70.58
21.	Fibre content	3.06	2.24-4.03	12.65	13.02	94.39	25.30
22.	T.S.S.	33.28	26.93-40.72	9.27	9.52	94.83	18.60
23.	Acidity	0.85	0.70-1.31	15.27	15.61	95.71	30.70
24.	Ascorbic acid	16.65	12.50-21.78	18.23	18.29	99.30	34.41

Table 3. Genotypic (above diagonal) and phenotypic (below diagonal) correlation coefficients among various traits in Bael.

	Character	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	Tree height	-	0.656*	0.544*	0.051	0.423	0.214	0.254	-0.243	0.119	0.068	0.215	0.009	-0.078	-0.176	0.256	0.234	0.181	-0.109	-0.175	-0.059	0.247	0.374	0.085	0.188
2	Tree spread	0.550*	-	0.363	0.286	0.373	0.122	0.183	0.359	-0.161	0.089	-0.090	0.175	0.251	0.210	0.122	0.154	-0.270	0.105	0.113	0.164	0.120	0.443	0.224	0.489*
3	Stem girth	0.264	0.242	-	-0.552*	-0.205	-0.267	-0.009	0.080	-0.018	0.067	0.089	0.191	0.200	-0.078	-0.105	0.063	0.578*	-0.363	-0.407	-0.205	0.146	0.158	0.065	0.310
4	Leaf length	0.015	0.292	-0.512*	-	0.509*	0.835*	-0.038	0.914*	0.885*	0.624*	0.892*	0.410	0.453*	0.368	0.782*	0.558*	-0.092	0.389	0.452*	0.492*	0.015	0.167	0.027	0.325
5	Petiole length	0.412	0.296	-0.182	0.491*	-	0.510*	-0.219	0.609*	0.681*	0.482*	0.570*	0.389	0.400	0.317	0.461*	0.358	-0.044	0.214	0.263	0.023	0.144	0.343	-0.114	0.374
6	Leaf fresh weight	0.001	-0.096	-0.240	0.744*	0.311	-	0.121	0.952*	0.785*	0.461*	0.492*	0.427	0.431	0.273	0.495*	0.397	0.194	0.432	0.366	0.499*	0.371	-0.184	0.629*	-0.285
7	Shoot length	0.210	0.169	-0.062	-0.087	-0.118	0.029	-	0.032	0.371	0.088	0.292	0.132	0.191	0.050	0.161	0.021	-0.213	0.807*	0.712*	0.615*	-0.121	-0.375	0.453*	-0.087
8	Leaf area	-0.194	0.309	0.056	0.832*	0.541*	0.931*	0.029	-	0.825*	0.622*	0.882*	0.459*	0.472*	0.298	0.689*	0.399	0.072	0.242	0.178	-0.384	0.504*	-0.065	0.674*	-0.219
9	Flower length	0.110	-0.172	-0.021	0.819*	0.642*	0.710*	0.351	0.810*	-	0.904*	0.886*	0.836*	0.706*	0.940*	0.900*	0.883*	-0.132	0.651*	0.599*	0.619*	0.017	0.311	0.357	0.327
10	Flower breadth	0.416	0.078	0.058	0.610*	0.433	0.435	0.063	0.638*	0.869*	-	0.996*	0.793*	0.555*	0.859*	0.908*	0.840*	-0.117	0.468*	0.448	0.548*	0.063	0.158	0.264	0.266
11	Petal length	0.199	-0.100	0.081	0.851*	0.520*	0.471*	0.264	0.832*	0.842*	0.974*	-	0.803*	0.571*	0.838*	0.891*	0.848*	-0.078	0.640*	0.613*	0.756*	0.033	-0.127	0.157	0.191
12	Petal breadth	0.004	0.159	0.175	0.125	0.281	0.383	0.115	0.412	0.779*	0.757*	0.766*	-	0.677*	0.871*	0.809*	0.735*	0.029	0.668*	0.578*	0.726*	-0.017	-0.069	0.151	0.032
13	Ovary length	-0.080	0.191	0.191	0.443	0.355	0.391	0.168	0.437	0.639*	0.543*	0.513*	0.562*	-	0.735*	0.709*	0.721*	0.232	0.400	0.383	0.359	-0.083	0.212	0.033	-0.158
14	Ovary diameter	-0.181	0.185	-0.082	0.355	0.262	0.255	0.037	0.254	0.790*	0.778*	0.768*	0.744*	0.694	-	0.893*	0.954*	-0.098	0.392	0.472*	0.662*	-0.023	0.098	0.067	-0.077
15	Bud length at flower opening	0.198	0.110	-0.110	0.752*	0.417	0.478*	0.147	0.651*	0.954*	0.894*	0.865*	0.755*	0.676*	0.791*	-	0.883*	-0.058	0.557*	0.493*	0.610*	0.025	0.253	0.318	-0.211
16	Bud breadth at flower opening	0.215	0.139	0.054	0.520*	0.273	0.355	0.008	0.344	0.831*	0.810*	0.797*	0.693*	0.671*	0.805*	0.865*	-	-0.074	0.215	0.366	0.523*	0.018	0.178	0.166	0.005
17	Fruit yield/ tree	0.132	0.172	0.463*	0.270	-0.177	0.153	-0.064	0.060	-0.099	-0.082	-0.039	0.034	0.227	-0.007	-0.049	-0.071	-	-0.400	-0.533*	-0.171	0.021	-0.010	-0.018	-0.028
18	Fruit length	-0.089	0.067	-0.321	0.360	0.210	0.428	0.580*	0.233	0.610*	0.430	0.611*	0.649*	0.346	0.213	0.528*	0.202	-0.367	-	0.975*	0.453	0.166	0.389	0.575*	-0.009
19	Fruit diameter	-0.114	0.077	-0.357	0.446	0.256	0.360	0.522*	0.174	0.533*	0.414	0.588*	0.555*	0.351	0.579*	0.458*	0.291	-0.451*	0.717*	-	0.550*	0.145	-0.333	0.485*	0.111
20	Fruit weight	-0.024	0.137	-0.171	0.469	0.024	0.455*	0.170	0.036	0.595*	0.696*	0.727*	0.693*	0.327	0.582*	0.601*	0.508	-0.161	0.449	0.545*	-	0.262	-0.236	0.170	0.228
21	Fibre content	0.111	0.072	0.082	0.057	0.133	0.356	-0.066	0.487*	0.005	0.063	0.015	-0.002	-0.095	-0.017	0.009	0.011	0.015	0.167	0.147	0.241	-	0.015	0.481*	-0.089
22	T.S.S.	0.242	0.314	0.145	0.144	0.325	-0.177	-0.225	-0.055	0.255	0.093	-0.132	-0.107	0.174	0.054	0.201	0.136	-0.051	-0.376	-0.318	-0.231	0.021	-	0.186	0.274
23	Acidity	0.085	0.196	0.095	0.039	-0.082	0.401	0.311	0.446	0.288	0.204	0.099	0.108	0.018	0.035	0.261	0.111	-0.032	0.361	0.326	0.119	0.295	0.208	-	-0.271
24	Ascorbic acid	0.144	0.399	0.266	0.291	0.366	-0.201	-0.058	-0.213	0.277	0.127	0.144	0.019	-0.168	-0.014	-0.237	0.004	-0.014	-0.030	0.111	0.206	-0.092	0.262	-0.232	-

*Significant at 5% level

their amelioration could be brought about by simple methods like mass selection.

The correlation parameters in general indicated high magnitude of genotypic correlation coefficients then the phenotypic ones for most of the characters studied (Table 3). High genotypic correlation coefficient suggests that there was inherent relationship between the traits under study and environment had not played much role in reducing their actual association. Of several pairs of correlations among quantitative traits, the correlation involving fruit yield along with other fruit traits as fruit length, fruit diameter, and fruit weight deserves special mention as these characters would be of primary interest for any fruit breeding programme. Further large plant size and long periods of juvenility severely impede the process of cultivar improvement in tree fruits. Hence the significant positive correlation between any trait which can be studied early in the juvenile phase and fruit traits having the economic importance would be of great significance in any fruit improvement programme. In the present investigation, leaf length and leaf fresh weight showed significant and positive correlation with fruit weight at both genotypic and phenotypic levels. Shoot length was significantly and positively associated with fruit length, fruit diameter and fruit weight at genotypic level, however, at phenotypic level, it had significant positive association with fruit length and fruit diameter. Leaf area exhibited significant positive correlation with fibre content at both the levels. None of the trait which can be studied at early phase of plant growth showed significant positive association with fruit yield/ tree (no.). The genotypes which had larger and broader leaflets with high leaf area and leaf fresh weight invariably showed large sized flowers and floral organs. Hence most of the floral organs exhibited significant positive correlation with leaf length, leaf fresh weight and leaf area. These floral traits in most of the cases also showed significant positive association with fruit length, fruit diameter and fruit weight. Fruit length and fruit diameter were significantly and positively correlated with each other and both traits were significantly and positively correlated with fruit weight.

Keeping in view the estimates of correlation coefficients, selection for improvement in economically important fruit traits viz., weight, length and diameter could be practiced on the basis of leaf length, leaf fresh weight and shoot length during the initial periods of plant growth. The present investigation also revealed that the wealth of genetic variability available in Bael offer bright prospects for its improvement in near future.

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