

Variability in Growth, Yield and Photosynthetic Parameters in Clones of Bael (*Aegle marmelos* Correa)

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Abstract

Nineteen clones of bael (*Aegle marmelos* Correa) were evaluated in 15 different traits during 2008-2010. Significant differences were observed for almost all the characters under study viz., tree height, tree spread, stem girth, tree volume, leaf area, per cent dry weight of leaf, chlorophyll *a* content, net photosynthetic rate (P_n), transpiration rate (*E*), stomatal conductance (g_s), internal CO_2 concentration (C_i), water use efficiency (WUE), mesophyll efficiency, yield and yield efficiency. A positive and significant correlation was found in tree height and tree volume, tree height and stem girth, chlorophyll content and P_n , C_i and P_n , *E* and C_i , WUE and P_n , WUE and mesophyll efficiency, yield and tree volume, stem girth and yield, yield and mesophyll efficiency. A positive but non-significant correlation was observed between P_n and yield.

Key words : *Aegle marmelos*, Clones, Growth, Photosynthetic rate, Yield.

Bael (*Aegle marmelos* Correa) has attained an important position among fruits in India because of its high medicinal, pesticidal and nutritional values. Bael belongs to the family Rutaceae and indigenous to India. The bael fruit is most nutritious and provide a lot of vitamins and minerals. It also contains riboflavin and marmelosin. Pulp of ripe fruits is tasty and can be consumed afresh or made into Sharbat which is one of the most popular drinks in the Indian subcontinent. Bael fruit has an untapped potential for being processed into products which can be attract both the internal and export markets (1). The plant produces timber and is especially valuable in reforestation program in arid and semi-arid areas and in wastelands because of its high drought tolerance and can be grown successfully in soils having pH range between 5—10 (2). However, 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. Though a wide range of variation is encountered in bael (3), no systematic work has been done on bael to analyze the amount of

clonal variability in relation to photosynthetic characteristics and its utilization in crop improvement. Productivity is governed by photosynthetic efficiency of the plant which, in turn, is affected by duration of photosynthesis, changes of photosynthesis with leaf size and age, efficiency of CO_2 assimilation, the rapidity with which leaf area enlarges to absorb the available solar radiation, plant height, photosynthesis by organs other than leaves and the efficiency of transport of photosynthates to the tissue is of economic importance. Since no such work has been done in Bael, therefore, the present study was undertaken to assess the clonal variation and correlation analysis of growth and photosynthetic characteristics in clones of bael.

Methods

An experiment was conducted at Horticultural Research Center, Patharchatta, Department of Horticulture, College of Agriculture, Govind Ballabh Pant University of Agriculture & Technology, Pantnagar, Uttarakhand during 2008—2010. Pantnagar is situated at 29° N latitude, 79.3° E longi-

Table 1. Growth parameters in various clones of bael.

Clones	Tree height (m)			Tree spread (m)			Stem girth (cm)		
	2008-09	2009-10	Mean	2008-09	2009-10	Mean	2008-09	2009-10	Mean
Pant Bael-1	7.75	7.75	7.75	6.57	7.05	6.81	94.75	97.75	96.25
Pant Bael-2	7.37	7.57	7.47	5.40	6.01	5.70	83.00	85.50	84.25
Pant Bael-3	7.52	7.35	7.43	7.25	7.35	7.30	103.50	104.60	104.05
Pant Bael-4	7.92	7.80	7.86	6.37	6.52	6.44	89.65	91.80	90.72
Pant Shivani	7.80	7.75	7.77	5.87	6.35	6.11	99.15	100.10	99.62
Pant Urvashi	7.55	7.65	7.60	5.18	5.36	5.27	90.50	91.35	90.92
Pant Bael-7	7.50	7.28	7.39	5.39	5.49	5.44	81.25	83.42	82.33
Pant Aparna	7.10	7.32	7.21	6.58	6.70	6.64	92.75	94.44	93.59
Pant Bael-10	7.80	7.63	7.71	5.85	5.95	5.90	85.00	86.45	85.72
Pant Bael-11	9.05	9.25	9.15	4.94	5.10	5.02	72.75	81.82	77.28
Pant Sujata	8.20	8.30	8.25	6.33	6.05	6.19	89.80	90.85	90.32
Pant Bael-13	8.80	8.10	8.45	5.16	5.26	5.21	98.50	100.85	99.67
Pant Bael-14	7.77	7.34	7.55	5.56	5.68	5.62	89.50	92.70	91.10
Pant Bael-15	7.20	7.29	7.24	6.41	6.51	6.46	85.75	88.34	83.29
Pant Bael-16	6.50	6.85	6.67	7.09	7.19	7.14	98.25	99.74	98.99
Pant Bael-17	5.62	5.72	5.67	5.78	5.90	5.84	64.75	66.66	65.70
Pant Vishal	5.60	5.68	5.64	4.88	4.98	4.93	60.00	61.83	60.91
NB-7	5.50	5.58	5.54	4.88	4.92	4.90	67.00	68.75	67.87
NB-9	5.50	5.60	5.55	4.20	4.68	4.44	58.00	60.40	59.20
SE ±	0.405	0.211	0.123	0.586	0.489	0.478	6.640	4.954	0.887
CD (<i>P</i> = 0.05)	1.20	0.62	0.368	NS	1.454	1.420	19.731	14.719	2.637

Table 1. Continued.

Clones	Tree volume (m ³)			Leaf area (cm ²)			Dry wt of leaf (%)		
	2008-09	2009-10	Mean	2008-09	2009-10	Mean	2008-09	2009-10	Mean
Pant Bael-1	173.69	202.90	188.29	138.82	140.00	139.41	45.95	40.88	43.41
Pant Bael-2	113.12	143.09	128.10	53.00	52.68	52.84	39.28	34.70	36.99
Pant Bael-3	207.51	207.98	207.74	69.70	70.00	69.85	37.89	37.28	37.58
Pant Bael-4	168.19	173.53	170.86	100.50	104.50	102.50	38.56	35.38	36.97
Pant Shivani	141.96	165.37	153.66	87.35	89.25	88.30	48.05	47.03	47.54
Pant Urvashi	109.58	116.52	113.05	93.58	90.58	92.08	44.27	43.36	43.81
Pant Bael-7	114.59	115.68	115.13	101.35	100.35	100.85	35.55	35.27	35.41
Pant Aparna	160.45	172.13	166.29	99.74	99.50	99.62	36.51	34.04	35.27
Pant Bael-10	140.30	147.03	143.66	35.70	36.20	35.95	45.78	48.46	47.12
Pant Bael-11	121.72	126.98	124.35	74.30	73.40	73.85	32.99	34.43	33.71
Pant Sujata	168.40	160.27	164.33	94.12	95.20	94.66	52.19	49.04	50.61
Pant Bael-13	129.81	118.45	124.13	115.39	106.40	110.89	29.53	30.25	29.89
Pant Bael-14	126.14	123.93	125.03	101.02	104.00	102.51	33.74	35.69	34.71
Pant Bael-15	165.55	164.96	165.25	61.47	64.50	62.98	40.04	39.03	39.53
Pant Bael-16	170.58	185.64	178.11	82.15	88.10	85.12	30.72	30.40	30.56
Pant Bael-17	98.60	104.25	101.42	51.10	53.55	52.32	31.41	30.80	31.10
Pant Vishal	69.49	73.89	71.69	143.15	145.25	144.20	57.03	56.16	56.59
NB-7	68.82	70.88	69.85	135.16	139.15	137.15	58.75	56.65	57.70
NB-9	52.09	64.42	58.25	91.75	92.25	92.00	31.79	31.73	31.76
SE ±	28.414	23.224	23.016	0.513	0.763	1.587	1.292	1.603	1.024
CD (<i>P</i> = 0.05)	NS	69.002	68.384	1.526	2.267	4.717	3.834	4.763	3.043

tudes and at an altitude of 243.8 m above mean sea level. The experimental material consisted of 22 - year old grafted trees of 19 selected genotypes of

bael. The experiment was laid out in randomized block design with two replications and each treatment has one tree per replication. All the recommended cultural

Table 2. Variation on net photosynthetic rate (P_n), transpiration rate (E), stomatal conductance (g_s), internal CO_2 concentration (C_i), water use efficiency (WUE) and mesophyll efficiency (P_n / C_i) in bael clones.

Clones	P_n (μ mol / m^2 / s)			E (m mole / m^2 / s)			g_s (m mole / m^2 / s)		
	2008-09	2009-10	Mean	2008-09	2009-10	Mean	2008-09	2009-10	Mean
Pant Bael-1	10.6	10.4	10.5	5.92	6.22	6.07	67	68	67.5
Pant Bael-2	6.0	6.2	6.1	4.68	4.74	4.71	276	273	274
Pant Bael-3	4.2	4.4	4.3	5.49	5.62	5.55	634	636	635
Pant Bael-4	3.72	4.2	3.9	4.29	4.25	4.27	49	51	50
Pant Shivani	11.5	12.5	12.0	6.18	6.80	6.49	752	740	746
Pant Urvashi	8.9	10.3	9.6	4.97	5.65	5.31	504	506	505
Pant Bael-7	5.3	6.7	6.0	5.12	5.14	5.13	22	25	23
Pant Aparna	4.7	5.2	4.9	6.84	6.86	6.85	52	58	55
Pant Bael-10	4.0	4.5	4.2	3.45	3.70	3.57	93	103	98
Pant Bael-11	9.0	8.9	8.9	9.54	8.84	9.19	323	335	329
Pant Sujata	4.3	5.0	4.6	6.15	6.20	6.17	370	360	365
Pant Bael-13	3.75	4.6	4.1	5.96	6.01	5.98	235	221	228
Pant Bael-14	4.2	4.9	4.5	3.51	3.95	3.73	171	175	173
Pant Bael-15	4.6	5.3	4.9	3.69	4.26	3.97	252	250	251
Pant Bael-16	6.28	7.2	6.7	6.75	7.05	6.90	427	430	428
Pant Bael-17	7.8	8.3	8.0	5.84	5.92	5.88	473	475	474
Pant Vishal	3.65	3.9	3.7	7.15	7.25	7.20	861	859	860
NB-7	4.8	4.9	4.8	6.14	6.18	6.16	677	680	678
NB-9	4.32	4.4	4.36	4.80	4.86	4.83	505	515	510
SE \pm	0.607	0.338	0.226	0.857	0.535	0.153	42.016	7.601	3.489
CD ($P = 0.05$)	1.806	1.004	0.672	2.547	1.591	0.455	124.831	22.585	10.368

Table 2. Continued.

Clones	C_i (ppm)			WUE (P_n / E)			Mesophyll efficiency (P_n / C_i)		
	2008-09	2009-10	Mean	2008-09	2009-10	Mean	2008-09	2009-10	Mean
Pant Bael-1	516	518	517	1.790	1.718	1.754	0.0205	0.0200	0.0202
Pant Bael-2	324	322	323	1.280	1.193	1.236	0.0185	0.0192	0.0188
Pant Bael-3	248	246	247	0.765	0.786	0.775	0.0169	0.0178	0.0174
Pant Bael-4	200	210	205	0.865	0.995	0.930	0.0186	0.0202	0.0194
Pant Shivani	233	238	235	1.860	1.838	1.849	0.0493	0.0524	0.0508
Pant Urvashi	257	260	258	1.791	1.821	1.806	0.0346	0.0395	0.0370
Pant Bael-7	311	310	310.5	1.035	1.306	1.170	0.0170	0.0216	0.0193
Pant Aparna	249	252	250	0.687	0.757	0.722	0.0188	0.0206	0.0197
Pant Bael-10	226	224	225	1.159	1.155	1.150	0.0176	0.0201	0.0188
Pant Bael-11	522	524	523	0.950	1.014	0.982	0.0173	0.0169	0.0171
Pant Sujata	277	282	279	0.699	0.831	0.765	0.0155	0.0177	0.0166
Pant Bael-13	257	261	259	0.629	0.734	0.681	0.0145	0.0175	0.0160
Pant Bael-14	249	257	253	1.196	1.342	1.269	0.0168	0.0191	0.0179
Pant Bael-15	234	237	235	1.246	1.245	1.245	0.0196	0.0223	0.0209
Pant Bael-16	240	245	242	0.930	1.024	0.977	0.0261	0.0295	0.0278
Pant Bael-17	253	255	254	1.335	1.412	1.373	0.0308	0.0325	0.0316
Pant Vishal	313	314	313	0.510	0.536	0.523	0.0117	0.0124	0.0120
NB-7	239	242	240	0.781	0.797	0.789	0.0200	0.0202	0.0201
NB-9	244	247	245	0.901	0.927	0.914	0.0177	0.0180	0.0178
SE \pm	14.926	12.091	1.597	0.110	0.116	0.041	0.002	0.001	0.0007
CD ($P = 0.05$)	44.345	35.924	4.746	0.329	0.344	0.123	0.006	0.004	0.0023

Table 3. Yield and yield contributing characteristics in various clones of bael.

Clones	No. of fruits / tree			Yield (kg fruits / tree)		
	2008-09	2009-210	Mean	2008-09	2009-210	Mean
Pant Bael-1	68	66	67.0	41.87	40.48	41.17
Pant Bael-2	44	43	43.5	27.50	26.87	27.18
Pant Bael-3	50	49	49.5	34.39	33.71	34.05
Pant Bael-4	100	96	98.0	32.79	31.65	32.22
Pant Shivani	56	57	56.5	97.04	98.77	97.90
Pant Urvashi	78	79	78.5	60.44	61.22	60.83
Pant Bael-7	42	43	42.5	34.56	35.38	34.97
Pant Aparna	74	75	74.5	68.08	69.00	68.54
Pant Bael-10	60	58	59.0	33.80	34.45	34.12
Pant Bael-11	84	84.5	84.2	46.20	46.47	46.33
Pant Sujata	46	47	46.5	69.73	71.25	70.49
Pant Bael-13	48	45	46.5	40.80	38.25	39.52
Pant Bael-14	52	53	52.5	40.12	38.94	39.53
Pant Bael-15	37	38	37.5	24.05	24.70	24.37
Pant Bael-16	72	74	73.5	53.85	55.35	54.60
Pant Bael-17	76	73	74.5	87.39	83.95	85.67
Pant Vishal	12	11	11.5	39.00	35.75	37.37
NB-7	10	9.5	9.7	18.00	16.20	17.10
NB-9	18	18	18.0	18.90	18.90	18.90
SE ±	2.077	1.939	0.859	2.001	2.000	0.908
CD (<i>P</i> = 0.05)	6.172	5.761	2.552	5.945	5.943	2.699

Table 3. Continued.

Clones	Yield efficiency (kg/cm ²)			No. of fruits / volume of tree		
	2008-09	2009-210	Mean	2008-09	2009-10	Mean
Pant Bael-1	0.0585	0.0531	0.0558	0.3915	0.3252	0.3585
Pant Bael-2	0.0500	0.0461	0.0480	0.3925	0.3000	0.3462
Pant Bael-3	0.0403	0.0398	0.0400	0.2435	0.2365	0.2400
Pant Bael-4	0.0513	0.0477	0.0495	0.5945	0.5560	0.5752
Pant Shivani	0.1241	0.1265	0.1253	0.3945	0.3445	0.3695
Pant Urvashi	0.0930	0.0879	0.0904	0.7820	0.7195	0.7507
Pant Bael-7	0.0656	0.0625	0.0640	0.3825	0.3875	0.3850
Pant Aparna	0.1023	0.0924	0.0973	0.4675	0.4365	0.4520
Pant Bael-10	0.0587	0.0578	0.0582	0.4315	0.4570	0.4442
Pant Bael-11	0.1181	0.0976	0.1078	0.6901	0.6654	0.6777
Pant Sujata	0.1132	0.0993	0.1062	0.2780	0.2990	0.2885
Pant Bael-13	0.0541	0.0463	0.0502	0.4330	0.3925	0.4127
Pant Bael-14	0.0628	0.0568	0.0598	0.4122	0.4276	0.4199
Pant Bael-15	0.0418	0.0456	0.0437	0.2745	0.2505	0.2625
Pant Bael-16	0.1139	0.1032	0.1085	0.4220	0.3986	0.4103
Pant Bael-17	0.1620	0.1543	0.1581	0.7707	0.7002	0.7354
Pant Vishal	0.1389	0.1122	0.1255	0.1725	0.1515	0.1620
NB-7	0.0506	0.0426	0.0466	0.1430	0.1360	0.1395
NB-9	0.071	0.063	0.066	0.3765	0.2870	0.3317
SE ±	0.013	0.004	0.0037	0.117	0.077	0.0211
CD (<i>P</i> = 0.05)	0.041	0.0125	0.011	0.347	0.231	0.0627

practices were followed. The soil of experimental plot has been classified as series VI of Patharchatta sandy

loam under the order Mollisol. The soil is moderately dark in color, well drained and having pH 6.4. The

Table 4. Correlation coefficient of different characters in bael (mean of two years). *Significant at 5% level of significance.

Characters	2	3	4	5	6	7	8
1 Tree height (m)	0.246	0.668*	0.560*	-0.202	-0.202	0.151	0.232
2 Tree spread (m)		0.712*	0.934*	-0.214	-0.159	-0.006	0.098
3 Stem girth (cm)			0.841*	-0.092	-0.211	0.131	0.211
4 Tree volume (m ³)				-0.229	-0.184	0.018	0.143
5 Leaf area (cm ²)					0.395	-0.056	-0.028
6 Per cent leaf dry wt						0.150	0.003
7 Chlorophyll content (mg/g fresh wt)							0.776*
8 Net photosynthetic rate (μ mol / m ² / s)							
9 Transpiration rate (m mole / m ² / s)							
10 Stomatal conductance (m mole / m / s)							
11 Internal CO ₂ conc. (ppm)							
12 Water use efficiency (P_n / E)							
13 Mesophyll efficiency (P_n / C_i)							
14 Weight of fruits / tree (kg)							
15 Yield efficiency (kg/cm ²)							

Table 4. Continued.

Characters	9	10	11	12	13	14	15
1 Tree height (m)	0.095	-0.492	0.365	0.181	-0.004	0.159	-0.197
2 Tree spread (m)	0.083	0.258	0.087	0.130	0.146	0.263	-0.072
3 Stem girth (cm)	-0.073	-0.328	-0.053	0.240	0.249	0.279	-0.251
4 Tree volume (m ³)	0.053	0.376	0.058	0.156	0.094	0.225	-0.189
5 Leaf area (cm ²)	0.302	0.169	0.219	-0.194	-0.194	-0.146	-0.048
6 Per cent leaf dry wt	0.067	0.455	0.020	0.018	0.035	0.023	0.050
7 Chlorophyll content (mg/g fresh wt)	0.351	0.060	0.328	0.583*	0.613*	0.587*	0.388
8 Net photosynthetic rate (μ mol / m ² / s)	0.374	0.137	0.466*	0.817*	0.756*	0.588*	0.421
9 Transpiration rate (m mole/m/s)		0.365	0.540*	0.217	0.065	0.376	0.576*
10 Stomatal conductance (m mole / m / s)			-0.167	-0.086	0.317	0.179	0.408
11 Internal CO ₂ conc. (ppm)							
12 Water use efficiency (P_n / E)				0.183	-0.220	-0.048	0.077
13 Mesophyll efficiency (P_n / C_i)					0.732*	0.382	0.111
14 Weight of fruits/tree (kg)						0.703*	0.451
15 Yield efficiency (kg/cm ²)							0.794*

tree growth was studied with respect to tree height, tree spread, stem girth, cross trunk sectional area and tree volume. To record the leaf area five month old twenty five mature leaves were randomly taken from the third and fourth position from the base of the shoot. The total chlorophyll was estimated by the method as described by Hiscox and Israelstam (4). A TPS-2 portable photosynthesis system was used to

measure photosynthetic parameters viz., net photosynthetic rate (P_n), transpiration rate (E), stomatal conductance (g_s), internal CO₂ concentration, reference H₂O concentration, leaf temperature (T_l), water use efficiency and mesophyll efficiency. All measurements were taken between 10 : 00 am and 2 : 00 pm on fully expanded leaves. The magnitude of photosynthetically active radiation (PAR) was more than 1500

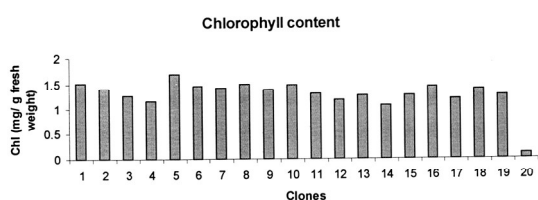


Figure 1. Effect of clones on mean chlorophyll content of bael leaves.

$\mu\text{ mol m}^{-2}\text{ s}^{-1}$ through out the experiments. To determine the above parameters, the terminal leaflets of each third and fourth position leaf from the base of the shoot were placed in leaf cuvette and were exposed to direct sunlight under field conditions. Measurements were repeated to obtain at least three stable readings for each of the marked leaves. The yield was calculated in terms of weight of fruits per tree in kilograms. Yield efficiency was calculated by dividing yield by cross trunk sectional area and expressed as kg/cm^2 . The data were subjected to analysis of variance in randomized block design (5).

Results and Discussion

Effect of Clones on Growth Parameters

There were significant variation in tree height, tree spread, stem girth, cross trunk sectional area and tree volume (Table 1). Tree canopy as evident from tree height and spread is very important character to be taken into consideration while determining the planting distance in the orchard and thereby the orchard density (6). The maximum tree height was recorded is Pant Bael-11 while the minimum tree height was found in NB-7 in 2008-09 and 2009-2010. The mean of two years showed that the maximum and minimum tree height were observed in Pant Bael-11 (9.15 m) and NB-7 (5.54 m), respectively. There was a non-significant difference in tree spread among Bael clones in 2008-09 while a significant difference was recorded in tree spread in 2009-2010. The mean of two years showed that the maximum and minimum tree spread were observed in Pant Bael-3 (7.30 m) and NB-9 (4.44 m), respectively. Stem girth was recorded to be maximum in Pant Bael-3 and the minimum in NB-9 in 2008-09 and 2009-2010. The mean of two years showed that the maximum and minimum stem girth were ob-

served in Pant Bael-3 (104.05 cm) and NB-9 (59.20 cm), respectively. A non-significant difference was found in tree volume among the clones in 2008-09 but a significant variation was recorded in tree volume in 2009-2010. The mean of two years showed that maximum tree volume was observed in Pant Bael-3 (207.74 m^3) while the minimum tree volume was observed in NB-9 (58.52 m^3). This variation in tree height, stem girth, tree spread and tree volume of clones might be due to the variation in genetic constitutions and interaction of clones with the agroclimatic conditions.

A significant variation was observed in leaf area among the clones. The maximum and minimum leaf area were recorded in Pant Vishal and Pant Bael-10, respectively. The mean of two years showed a variation from 35.95 to 144.20 cm^2 in leaf area among the clones. There was a significant difference in per cent dry weight of leaf among the clones in both the years. A positive and significant correlation was found in tree height and stem girth, tree volume and tree height, tree spread and stem girth, tree spread and tree volume. Considerable variability was observed in the different clones of Bael with regard to different growth parameters like tree height, tree spread, stem girth, tree volume, leaf area and per cent dry weight of leaf (Table 1). Tree size of Bael was reported to be medium (7). There was a significant variation in tree height, tree spread, stem girth and tree volume among eleven clones of Bael (8).

Effect of Clones on Chlorophyll Content

There was a non-significant difference in total chlorophyll content among the clones in 2008-09 and 2009-2010 (fig. 1). The chlorophyll a : b ratio was not affected by the clones significantly in both the years. A positive and significant correlation ($r = 0.776$) was observed in chlorophyll content and net photosynthetic rate (Table 2). Similar findings were reported by Gupta (9). The decrease in net photosynthetic rate (P_n) was in close connection with the decrease of chlorophyll content (10).

Effect of Clones on Photosynthetic Parameters

Clones had significant effects on net photosyn-

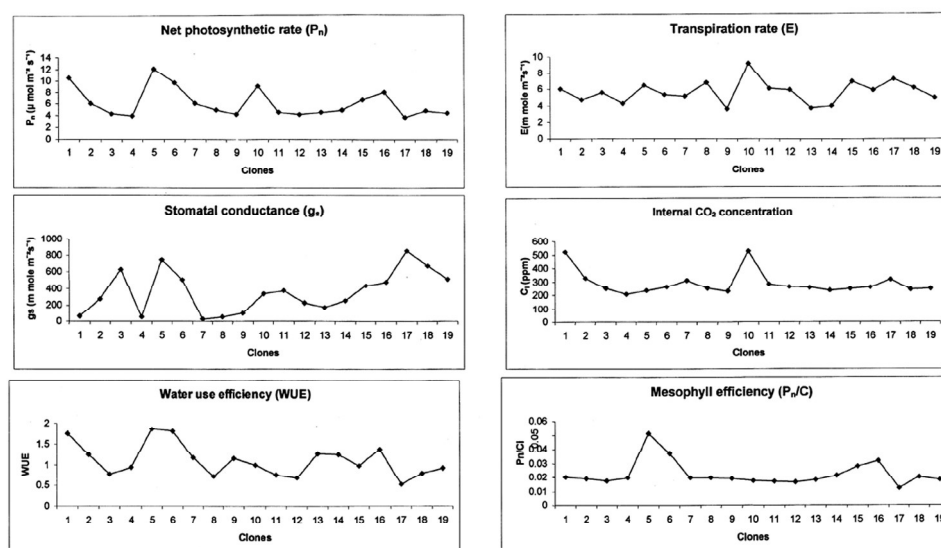


Figure 2. Effect of clones on mean of net photosynthetic rate (P_n), transpiration rate (E), stomatal conductance (g_s), internal CO_2 concentration (C_i), water use efficiency and mesophyll efficiency of bael.

thetic rate (P_n), transpiration rate (E), stomatal conductance (g_s), internal CO_2 concentration, water use efficiency (P_n / E) and mesophyll efficiency (P_n / C_i) 2008-09 and 2009-2010 (Table 2). The maximum P_n was observed in Pant Shivani and the minimum P_n was recorded in Pant Vishal in both the years. The mean of two years showed that the maximum and minimum P_n were recorded in Pant Shivani ($12.0 \mu\text{mol} / \text{m}^2 / \text{s}$) and Pant Vishal ($3.7 \mu\text{mol} / \text{m}^2 / \text{s}$), respectively (Fig. 2). A significant variation in photosynthetic efficiency in different Bael clones (8). E was recorded maximum in Pant Bael-11 and minimum in Pant Bael-10 in both the years. The mean of two years showed that the maximum and minimum E were recorded in Pant Bael-11 ($9.19 \text{ m mole} / \text{m}^2 / \text{s}$) and Pant Bael-10 ($3.57 \text{ m mole} / \text{m}^2 / \text{s}$), respectively (Fig. 2). The highest g_s was observed in Pant Vishal and the lowest g_s was found in Pant Bael-7 in both the years. The mean of two years showed that the maximum and minimum g_s were recorded in Pant Vishal ($860 \text{ m mole} / \text{m}^2 / \text{s}$) and Pant Bael-7 ($23 \text{ m mole} / \text{m}^2 / \text{s}$), respectively (Fig. 2). Leaf photosynthesis in higher plants depends upon not only environmental conditions (11) but also internal regulation and genetic factors. Stomatal closure and leaf temperature were reported

to play important roles in photosynthetic reduction (12).

The maximum and minimum C_i were recorded in Pant Bael-11 and Pant Bael-4, respectively in both years. The mean of two years showed that maximum C_i was found in Pant Bael-11 (523 ppm) while the minimum C_i was observed in Pant Bael-4 (205 ppm). The maximum water use efficiency (WUE) was observed in Pant Shivani and the minimum WUE was recorded in Pant Vishal in both the years. The mean of two years showed that the maximum and minimum WUE were recorded in Pant Shivani (1.849) and Pant Vishal (0.523), respectively (Fig. 2). The reduction of WUE probably was due to a higher increase in the rate of transpiration compared to photosynthesis (13). The maximum mesophyll efficiency was observed in Pant Shivani and the minimum mesophyll efficiency was recorded in Pant Vishal in both the years. The mean of two years showed that the maximum and minimum mesophyll efficiency were recorded in Pant Shivani (0.0508) and Pant Vishal (0.0120), respectively (Fig. 2). A close relationship between photosynthesis and stomatal conductance has been recorded. There was a positive and significant relationship was observed in P_n and C_i , E and C_i , WUE and

P_n , WUE and mesophyll efficiency. The variation in photosynthetic characteristics of clones of Bael might be due to the variation in leaf orientation of various clones which might affect the light interception : transmission ratio, activity of carboxylation enzymes and photorespiration losses per unit time and total leaf area might have also caused this variation.

Effect of Clones on Yield and Yield Contributing Characteristics

The maximum number of fruits per tree was recorded in Pant Bael-4 followed by Pant Bael-11, Pant Urvashi, Pant Aparna and Pant Bael-17 whereas minimum number of fruits was recorded in NB-7 in 2008-09 and 2009-10. The mean of two years showed maximum number of fruits per tree in Pant Bael-4 and minimum number of fruits per tree was found in NB-7 (Table 3). Maximum fruit yield per tree was found in Pant Shivani followed by Pant Bael-17, Pant Sujata, Pant Aparna and Pant Urvashi in 2008-09 and 2009-2010. The mean of two years showed that the maximum and minimum yield were recorded in Pant Shivani (97.90 kg / tree) and NB-7 (17.10 kg / tree), respectively (Table 3). A significant difference was reported in yield per tree among the various clones of Bael (14). Yield efficiency was recorded to be maximum in Pant Bael-17 and the minimum yield efficiency was observed in Pant Bael-3 in both the years. The mean of two years showed that the maximum and minimum yield efficiency were recorded in Pant Bael-17 (0.1581 kg / cm²) and Pant Bael-3 (0.0400 kg/cm²), respectively (Table 3). The maximum and minimum number of fruits / unit volume of tree were recorded in Pant Urvashi and NB-7, respectively in both the years. The mean of two years showed that maximum and minimum number of fruits per unit volume of tree were in Pant Urvashi (0.7507) and NB-7 (0.1395), respectively (Table 3). A significant difference was found in yield and yield efficiency among the clones (8). A positive and significant correlation was recorded in yield and tree volume, stem girth and yield, yield and mesophyll efficiency (Table 4). Fruit yield had a positive but non-significant relationship with photosynthesis (9, 15).

Conclusion

The environment and edaphic conditions in In-

dia are suitable for Bael. The responses of Bael tree to fluctuating or changing climatic conditions may help in understanding current practical problems of yield variability. The promising cultivars of Bael viz., Pant Shivani, Pant Bael-17, Pant Sujata, Pant Aparna and Pant Urvashi can be profitably exploited in commercial production as Bael fruit, leaves and other parts of the plant are used as medicine and its fruit also has immense processing potential and can be made into different fruit products, such as preserve, soft drinks. The photosynthetic parameters need to be considered in relation to climatic adaptation and crop improvement.

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