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Seed Source Variation in *Aegle marmelos* (L.) Correa.

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ABSTRACT

Aegle marmelos (L.) Correa commonly called a Bael is one of the most important indigenous medicinal plants with a multiple therapeutic uses. It is used to improve human health from the ancient times. The present study was carried out at Navsari, Gujarat (AES-III, South Gujarat Heavy Rainfall Zone). Seeds of *A. marmelos* were collected from 4 regions with 10 different locations. Central Gujarat 01 (Gandhinagar), South Gujarat 04 (Navsari, Netrang, Rajpipla and Waghai), North Gujarat 04 (Danta, Ratanmahal, Shamlaji and Vijaynagar) and Saurashtra 01 (Junagadh). The highest seed length (0.83 cm), seed width (0.39 cm), seed weight (17.87 g), collar diameter (3.81 mm), root length (54.87 cm) and fresh weight of seedling (6.64 g) was observed in the seed collected from Junagadh seed source. Highest survival percentage (25.99 %) root diameter (5.57 mm) was observed in Rajpipla seed source. The highest fruit length (8.62 cm) was recorded from fruits collected from Shamlaji seed source; maximum fruit diameter (6.56 cm) was recorded from fruit collected from Navsari seed source. The data revealed that maximum germination percentage (28.36 %) was recorded in Vijaynagar seed source and the maximum shoot length (18.92 cm) was recorded for Ratanmahal seed source; the highest number of leaves/plant were observed in Gandhinagar seed source (10.97); however, the maximum dry weight of seedling (2.22 g) was observed in Waghai seed source. Study was aimed to throw insight in to seed source variation and their morphological characters.

Key Words:

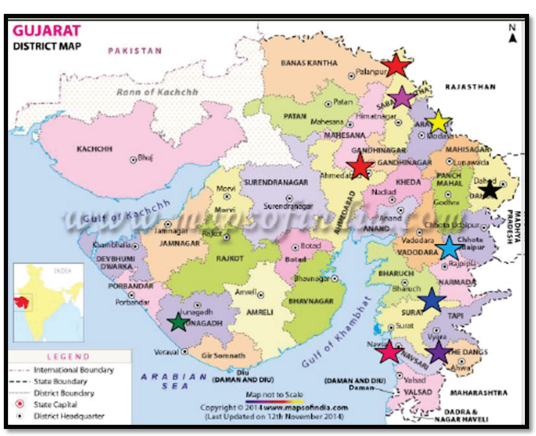
Aegle marmelos, ECV, GCV, Morphological variation, Seed source variation, and PCV

INTRODUCTION

Bael (*Aegle marmelos* L.) Correa., belongs to family Rutaceae and it is indigenous to India. The deciduous tree with trifoliate aromatic leaves is traditionally used as sacred offering to 'Lord Shiva'. It is commonly planted in temple gardens. As wild, bael is found in Uttar Pradesh, Odisha, Bihar, West Bengal and Madhya Pradesh. Fruit is a hard-shelled berry and very well-known for its medicinal properties due to Marmelosin content. Mature fruits possess astringent properties and are usually prescribed for diarrhea and dysentery. The ripe fruit administered is administered tonic, restorative, laxative and good for heart and brain (Khare 2007). It is a small to moderate-sized tree with branches armed with strong axillary spine 1-3 cm long. Bark dark grey, slightly corky, leaves alternate, 3-foliate and rarely 5-foliate. Flowers greenish white, sweet scented fruits globose, grey or yellowish, shell woody. Seeds numerous, oblong compressed, with a woolly mucous testa, embedded in a clear mucilage and a mass of yellow or orange-colored sweet aromatic mealy pulp (Khare 2007).Fruit is broken open by deer, monkeys and possibly bears which consumes the pulp and seeds get dispersed. Many parts of the tree possess highly medicinal properties and the dried unripe fruit has been long used as remedy for dysentery. The leaves are good fodder and the wood is used in agricultural implements. Besides fruits, leaves, stem, bark, root and seeds contain essential oils, chiefly 'Marmelosin' which has been found to possess very good purgative property (Anonymous, 2008). Fruit obtained from Bengal and Assam has more than five times as much Marmelosin as those obtained from Uttar Pradesh and Punjab (Khare 2007). Within the Gujarat state, the tree is found mainly in deciduous forests, scrub jungles and also seldom planted in gardens. This plant is commonly protected for religious purposes. Forest department has taken up its plantations at many places and it is successfully growing in almost all localities with maximum populations in Rajpipla, Chhota-udepur, Ratanmahal and Vijaynagar forests. (Anonymous 2008). Hence the study was conducted to investigate the variations among the different sources of seed.

MATERIAL AND METHODS

The present research was carried out at the Model Nursery on Medicinal and Aromatic Plants Nursery, ASPEE College of Horticulture and Forestry, Navsari Agricultural University Navsari, Gujarat (AES-III, South Gujarat Heavy Rainfall Zone). Seeds were collected from 4 Regions with 10 different locations. Central Gujarat 01 (Gandhinagar), South Gujarat 04 (Navsari, Netrang, Rajpipla and Waghai), North Gujarat 04 (Danta, Ratanmahal, Shamlaji and Vijaynagar) and Saurashtra 01 (Junagadh) (Fig. 1). Seed from different places were sown with three replication and each place/district was conducted as separate treatment. Ten treatments and three replications were applied for investigation and each replication consists of 30 seeds. Seeds were sown in sandy surface soil from a depth of 0-15 cm. Observation were taken on fruit length, seed length, root length, fruit width/diameter, seed width, collar diameter, seed weight, fresh weight of seedling, dry weight of seedling (Venudevan and Srimathi, 2013). Number of seedling; germination percentage (%) (Abugre and Boateng, 2011) and survival percentage (%) were recorded at 180 days after sowing (DAS). Recorded observations were analyzed with the Completely Randomized design (CRD) as a statistical tool.



STAR	LOCALITY / SEED SOURCE	STAR	LOCALITY / SEED SOURCE
★	Danta (North Gujarat/Aravalli district)	★	Rajpipla (South Gujarat, District Narmada)
★	Gandhinagar (Central Gujarat)	★	Ratanmahal (Central Gujarat, District Dahod)
★	Junagadh (Saurashtra)	★	Shamlaji (North Gujarat)
★	Navsari (South Gujarat)	★	Vijaynagar (North Gujarat)
★	Netrang (South Gujarat, District Surat)	★	Waghai (South Gujarat)

Note: Stars indicates the localities for seed source

Fig. 1. *Aegle marmelos* L. Correa. seed sources collected from different regions of Gujarat

RESULTS AND DISCUSSION

Fruits collected from Shamlaji (T_8) seed source had the largest value for fruit length (8.62 cm) and the lowest (5.5 cm) being for seeds collected from Waghai (T_{10}) seed source. The maximum fruit diameter was recorded for the fruits collected from Navsari (T_4) seed source whereas the minimum diameter was recorded for fruits collected from Gandhinagar (T_2) seed source (Table 1). The variation could be attributed to isolations that in turn influence gene flow and also could be attributed both to parental origin and to fruits within individual trees as indicated by Andrew et al. (2000).

The highest seed width was recorded for seed collected from Junagadh (T_3) seed source with the lowest being for seed collected from Shamlaji (T_8) seed source. Mean 100-seed weight varied from 14.64 to 17.87 g. The highest seed weight was recorded for seed collected from Junagadh (T_3) seed source and the lowest was for seed collected from Shamlaji (T_8) seed source (Table 1). As reported by Fenner (2000), variability in seed size (width, length and thickness) was probably a consequence of a compromise between the requirements for dispersal (which would favor small seeds) and the requirements for seedling establishment (which would favor large seeds).

Table 1. Variation in morphological characters of fruit and seed in *A. marmelos*

Region	Treatment	Seed Sources	Fruit length (cm)	Fruit diameter (cm)	Seed lengt h (cm)	Seed width (cm)	100 seed weight (g)
NG	T_1	Danta	6.19	6.49	0.64	0.33	15.16
CG	T_2	Gandhinagar	5.66	6.00	0.53	0.23	16.77
SAU	T_3	Junagadh	6.20	6.40	0.83	0.39	17.87
SG	T_4	Navsari	6.58	6.56	0.68	0.37	15.87
SG	T_5	Netrang	6.52	6.53	0.70	0.37	15.70
SG	T_6	Rajpipla	5.96	6.34	0.62	0.27	17.33
NG	T_7	Ratanmahal	6.18	6.40	0.73	0.33	17.24
NG	T_8	Shamlaji	8.62	6.42	0.50	0.23	14.64
NG	T_9	Vijaynagar	6.26	6.47	0.62	0.27	15.93
SG	T_{10}	Waghai	5.55	6.11	0.60	0.31	16.57
CD			0.39	0.23	0.11	0.05	1.45
SE(d)			0.19	0.11	0.05	0.02	0.69
SE(m)			0.13	0.08	0.04	0.02	0.49
CV			3.6	2.1	10.03	8.94	5.20

(Note- NG: North Gujarat, CG: Central Gujarat, SAU: Saurashtra, SG: South Gujarat)

Vijaynagar (T_9) seed source showed maximum germination however the lowest germination percent showed by Navsari (T_4) seed source. Seedling survival percent varied from 16.33 to 25.99. The number of seedlings survived in Rajpipla (T_6) seed source whereas Navsari (T_4) seed source recorded lowest survival of seedlings (Table 2). Similarly germination exhibited a significant variation among seed sources of *A. marmelos*. In most plant species, seeds vary in their degree of germinability between and within populations and between and within individuals (Assogbadjo et al. 2010, Pavithra et al. 2013, Shine et al. 2015, Singh et al. 2015, Xu et al. 2015) due to maternal and/or environmental factors (Gutterman et al. 1992, Wulff 1986).

Seed sources displayed highly significant differences in shoot length except after 4 months. The average tree height after 1, 2, 3, 4 and 5 months varied between 6.55 to 8.19 cm, 7.18 to 11.96 cm, 8.66 to 13.43 cm, 10.97 to 14.67 and 14.51 to 18.92 cm, respectively. Tree height was considerably higher for the Netrang (T_5) seed source compared to the other seed sources after 2, 3 and 4 months while the height of the Ratanmahal (T_7) seed source was highest after 5 months. The slowest shoot length growth was observed for Gandhinagar (T_2) seed source after 1 month and Shamlaji (T_8) seed source after 2, 3, and 4. However, Danta (T_1) seed source recorded minimum shoot length after 5 month (Fig. 2).

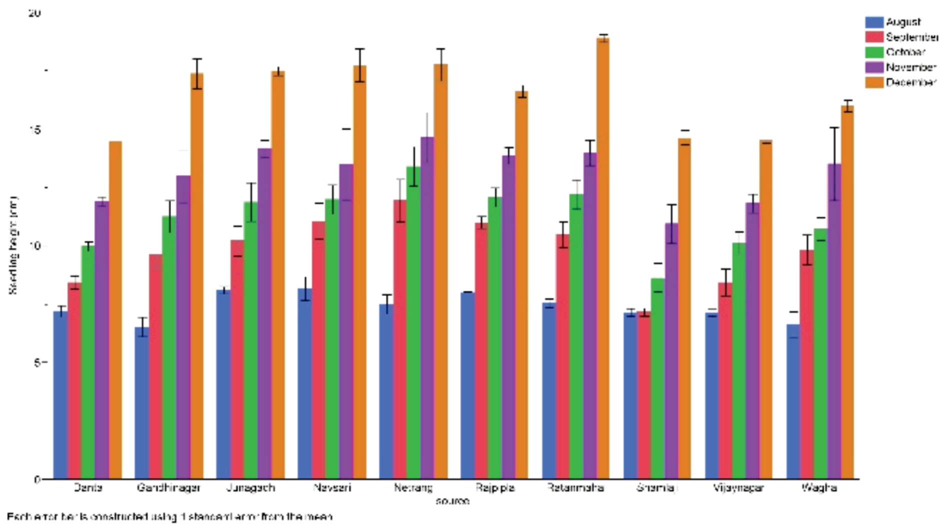


Fig 2. Seed source variation for shoot length at different age in *A. marmelos*

Highly significant differences among *A. marmelos* seed sources were reported for root length and root diameter. Mean root length varied from 17.97 to 54.87 cm, the root diameter varied from 2.74 mm to 5.57 mm and the root: shoot ratio varied between 1.10 to 3.23. Seedlings from Junagadh (T_3) seed sources had the longest root and highest root: shoot ratio with the lowest being for Ratanmahal (T_7) seed source. The maximum root diameter was recorded for the Rajpipala (T_6) seed source whereas the minimum diameter recorded for Danta (T_1) seed source (Table 2).

Table 2. Variation in germination, fresh weight, dry weight and root characters of *A. marmelos*

Region	Treat - ments	Seed sources	Germin ation percent age (%)	Survival percent age (%)	Fresh weight of plant (g)	Dry weigh t of plant (g)	Root length (cm)	Root diamet er (mm)
NG	T_1	Danta	24.62	25.30	2.53	0.87	33.57	2.74
CG	T_2	Gandhinagar	22.33	21.11	3.04	1.10	43.17	2.78
SAU	T_3	Junagadh	21.27	20.58	6.64	2.19	54.87	3.93
SG	T_4	Navsari	17.81	16.33	4.75	2.03	28.64	3.37
SG	T_5	Netrang	19.13	17.88	4.65	1.61	28.64	3.37
SG	T_6	Rajpipla	26.64	25.99	4.14	1.29	48.60	5.57
NG	T_7	Ratanmahal	25.87	25.29	5.34	1.69	17.97	4.35
NG	T_8	Shamlaji	23.46	21.94	4.05	1.36	22.13	3.45
NG	T_9	Vijaynagar	28.36	23.94	2.62	0.84	26.30	3.45
SG	T_{10}	Waghai	21.13	21.06	6.06	2.22	21.22	3.23
CD			4.07	4.67	1.53	0.56	6.71	0.60
SE(d)			1.94	2.22	0.73	0.27	3.20	0.29
SE (m)			1.37	1.57	0.52	0.19	2.26	0.20
CV			10.30	12.40	20.33	21.43	12.04	9.68

Seedling fresh and dry biomass varied between 2.53 to 6.64 g and 0.84 to 2.22 g. There was a significant difference between seed sources for dry and fresh biomass. The highest value for fresh and dry biomass recorded in Junagadh (T_3) seed source and Waghai (T_{10}) seed sources, respectively. However, Danta (T_1) seed source and Vijaynagar (T_9) seed source recorded the lowest value for fresh and dry biomass, respectively. There was no consistent trend for the best seed source regarding growth and biomass. However, overall superiority of Junagadh (T_3) seed source was evident, and Shamlaji (T_8) seed source poorly performed for all the growth traits (Table 2). Whereas large differences in growth and biomass were found among *A. marmelos* seed sources after 5 months of growth in the nursery, and much of the total variation was due to the genetic effect as evidenced from high heritability and fairly good genetic advance estimates. This indicates that there is adequate genetic variability for growth and biomass in the present material for future selection or improvement endeavor. Genetic variation in shoot length at nursery stage or based on the common garden studies have been reported for several tree species (Assogbadjo et al. 2010, Fredrick et al., 2015, Ky-Dembele et al. 2014, Munthali et al., 2012, Xu et al. 2015).

Collar diameter showed significant variation after 1, 2, 3, 4 and 5 months of growth. collar diameter varied between 1.39-1.88 mm, 1.52-2.60 mm, 1.74-2.98 mm, 2.11-3.37 mm and 2.62-3.81 mm after 1, 2, 3, 4, and 5 months, respectively. At age 1 month, collar diameter was highest for the Navsari (T_4) seed sources. However, after 1 month, the Junagadh (T_3) seed source consistently showed maximum value for collar diameter till five months. The minimum collar diameter was observed for the Shamlaji (T_8) seed source provenance after 1, 4 and 5 months and for the Vijaynagar (T_9) seed sources after 2 and 3 months (Fig. 3).Whereas, collar diameter also varied significantly among seed sources. The extent of genetic variation in seedling diameter at the nursery stage varies between species, for example considerable genetic variation in root collar diameter has been observed in *Faidherbia albida* (Ibrahim et al. 1997), in *Dalbergia sissoo* (Sagta and Nautiyal 2001), in *Tectona grandis* (Jayasankar et al. 1999), and in *Cordia Africana* (Loha et al. 2006).

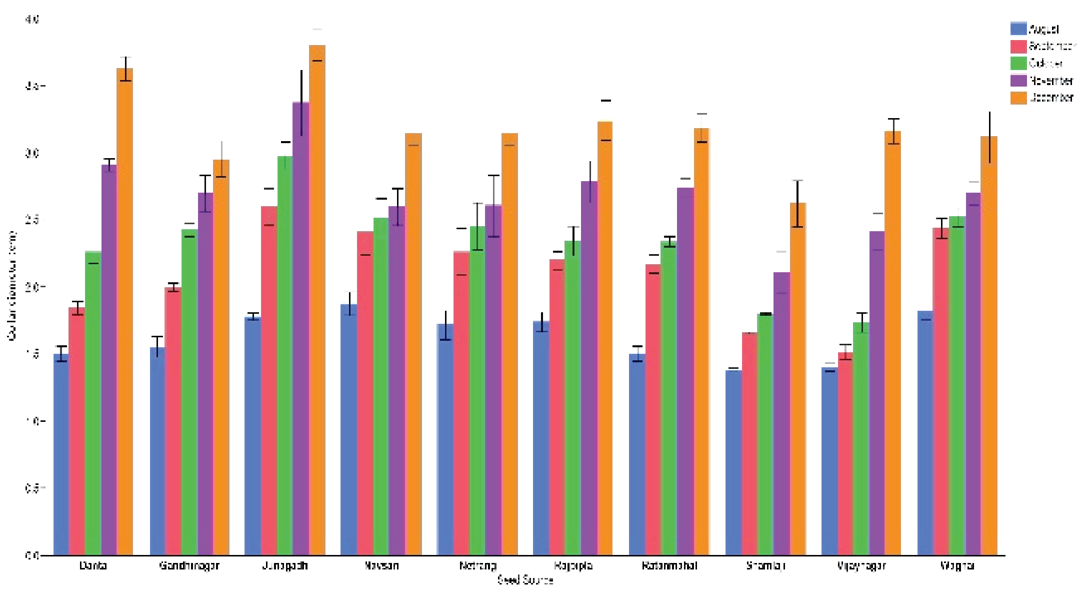


Fig 3. Seed source variation for collar diameter at different age in *A. marmelos*

Number of leaves showed significant variation after 1, 2, 3, 4 and 5 months of growth. Number of leaves varied between 3.93-6.40, 3.60-7.60, 4.57-8.47, 4.27-10.0 and 4.27-10.97 after 1, 2, 3, 4, and 5 months, respectively. At age 1, 3 and 4 months, number of leaves was maximum in Navsari (T_4) seed sources. The minimum number of leaves was observed for the Shamlaji (T_8) seed source after 3, 4 and 5 months (Fig. 4).

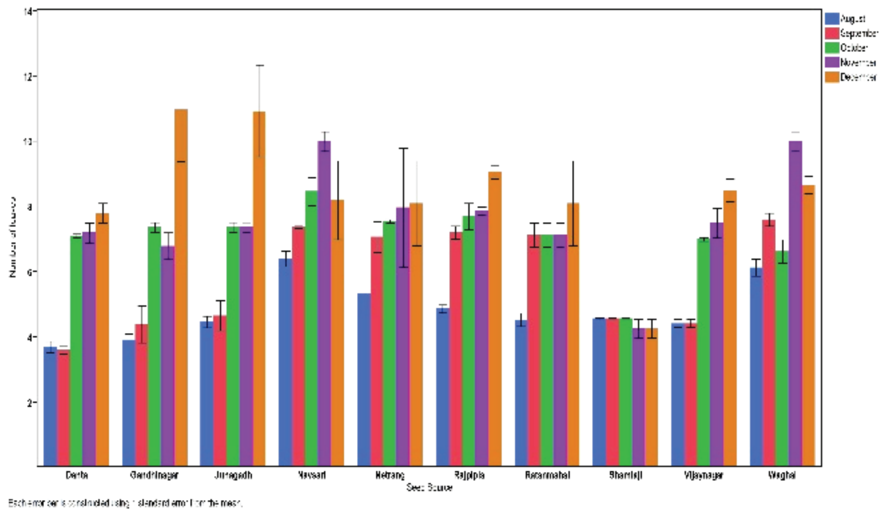


Fig 4. Seed source variation for number of leaves at different age in *A. marmelos*

The variability was estimatedin terms of coefficient of variability of phenotype, genotype and environmental levels (PCV, GCV and ECV). To study genetic parameters, the estimates were worked out for heritability (broad sense) and genetic gain (genetic advance as percent of mean). The results obtained for different characters are presented in Table 3. Wide differences have been recorded for the coefficient of variation and genetic parameters for fruit, seed and germination characters of *A. marmelos*. For all the seed traits, the phenotypic (PCV) and genotypic (GCV) coefficient of variability were found to be higher than the corresponding environmental coefficient of variability (ECV). The PCV and GCV were maximum for seed width 20.01 and 17.78 respectively, whereas the environmental coefficient of variation was maximum for seed length (10.56). The study of genetic parameters revealed higher heritability for fruit length (0.93) followed by seed width (0.79) than for other traits. Genetic gain was also recorded maximum for seed width (32.43 %) followed by fruit length (26.24 %), whereas the genetic gain was minimum for fruit diameter among the various fruit and seed characters studied. For seedling growth and biomass, the value for the phenotypic coefficient of variation and genotypic coefficient of variation for all the traits were comparatively high from the environmental coefficient of variation. The phenotypic coefficient of variation and genotypic coefficient of variation were maximum for root length (39.54 and 37.52, respectively). ECV was maximum for fresh seedling biomass (19.72) (Table 3).

Table 3. Coefficient of variability (PCV, GCV and ECV), heritability (broad sense), genetic advance and genetic gain estimation for fruit and seed characters in *A. marmelos*

Character	PCV	GCV	ECV	Heritability	GA	GG
FL	13.74	13.25	3.61	0.93	16.78	26.34
FD	3.24	2.67	1.84	0.68	2.88	4.53
Sl	17.18	13.58	10.56	0.62	0.14	22.10
Sw	20.01	17.78	9.03	0.79	0.10	32.54
100 seed weight	7.22	5.75	4.37	0.63	1.54	9.43

(**: PCV: phenotypic coefficient of variation, GCV: genotypic coefficient of variation, ECV: environment coefficient of variation, GA: genetic ability, GG: genetic gain, FL: fruit length, FD: fruit diameter, Sl: seedling length, Sw: seedling width)

The results of genetic components presented in Table 4 revealed maximum heritability (0.90) in root length, closely followed by root diameter (0.85). Genetic gain was also maximum in root length (73.33 %), while it was minimum for shoot length at five months (5.85 %). Based on the current results, it can be suggested that variation in seed morphometric traits could also be the result of adaptation to the diverse environmental conditions over the large natural distribution of this species. The GCV of seed traits was higher than the ECV, while the PCV and GCV were close to each other. This indicates that the most of the variability observed in the phenotype for seed traits has more of a genetic than a non-genetic basis. This variability that resulted from genotypic variance indicates considerable scope for selection. Genetic control of seed size traits has been observed in several tree species (Dembele et al. 2014; Loha et al. 2009; Loha et al. 2008; Rawat and Uniyal 2011; Shaukat et al. 1999; Vakshasya et al. 1992).

Table 4. Coefficient of variability (PCV, GCV and ECV), heritability (broad sense), genetic advance and genetic gain estimation for germination, seedling growth and biomass characters in *A. marmelos*

Character	PCV	GCV	ECV	Heritability	GA	GG
GP	16.91	13.28	10.47	0.62	4.96	21.49
SP	18.15	12.71	12.96	0.49	4.02	18.33
Ht5	9.93	9.28	3.54	0.87	2.96	17.86
CD5	11.26	9.64	5.82	0.73	0.54	17.00
NL5	25.89	19.76	16.73	0.58	2.63	31.07
RL	39.54	37.52	12.49	0.90	23.84	73.33
RD	24.32	22.36	9.56	0.85	1.53	42.36
FWP	35.64	29.69	19.72	0.69	2.23	50.94
DWP	36. 99	32.00	18.55	0.75	0.87	57.02

(PCV: phenotypic coefficient of variation, GCV: genotypic coefficient of variation, ECV: environment coefficient of variation, GA: genetic ability, GG: genetic gain, GP: , SP: , Ht5: height at 5^{th} month, CD5: collar diameter at 5^{th} month, NL5: number of leaves at 5^{th} month, RL: root length, RD: root diameter, FWP: fresh weight of plant, DWP: dry weight of plant)

CONCLUSIONS

Junagadh (T_3) and Navsari (T_4) seed sources had overall superiority over others, whereas Shamlaji (T_8), Danta (T_3) and Vijaynagar (T_9) seed source performed poorly for the growth parameters opted. Further, work can be focused on Marmelosin content from various seed sources and its correlation with environmental and genotypic factors as *A. marmelos* is not only one of the most valued NTFP's, but also has cultural and religious significance. Overall for fruit characters, Shamlaji (T_8) treatment was found to be best, whereas seed character was superior in Junagadh (T_3). Overall seedling performance was superior for Junagadh (T_3) seed source. Hence, Junagadh (T_3) seed source can be better utilized for nursery establishment. However, fruit collection should be carried out from Shamlaji (T_8), if the objective is larger fruit. There is promising scope for improvement in seed and seedling characters since most of the characters are under strong genetic control. Selection for fruit length can be more beneficial since it gives higher heritability and genetic gain. However maximum improvement chance is for root quality through selection among seedling characters.

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