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Research Article

GENETIC DIVERGENCE IN FRUIT AND STONE TRAITS OF *Melia dubia* Cav. IN INDIA

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Abstract- Thirty-three Plus Trees (PTs) of *Melia dubia* were selected based on the morphometric traits to identify suitable seed sources with clear bole and for production of quality seedlings for operational planting in different forestry and agroforestry programmes. Significant genetic variability and association were recorded among 33 PTs for fruit and stone traits. Maximum 100 fruit weight (1.00 kg) was observed in Nagondapalli while maximum 100 seed weight (280 g) was observed in Kollegal 10. The stones were observed to have variations in their locule filling which could contribute to poor germination of seedlots. Locule filling was high in Kodipuram I (an average of 4 out of 5) which also recorded the highest germination. Mahalanobis' D2 statistics and Tocher's clustering method grouped the 33 seed sources into seven clusters when fruit characteristics were considered while the seed sources were grouped into 6 clusters when stone characteristics were considered. 100 Fruit Weight contributed maximum to divergence for fruits (87.88). Seedling traits in *Melia dubia* provide highest information on genetic divergence followed by stone traits. Fruits traits can also be considered when there is a need to further broaden the genetic base. Information on genetic divergence and genetic distance between genotypes helps in developing planting design to facilitate equal opportunity for hybridization among the genotypes. Seed orchards developed using genotypes from the clusters identified in the study would produce wider segregation. This will enhance the quality of seed produced in the ensuing generations and can be used for development of improved varieties.
Key words- Genetic Divergence, *Melia dubia*, Tree Breeding, Seed sources, Mahalanobis' D^2, Tocher's clustering.

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Introduction

An increasing pressure on natural forest resources has encouraged the search and cultivation of economically important tree species as plantations. *Melia dubia* belonging to Meliaceae is one such species that produces raw material suitable for pulpwood and matchwood [1,2]. Due to its fast growth and high economic returns, it is a favourite of the farmers. Its promise as a multipurpose species and its suitability in agroforestry and farm forestry necessitates the need for identification of appropriate genetic resources for various end uses [2]. In India, exotics like Casuarinas, Eucalypts, Leucenea, Acacias and Populus dominate in tree cultivation. These species are the major raw materials for pulp and plywood industries. Narrow genetic base of poplar, susceptibility to blight [3] and insect pests [4] are some of the causes for decline in its popularity in introduced areas. Gall infestation of Eucalyptus trees by *Leptocybe invasa* is a rampant problem in India resulting in huge economic losses [5]. Vulnerability to pests and diseases [6] in Casuarina is a major setback in the wet tropics. Ecological concerns of Acacias and Leucenea in terms of its invasiveness [7], threat to native species and habitat degradation are well established. Planting indigenous fast growing species in wastelands and degraded forest lands and in agroforestry systems is a viable option as alternatives to the species in demand by the industries. The growth potential of indigenous species remains untapped in India. There exists great variability among the indigenous tree species, which can be exploited for increasing the productivity. Presence of high variability in a species offers a wide scope for selection to a tree breeder. Major yield improvements can easily be achieved through careful selection of species suitable to the area followed by proper provenance. The selection made through progeny and clonal testing always offers higher gains than that of the selections made from the plantation without known pedigree. Progeny and clonal tests have played a significant role in deciding strategy for multi-generation improvement programme [8]. According to scientists [9] progeny testing is best directed at the production of families most suitable for second-generation selection. The selection made from progeny tests gives higher gain than that made from the original population. As *M. dubia* has high utility value, knowledge of genetic variability and association between fruit and seed traits would help develop tree improvement programs. Information thus generated would support selection of good families for agroforestry plantations. Hence the present study was envisaged to evaluate the source variation in fruit and stone traits in *M. dubia* in its natural occurring zones in India.

Materials and Methods

Thirty-three seed sources of *Melia dubia* selected from naturally growing regions of India were the experimental materials. The experiment was laid out in Completely Randomized Block Design with five replications. Twenty-five stones / fruits formed the experimental units. For fruit characteristics, area, length, breadth, perimeter, roundness, aspect ratio, fullness ratio and 100 fruit weight were the characters studied. Area, length, breadth, perimeter, roundness, aspect ratio, fullness ratio, 100 stone weight, number of locules, number of filled locules, germination percentage, height, collar diameter and number of leaves were the characters studied for the stones. Mahalanobis' D^2 technique [10] was used to study the genetic divergence. The estimation of D^2 values is very complicated especially when the number of characters being studied becomes large because it needs inversion of matrix of higher order. The computation is very much simplified when the characters under study are independent and are expressed in terms of their respective standard errors. Therefore, the correlated variables were transformed into uncorrelated ones by using pivotal condensation method.

Table-1 Mean performance of PTs variation for fruit and stone traits (n=125) in *Melia dubia*

PTs	Fruit traits								Stone traits								No. of locules	No. filled	Germin ation (%)	Seedling Traits		
	Area (cm^2)	Length (cm)	Breadth (cm)	Peri Meter (cm)	Round ness	Aspect Ratio	Fullness Ratio	100 Weight (kg)	Area (cm^2)	Length (cm)	Breadth (cm)	Peri Meter (cm)	Round-ness	Aspect Ratio	Fullness Ratio	100 Weight (g)				Height (mm)	Collar Diameter (mm)	No. of Leaves
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Ardhanalli	3.90	2.61	2.02	9.36	1.74	1.30	0.96	0.59	2.82	2.44	1.52	8.33	1.85	1.61	0.94	0.18	2.50	2.00	24.00	36.10	4.02	4.25
Bedamula	4.52	3.00	2.02	9.99	1.69	1.49	0.96	0.61	1.91	2.09	1.20	5.69	1.28	1.74	0.94	0.17	3.50	3.50	36.50	35.78	3.36	4.50
Basapura	4.78	2.89	2.20	9.91	1.55	1.32	0.97	0.74	1.80	1.88	1.28	5.67	1.36	1.48	0.95	0.17	4.25	2.00	64.75	46.13	3.74	4.75
Chikkahole 1	5.02	3.09	2.18	10.09	1.55	1.42	0.97	0.78	2.34	2.43	1.29	6.63	1.41	1.89	0.93	0.23	4.25	2.50	36.00	43.60	4.35	5.00
Chikkahole 2	4.70	2.95	2.11	9.94	1.60	1.40	0.97	0.75	2.00	2.39	1.15	6.35	1.51	2.07	0.90	0.20	2.00	1.75	37.25	47.08	4.43	5.25
Chikkali	5.07	2.89	2.30	9.93	1.48	1.26	0.98	0.78	2.33	2.45	1.37	7.44	1.82	1.80	0.92	0.19	4.75	2.50	79.75	53.05	4.69	5.00
Ellakatti	4.19	2.79	2.00	9.41	1.61	1.39	0.97	0.63	1.68	1.98	1.15	5.79	1.50	1.73	0.93	0.16	2.75	1.75	4.00	39.50	3.65	4.75
Maharajapuram	4.66	2.84	2.22	10.43	1.80	1.28	0.97	0.73	2.15	2.28	1.27	6.61	1.52	1.79	0.92	0.19	1.25	1.25	14.75	45.48	4.10	5.75
Thalamalai	6.59	3.48	2.45	12.52	1.82	1.42	0.97	1.00	2.38	2.35	1.37	6.88	1.49	1.72	0.93	0.21	2.50	2.50	47.50	53.30	3.54	5.25
Chamrajnagar	3.93	2.73	1.91	8.57	1.41	1.43	0.97	0.45	2.15	2.28	1.27	6.61	1.52	1.79	0.92	0.16	3.00	3.00	46.00	45.33	3.70	6.00
Doddapuram	5.35	3.05	2.33	12.23	2.18	1.31	0.97	0.79	1.94	2.10	1.30	6.27	1.52	1.62	0.93	0.19	3.75	1.50	6.75	34.58	3.84	4.75
Kodipuram 1	4.47	2.61	2.27	10.80	2.00	1.15	0.98	0.85	2.03	2.19	1.21	6.13	1.39	1.81	0.93	0.19	4.75	4.00	87.00	53.08	4.16	4.75
Kodipuram 2	5.25	2.90	2.37	10.76	1.68	1.23	0.98	0.81	1.63	1.94	1.14	5.97	1.64	1.71	0.94	0.16	4.50	1.50	76.25	45.35	4.56	5.25
Thalavady	4.74	2.77	2.26	10.12	1.65	1.23	0.98	0.80	1.79	2.07	1.17	5.65	1.34	1.77	0.94	0.17	3.50	3.50	45.00	33.25	3.71	3.75
Samayeri	4.42	2.92	2.01	9.45	1.72	1.49	0.95	0.45	1.83	2.10	1.18	5.68	1.32	1.79	0.93	0.23	3.75	3.75	65.00	44.98	4.02	4.25
Dhalsur	4.35	2.63	2.20	9.98	1.76	1.20	0.97	0.77	1.71	2.02	1.18	5.32	1.24	1.72	0.94	0.14	2.50	2.50	2.00	40.38	3.35	5.00
Dinoor	4.58	2.83	2.15	10.30	1.77	1.31	0.97	0.76	1.87	2.12	1.15	6.19	1.54	1.84	0.92	0.18	3.25	3.25	3.00	37.23	3.38	4.75
Nagondapalli	5.43	3.02	2.36	10.97	1.70	1.28	0.98	1.00	2.19	2.23	1.34	6.32	1.37	1.68	0.93	0.20	2.75	2.75	16.50	43.25	3.73	5.50
Panampally	4.78	3.05	2.10	9.92	1.56	1.46	0.96	0.61	1.94	2.05	1.31	6.33	1.55	1.57	0.94	0.18	1.50	1.00	10.75	22.60	3.23	4.00
Theni	4.56	2.98	2.05	10.37	1.82	1.45	0.96	0.56	2.00	2.40	1.23	7.36	2.07	1.95	0.90	0.14	2.50	1.25	5.75	38.20	3.87	4.50
Kollegal 1	5.41	3.00	2.38	11.18	1.80	1.26	0.98	0.61	2.19	2.25	1.34	6.16	1.30	1.67	0.94	0.18	3.75	3.75	39.00	37.88	3.87	4.75
Kollegal 2	6.01	3.09	2.55	11.43	1.67	1.21	0.98	0.46	1.64	1.89	1.19	5.16	1.22	1.59	0.95	0.16	2.50	2.50	33.75	39.88	4.43	5.50
Kollegal 3	5.01	2.78	2.39	10.35	1.62	1.17	0.98	0.46	1.70	2.02	1.17	5.75	1.46	1.73	0.93	0.14	2.00	2.00	11.50	45.68	3.99	6.00
Kollegal 4	5.38	2.99	2.36	10.73	1.61	1.27	0.98	0.42	2.23	2.43	1.24	6.60	1.46	1.96	0.92	0.11	2.00	2.00	13.00	52.05	3.99	5.00
Kollegal 5	5.68	3.10	2.42	10.86	1.56	1.28	0.98	0.40	1.63	1.83	1.25	5.52	1.40	1.47	0.94	0.13	2.25	2.25	14.25	41.48	4.03	4.75
Kollegal 6	5.13	2.99	2.25	10.26	1.55	1.33	0.98	0.45	1.56	1.72	1.22	5.18	1.29	1.41	0.96	0.15	4.00	4.00	37.50	43.08	3.97	5.25
Kollegal 7	5.89	3.22	2.42	10.78	1.48	1.33	0.98	0.57	2.21	2.34	1.27	6.54	1.45	1.85	0.92	0.24	3.50	3.50	24.50	47.40	3.92	6.00
Kollegal 8	5.19	2.89	2.33	9.90	1.41	1.24	0.98	0.40	1.67	2.02	1.09	6.06	1.66	1.88	0.93	0.11	2.75	2.75	9.25	44.15	3.31	5.50
Kollegal 9	6.68	3.53	2.46	12.69	1.82	1.44	0.97	0.68	1.98	2.19	1.25	7.26	2.11	1.76	0.92	0.21	2.25	2.25	61.00	36.45	3.22	6.75
Kollegal 10	5.45	3.01	2.35	10.16	1.43	1.28	0.98	0.98	1.71	1.98	1.20	5.86	1.53	1.65	0.94	0.28	2.50	2.50	56.75	57.18	3.85	4.75
Kollegal 11	5.18	2.97	2.28	9.57	1.33	1.30	0.98	0.55	1.79	2.07	1.17	5.65	1.34	1.77	0.94	0.18	2.25	2.25	52.25	61.78	4.24	6.00
Kollegal 12	5.88	3.14	2.44	12.31	1.95	1.29	0.98	0.41	2.21	2.24	1.30	6.41	1.39	1.73	0.94	0.15	4.00	4.00	48.75	35.93	3.37	5.50
Hoskote	5.45	3.26	2.18	10.93	1.65	1.50	0.97	0.46	2.02	2.30	1.18	6.33	1.49	1.96	0.92	0.16	4.00	4.00	58.00	19.20	2.99	4.00
Average	5.08	2.97	2.25	10.49	1.67	1.32	0.97	0.65	1.97	2.15	1.24	6.23	1.50	1.74	0.93	0.18	3.07	2.59	35.39	42.44	3.84	5.05
SD (±)	0.67	0.21	0.16	0.94	0.18	0.10	0.01	0.18	0.28	0.20	0.09	0.69	0.21	0.15	0.01	0.04	0.94	0.89	24.49	8.78	0.42	0.67

Table-4 Intra and inter cluster D Square values and distances for fruits of *Melia dubia*

S	D Square values							Cluster distances						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
1	126.55	298.89	212.18	170.00	96.08	94.27	112.19	11.25	17.29	14.57	13.04	9.80	9.71	10.59
2		109.33	56.27	65.97	238.18	443.39	321.97		10.46	7.50	8.12	15.43	21.06	17.94
3			2.70	8.06	159.18	326.32	236.44			1.64	2.84	12.62	18.06	15.38
4				5.45	125.26	274.27	194.14				2.34	11.19	16.56	13.93
5					109.15	109.54	107.14					10.45	10.47	10.35
6						9.58	99.85						3.10	9.99
7							132.38							11.51

Table-5 Cluster Means for fruits of *Melia dubia*

S	Area	Length	Breadth	Perimeter	Roundness	Aspect Ratio	Fullness Ratio	100 Fruit Weight
1	4.851	2.917	2.202	10.168	1.632	1.332	0.972	0.552
2	5.138	3.008	2.249	10.431	1.623	1.343	0.972	0.883
3	4.997	2.839	2.315	10.44	1.666	1.229	0.978	0.808
4	4.467	2.727	2.175	10.141	1.761	1.256	0.973	0.766
5	5.086	2.993	2.237	10.287	1.601	1.343	0.975	0.593
6	5.512	2.935	2.466	10.889	1.646	1.189	0.981	0.461
7	5.198	3.036	2.248	10.782	1.682	1.361	0.972	0.548

Table-8 Intra and inter cluster D Square values and distances for stones of *Melia dubia*

S	D Square values						Cluster distances					
	1	2	3	4	5	6	1	2	3	4	5	6
1	1.329	2.786	5.493	10.395	8.553	15.867	1.153	1.669	2.344	3.224	2.924	3.983
2		1.645	3.620	9.734	8.301	11.673		1.282	1.903	3.120	2.881	3.417
3			1.764	5.788	6.004	9.258			1.328	2.406	2.450	3.043
4				1.970	7.439	12.941				1.404	2.727	3.597
5					8.500	13.350					2.916	3.654
6						3.800						1.949

Table-9 Cluster means for stones of *Melia dubia*

S	Area	Length	Breadth	Perimeter	Roundness	Aspect Ratio	Fullness Ratio	100 Stone Weight	Number of locules	Number of filled locules	Germination	Height	Collar Diameter	Number of leaves
1	1.74	2.06	1.25	5.81	1.36	1.76	0.93	0.15	2.25	1.88	22.63	45.25	4.09	5.25
2	1.91	2.02	1.25	5.89	1.40	1.60	0.94	0.16	2.25	2.63	22.13	46.11	3.93	5.63
3	2.08	2.27	1.29	6.61	1.53	1.68	0.93	0.18	2.50	2.25	29.13	45.36	3.81	5.13
4	1.94	2.13	1.20	5.92	1.39	1.80	0.93	0.18	3.88	4.00	25.50	35.96	3.51	4.13
5	1.93	2.08	1.19	6.00	1.43	1.65	0.88	0.17	2.98	2.39	35.46	39.50	3.73	4.71
6	1.93	2.12	1.20	6.75	1.91	1.75	0.93	0.20	2.88	2.63	49.50	48.03	3.50	5.88

Table-2 Cluster formation using data on fruits of *Melia dubia*

Cluster number	Locations
Cluster 1	Ardhanalli, Bedamula, Basapura, Kollegal 4, Kollegal 5
Cluster 2	Chikkahole 1, Chikkahole 2, Chikkali, Ellakatti, Maharajapuram, Thalamalai, Nagondapalli, Kollegal 10
Cluster 3	Kodipuram 2, Thalavady
Cluster 4	Dhalsur, Dinoor
Cluster 5	Chamrajnagar, Doddapuram, Kollegal 7, Kollegal 11
Cluster 6	Kollegal 2, Kollegal 3
Cluster 7	Kodipuram I, Samayeri, Panampally, Theni, Kollegal 1, Kollegal 6, Kollegal 8, Kollegal 9, Kollegal 12, Hoskote

Table-3 Contribution of each character to divergence for Fruits of *Melia dubia*

Character	No. of First Rank	% Contribution
Area	9	1.7045
Length	27	5.1136
Breadth	8	1.5152
Perimeter	3	0.5682
Roundness	3	0.5682
Aspect Ratio	8	1.5152
Fullness Ratio	6	1.1364
100 Fruit Weight	464	87.8788
TOTAL	528	100

Table-6 Cluster formation using data on stones of *Melia dubia*

Cluster Number	Locations
Cluster 1	Kollegal 5, Kollegal 7
Cluster 2	Kollegal 8, Kollegal 9
Cluster 3	Doddapuram, Kodipuram 2
Cluster 4	Nagondapalli, Panampally
Cluster 5	Ardhanalli, Bedamula, Basapura, Chikkahole 1, Chikkahole 2, Chikkali, Ellakatti, Maharajapuram, Thalamalai, Chamrajnagar, Kodipuram 1, Thalavady, Samayeri, Dhalsur, Dinoor, Theni, Kollegal 1, Kollegal 2, Kollegal 3, Kollegal 4, Kollegal 6, Kollegal 10, Kollegal 11
Cluster 6	Kollegal 12, Hoskote

Table-7 Contribution of each character to divergence for stones of *Melia dubia*

Character	No. of First Rank	% Contribution
Area	0	0
Length	3	0.5682
Breadth	4	0.7576
Perimeter	4	0.7576
Roundness	2	0.3788
Aspect Ratio	6	1.1364
Fullness Ratio	5	0.947
100 Stone Weight	39	7.3864
Number of locules	26	4.9242
Number of filled locules	52	9.8485
Germination	104	19.697
Height	29	5.4924
Collar Diameter	96	18.1818
Number of leaves	158	29.9242
TOTAL	528	100

The significance of the D^2 values was tested against the tabulated value of chi-square for 'p' degrees of freedom where, 'p' is the number of characters considered. The seed sources were grouped into different clusters using the Tocher's method [11]. The first step for grouping was to arrange the clones in order of their relative distances from each other based on D^2 values. Two seed sources having smallest distance from each other were considered first to which a third seed source having smallest average D^2 value from the first two seed sources was added. The nearest fourth seed source was chosen next and the process was continued up to a stage where there was abrupt increase in the average D2 after adding a particular seed source. Similarly, other clusters were formed omitting the seed sources, which had already been included. The process was continued till all the seed sources were included into one or other cluster. After forming the clusters, the intra and inter cluster relationships were studied. The average intra cluster distances were measured using the formula $\sum Di^2 / n$ where, $\sum Di^2$ is the sum of distances between all possible combinations (n) of the seed sources included in a cluster. The average inter cluster distances were worked out by taking into consideration all the component D^2 values possible among the members of the two clusters considered. The square root of the average D^2 values gave the genetic distance 'D' between or within clusters. The analysis was performed using the software SPAR (Statistical Package for Agricultural Research developed by the Indian Agricultural Statistics Research Institute, New Delhi, India).

Results and Discussion

A logical way to start any breeding programme is to survey the variations present in the germplasm [12]. A clear understanding of the degree of divergence for important traits will be an added advantage in this regard, as inter-mating of divergent groups would increase variability and range of frequency distribution [13]. When large number of phenotypically superior genotypes of a species are available due to initial selections, the D^2 statistics and clustering technique help to form genetically homogeneous groups and representative samples from such groups will reduce the number of entries of genetically similar selections / provenances for inclusion in the establishment of provenances trials, progeny trials and seed orchards [14]. Reduced entries will reduce the total area required for planting and in turn reduce the cost of the tree improvement programme.

Descriptive statistics of the mean performance of the 33 seed sources revealed wide variation. Maximum 100 fruit weight (1.00 kg) was observed in Nagondapalli and minimum (400g) in Kollegal 5. Maximum 100 seed weight (280 g) was observed in Kollegal 10 and minimum (110 g) in Kollegal 4. Germination percentage also varied significantly among all the PTs. It varied from 2 in Dhalsur to 87 in Kodipuram 1. Maximum value for seedling length (61.78 mm) was observed in Kollegal 11. Maximum locule filling of 4.00 was observed in Kodipuram 1, Kollegal 6, Kollegal 12 and Hoskote [Table-1].

Application of Mahalanobis' D^2 statistics and Tocher's clustering method grouped the 33 seed sources into seven clusters when fruit characteristics were considered with cluster strength varying from two (clusters 3, 4 and 6) to ten (cluster 7). Cluster 7 which contained ten seed sources, Kodipuram 1, Samayeri, Panampally, Theni, Kollegal 1, Kollegal 6, Kollegal 8, Kollegal 9, Kollegal 12, Hoskote registered the maximum mean values for all the important traits [Tables-1-5] followed by cluster 6 consisting of two seed sources, Kollegal 2 and 3. Among the various characters, 100 fruit weight contributed the maximum (87.88%) towards genetic divergence. The 33 seed sources of *Melia dubia* were grouped into 6 clusters when stone characteristics were considered. The cluster strength varied from two (clusters 1,2,3,4 and 6) to 23 (cluster 5). Kollegal 5 and 7 formed a single cluster. Similarly, Kollegal 8 and 9 were grouped into a single cluster. The cluster 5 which contained 23 clones registered the maximum value for all the important stone traits [Tables-6-9]. Among the various characters, number of leaves contributed the maximum (29.93%) towards genetic divergence followed by germination (19.70) and height of the seedlings (18.18) while stone area did not contribute to the divergence. Cluster 6 which contained two seed sources, Kollegal 12 and Hoskote registered the maximum mean values for stone perimeter, roundness, germination, height and number of leaves [Tables-2-5] followed by clusters 3 and 4. Three important points which need to be essentially considered while selecting genotypes include (a) choice of the particular cluster from which genotypes are to be used as parents (b) selection of a particular genotype from the selected clusters and (c) relative contribution of characters to total divergence [15]. In our study, genetic divergence of *Melia dubia* considering the fruit traits and stone traits varied considerably. All the fruit traits contributed to the divergence in the case of fruit traits, while in the case of stone traits only 13 out of the 14 contributed. Fruit perimeter and roundness contributed to less than one per cent of the divergence, while the Length, Breadth, Perimeter, Roundness, Fullness Ratio showed similar trend in the case of stones. This implies that the traits roundness and perimeter do not significantly influence divergence. Hence these traits need not be included while studying fruits and stone traits in the species. The weight of the fruits and stones is an important measure which plays a crucial role in estimating divergence. Considering the results at [Table-3] and [Table-7], it could be inferred that seedling traits followed by weight of the fruits and seeds played a major role in clustering the seed sources. Number of leaves followed by germination and collar diameter showed highest cluster mean values indicating that the stone traits should be given priority while estimating the genetic divergence in *Melia dubia*. Another observation relates to the clustering of the seed sources. Cluster 7 of fruit traits brought together the seed sources Kollegal 8, Kollegal 9, Kollegal 12, Hoskote whereas clustering using the stone traits separated them into two independent clusters, Clusters 2 and 6. Thus, these seed sources could be considered genetically divergent and deployed in breeding programmes. However, cluster 5 formed using seed traits encompassed 23 seed sources. However, the cluster mean of this specific cluster did not show maximum values for any of the traits. Under these circumstances, it is advisable to consider the fruit traits also to identify genetically divergent material within this group to obtain a broader base for breeding programmes. The results obtained in this study suggest that selected seed sources included in clusters 2, 6 and 7 with reference to fruit characters and seed sources in 2, 4 and 6 with reference to stone characters in general can be used for further hybridization programmes to create variability and exploit hybrid vigour. As the intra-cluster distances among the cluster 7 and 5 with respect to fruit and stone respectively were high, seed sources within those cluster are also adequately divergent for tree improvement programme through hybridization. In selecting genotypes from the already chosen groups, other important characteristics like disease resistance quality or even performance of a particular character should also be considered [16]. Information on genetic distance between genotypes helps in developing planting design, such that it can facilitate equal opportunity for hybridization among the genotypes and obtaining quality seed with high vigour [17].

Conclusion

In the case of *Melia dubia*, it would be appropriate to consider seedling traits to identify genetically diverse material. To broaden the base further, stone traits followed by fruit traits could also be assessed for the genetic divergence. This information is of importance, as the results on genetic divergence have got an immediate application in the establishment of seed orchards.

Application of research: *Melia dubia* is fast-growing species, attracting the attention of farmers due to its high economic returns. For a systematic tree improvement programme of the species, information on variability and genetic divergence is very crucial. This paper provides information on genetic divergence estimates, which will serve as the base for further breeding programmes.

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