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Half SIB family variation in seedling traits of *Simarouba glauca* DC.

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ABSTRACT

A successful promotion of large scale plantation needs a carefully planned and well directed seed source research. The investigation on the variability present in *Simarouba glauca* was carried out at College of Forestry, Ponnampet, Kodagu district of Karnataka state. The seeds were collected from unpedigreed seedling seed orchards of *S. glauca* established by the research wing of Karnataka Forest Department at Madahalli, Mysore and Ingalagere near Kushalnagar. Existence of considerable variation among location and families within the location was observed in different seedling traits. Seedling growth parameters like collar diameter and seedling height were found to be significant after three months of sowing whereas the same parameters were insignificant after six months of sowing among the both locations. Among the families seedling growth parameters were evident. Seedling biomass parameters like shoot height, root height, shoot dry weight, root dry weight and total biomass were also assessed among the locations as well as among the families. Seedling quality parameters viz., sturdiness quotient and Dickson's quality index were studied. Estimated heritability values for different seedling parameters like seedling diameter and seedling height was found to be 0.63 and 0.78 respectively. Significant relationship between height and collar diameter of seedlings were found which implied better height growth would bring higher collar diameter. These assessed variations can be used for tree improvement programme.

Key words:

Simarouba glauca, variability, seedling traits, heritability, tree improvement programme.

INTRODUCTION

Scrupulously planned and well directed seed source research is of greater substance for successful promotion of large scale forest plantations. The most triumphant tree improvement programme is that where proper seed sources are used. The loss from using the wrong sources can be great and even disastrous (Zobel and Talbert 1984). Study of variability and exploitation of variability by understanding the genetic diversity of the population is the first step in domestication of any species and genetic improvement programme of a species. Variations within a species develop in response to evolutionary forces such as natural selection that vary in different parts of the natural range of a species. The existence of variability has certain influence on economic characteristics of an individual tree. In order to exploit the natural variability for higher production, it is essential to understand the nature and cause of variability. Identification and exploitation of natural variability is the easier and faster way of accomplishing gain in the forest tree improvement. Variation is also essential for selection and breeding to meet present and future human needs.

Simarouba glauca, DC. commonly known as aceituno, paradise- tree or bitter wood is a medium sized evergreen tree (height 7-15 m). It grows well up to 1000 m above sea level in all types of well drained soils (pH 5.5 to 8) and has been found to be established in places with 250 mm to 2500 mm annual rainfall and temperatures going up to 450C (Joshi and Hiremath 2000). It is a multipurpose tree that can grow well under a wide range of hostile ecological conditions. S. glauca is indigenous to Southern Florida, West Indies and Brazil. It is native to Bahamas, Costa Rica, Cuba, El-Salvador, Guatemala, Haiti, Honduras, Jamaica, Mexico and United States of America. In India, it was first introduced by National Bureau of Plant Genetic Resources in the research station at Amravati in Maharashtra in 1966 (Rath 1987; Juyal et al. 1991; Bhagmal 1994). It can grow well in marginal lands and wastelands with degraded soils.

The ever growing demand of energy and its consistent impact on the import bill for fossil fuel has necessitated the search for alternative and complementary sources of energy. Biodiesel, an alternative fuel, is gaining worldwide acceptance as a solution to environmental problems, energy security, reducing imports and improving agricultural economy. The kernel of S. glauca has high non-edible oil content, which can be an appropriate candidate for production of biodiesel (Simarouba oil methyl ester). Owing to its use as biofuel it has been planted in India as biofuel species especially in degraded areas.

MATERIALS AND METHODS

The investigations on the variability in *Simarouba glauca,* was carried at the nursery of College of Forestry, Ponnampet, Kodagu district of Karnataka state. The present study was carried out in unpedigreed seedling seed orchards of *Simarouba glauca* established by the research wing of Karnataka Forest Department. The orchards were located at two distinct places in Karnataka 'i.e.' Madahalli research station under Genetics Research Range, Mysore and Ingalagere research station near Kushalnagar under Research Range, Madikeri. The details of the study plantation areas are presented in Table 1. In these locations, 30 trees were selected based on phenotypical superiority.

Table 1. Location details of unpedigreed seedling seed orchards

Locations	Ingalagere	Madahalli
Latitude	12^{0} 26' N	12^{0} 21' N
Longitude	76^{0} 00' E	76^{0} 31' E
Altitude (m)	859.84	800
Soil type	Black and Red soils	Red and Lateritic soils
Annual rainfall (mm)*	1000	771.86
Annual Temperature ^{0}(C)	18-34	20-34

*Average of ten years rainfall 2003-2012

The ripe fruits were collected from selected trees along with its identity during the month of April. De-pulping of collected fruits was done manually. De-pulped seeds were shade dried for four days and were soaked in Gibberellin Acid (GA3) of 1000 ppm for 24 hours. The experiment was laid out in Randomized Complete Block Design (RCBD) with four replications comprising of 120 seeds (30 seeds per replicate) per treatment. Seeds were sown in polythene bags containing potting mixtures of Soil: Sand: FYM in 1:1:1 proportion. In each polybag one seed was dibbled. The polythene bags were arranged as per the layout of the experiment in the nursery. The seedlings were provided with shade by using shade net to protect from direct sunlight. Weeding and watering was done regularly throughout the experimental period.Observations on plant shoot parameters such as plant height and collar diameter were recorded after 90 and 180 days of sowing. The plant biomass parameters like fresh weight and dry weight of the shoot and root were recorded after 180 days of sowing.

The seedling quality indices such as sturdiness quotient (SQ) and Dickson's quality index (QI) were calculated using the following formulae (Dickson et al. 1960).

$$\text{Sturdiness Quotient (SQ)} = \frac{H}{D}$$

Where, H = Final shoot height (cm)

D = Final stem diameter (mm)

$$\text{Quality Index (QI)} = \frac{TDW}{SQ + [SDW/RDW]}$$

Where, TDW = Final total seedling dry weight (g)

SDW = Final shoot dry weight (g)

RDW = Final root dry weight (g)

Broad sense heritability of growth traits observed at nursery stage was estimated as suggested by Brewbaker (1996). Phenotypic and genotypic coefficients of variances were calculated as suggested by Burton and Devane (1953). Data collected on various parameters were analyzed by using two statistical tools SPSS and Genstat.

RESULTS AND DISCUSSION

Extent of variation in seedling growth and biomass parameters of Simarouba plantation were assessed. Existence of considerable variations among location and families within the location were observed in growth traits.

Variability in seedling growth parameters

Growth performance of seedlings from different locations, after 90 and 180 days of sowing were studied. After 90 days of sowing the seedlings of two locations exhibited significant difference in collar diameter (Table 2). Collar diameter for the seedlings from Ingalagere (3.37 mm) was significantly lower when compared with the seedlings of Madahalli location (3.49 mm). However, collar diameter of seedlings (after 180 days of sowing) of different locations did not differ significantly. Collar diameter of 6 months old seedling of Madahalli location (4.54 mm) was on par with seedlings of Ingalagere location (4.50 mm).The average height of seedlings (after 90 days of sowing) of different locations differed significantly (Table 2). Among the different locations, seedlings from Ingalagere recorded the lowest height (13.29 cm). Average height of seedlings from Madahalli was 13.67 cm which was significantly superior over Ingalagere location (13.29). Average height of 180 days old seedlings did not differ significantly (Table 2). Mean seedling height from Madahalli location (18.19 cm) was found to be on par with seedlings from Ingalagere location (18.18 cm).

Table 2. Growth parameters of seedlings of half sib families of different locations

Locations	Collar diameter (mm)		Seedling height (cm)	
	3 months	6 months	3 months	6 months
Madahalli	3.49	4.54	13.67	18.19
Ingalagere	3.37	4.50	13.29	18.18
LSD(0.05)	0.06	NS	0.21	NS
S. Em(±)	0.03	0.04	0.11	0.15
CV (%)	26.1	24.7	23.1	24.1

Collar diameter (90 days after sowing) of different families varied from 2.71 mm to 4.06 mm (Table 3). Close perusal of the data presented in Table 3 revealed the significant difference in the collar diameter (90 days after sowing) of individual half sib family. Among the different families, least collar diameter was observed for the family 2 (2.71 mm). The maximum collar diameter was observed for the family 20 (4.06 mm) which was significantly superior over almost all the families and was found to be on par with family 15. The collar diameter of 180 days old seedlings of different families differed significantly (Table 3). The mean collar diameter of 6 months old seedling was 4.53 mm. Among the different families least value was observed in the family 1 (3.87 mm) which was on par with family 2 (4.03 mm), 18 (4.04 mm) and 27 (4.14 mm). Maximum collar diameter was observed in family number 20 (5.12 mm) which was on par with families 16, 5 and 9. The average height of seedlings of different families differed significantly (Table 3). Average height of all families observed was 13.39 cm. Among the different families, seedlings from family 18 (9.57 cm) recorded the lowest height.

Table 3. Growth parameter of different half sib families

Family	Locations	Collar diameter (mm)		Seedling height (cm)	
		3 months	6 months	3 months	6 months
1	Madahalli	2.83	3.87	11.60	16.09
2		2.71	4.03	11.77	17.76
3		3.61	4.58	13.23	18.59
4		3.41	4.25	12.56	17.20
5		3.77	4.90	15.29	21.23
6		3.39	4.61	13.83	18.54
7		3.35	4.59	13.14	18.71
8		3.47	4.52	15.30	20.85
9		3.83	4.85	14.13	19.24
10		3.52	4.64	12.55	17.33
11		3.26	4.21	12.84	17.23
12		3.21	4.26	14.22	20.34
13		3.80	4.72	14.12	18.77
14		3.63	4.68	12.87	17.24
15		3.98	4.75	12.72	16.82
16		3.51	4.96	12.05	16.91
17		3.51	4.46	12.69	17.32
18		3.16	4.04	9.57	13.69
19		3.61	4.77	14.18	18.61
20		4.06	5.12	16.22	20.78
21	Ingalagere	3.64	4.57	12.89	17.14
22		3.30	4.44	13.54	17.57
23		2.87	4.33	12.28	17.47
24		3.34	4.69	15.37	19.89
25		3.31	4.65	14.88	19.70
26		3.42	4.61	13.29	18.56
27		3.05	4.14	11.82	17.28
28		3.66	4.56	14.84	18.35
29		3.59	4.58	13.18	17.42
30		3.49	4.45	14.64	18.40
LSD(0.05)		0.23	0.28	0.78	1.11
S. Em(±)		0.08	0.10	0.28	0.40
CV (%)		26.1	24.7	23.1	24.1

Family number 20 was found to be significantly superior over all 30 families with a mean height of 16. 22 cm (Table 3).The significant difference in seedling height of 180 days old seedlings was found in the present study (Table 3). Among the different families, the seedling height of family 5 (21.23 cm) was significantly higher over almost all families. The least height was observed for the seedling from family 18 (13.69 cm). Existence of variation in the collar diameter and height growth of the seedlings of different seed sources and families were reported in Eucalyptus tereticornis by Puri et al. (2002), Sidhu and Singh (2002) and Hegde et al. (2008). Existence of variation in the collar diameter growth of the seedlings of different seed sources and families was reported in Eucalyptus tereticornis by Puri et al. (2002) and Sidhu and Singh (2002).

Variation in seedlings biomass

Analysis of variance of data on shoot length of the seedlings revealed statistical similarity among the locations (Table 4). Shoot length for Madahalli location seedling was 17.93 cm which was on par with the seedling of Ingalagere location (17.92 cm).The root length of seedlings recorded at the end of experiment did not differ significantly.

Table 4. Seedling biomass parameters at different locations

Locations	Shoot length (cm)	Root length (cm)	Shoot dry weight (g)	Root dry weight (g)	Biomass (g)
Madahalli	17.93	17.63	2.30	0.66	2.97
Ingalagere	17.92	16.89	1.53	0.51	2.04
LSD(0.05)	NS	NS	0.32	0.14	0.44
S. Em(±)	0.07	0.10	0.13	0.05	0.18
CV (%)	2.7	31.5	40.8	57.2	43.0

Root length for Madahalli location seedling was 17.63 cm which was on par with the seedling of Ingalagere location (16.89 cm).The results indicated that, the dry shoot weight of the seedlings from different locations were significantly different (Table 4). Highest dry shoot weight at the end of experiment was recorded for Madahalli location (2.30 g) and the least was registered for Ingalagere location (1.53 g). Significant difference in root dry weight of seedling of different locations was observed in the study (Table 4). Among the different locations minimum root dry weight was found in Ingalagere (0.51 g) which was significantly inferior over Madahalli Location (0.66 g). Data pertaining to the total biomass of the seedlings at the end of experiment ranged from 2.04 g to 2.97 g among the locations. Maximum recorded biomass was 2.97 g that was found to be significantly superior to other location and minimum value was observed for Ingalagere location (2.04 g).

Data related to biomass of different half sib families after 180 days of sowing is presented in Table 5. The shoot length of different half sib families differed significantly (Table 5). The data on shoot length of seedlings at the end of experiment ranged from 13.33 to 20.90 cm. The results showed maximum value for family 5 (20.90 cm) that was found to be on par with family 8 (20.38 cm) and family 20 (20.33 cm), whereas, the least value was recorded for the family 18 (13.33 cm). Existences of half sib variation in the shoot length of different families were also reported by Mwitwa et al. (2007).The root length of different half sib families was not found significant. Average of root length of different families varied 11.60 cm (family 18) to 27.22 cm (family 25).The findings of this study did not confirm the findings of George et al. (2003) wherein the family variation was prevalent in root length of Madhuca latifolia. The results pertaining to the dry shoot weight of 30 half sib families are presented in Table 5 and were found to be non-significant. Recorded shoot dry weight values varied from 1.18 g (Family 25) to 3.28 g (Family 5) with a mean of 2.04 g. Data presented in Table 5 revealed that, the root dry weight of different seed lots did not differ significantly. Recorded root dry weight values varied from 0.33 g to 0.99 g with a mean of 0.61g. Estimated total biomass between different half sib families was insignificant. Observed biomass varied from 1.58 g to 4.28 g between all 30 half sib families with mean of 2.65 g. The findings of this study did not confirm the findings of George et al. (2003).

In this study, almost all the germination and seedling parameters showed consistent differences among the sources selected from different agro-climatic zones and this might reflect the presence of substantial amount of genetic variation. This is also indicated from the results of analysis of variance for different characteristics. It is reasonable to believe that these differences could be genetic mainly because of the fact that the seed material collected from different sources were tested and grown under the similar environmental conditions and they received similar treatments. Under such situation, whatever the differences in seed germination and seedling growth can be attributed to the genetic factor. However, the influence of the environmental factors cannot be ruled out (Varun Kumar 2010).

Table 5. Seedling biomass of different half sib families

Sl. No	Family	Locations	Shoot length (cm)	Root length (cm)	Shoot weight (g)	Root weight (g)	Biomass (g)
1	1	Madahalli	15.88	17.17	2.00	0.67	2.67
2	2		17.32	19.27	1.93	0.65	2.58
3	3		18.49	16.85	2.00	0.62	2.61
4	4		17.06	25.34	1.47	0.65	2.12
5	5		20.90	24.48	3.28	0.99	4.28
6	6		18.73	20.37	2.33	0.54	2.87
7	7		17.78	18.07	2.81	0.66	3.47
8	8		20.38	15.50	2.76	0.67	3.44
9	9		19.16	18.65	1.87	0.47	2.35
10	10		17.29	19.70	2.41	0.71	3.12
11	11		17.36	14.20	2.65	0.78	3.43
12	12		20.18	17.43	2.14	0.63	2.76
13	13		18.52	19.08	2.36	0.89	3.26
14	14		17.31	17.23	2.93	0.81	3.74
15	15		16.71	18.60	2.95	0.66	3.61
16	16		16.41	17.67	2.13	0.61	2.74
17	17		17.28	12.00	2.11	0.59	2.70
18	18		13.33	11.60	1.53	0.33	1.86
19	19		18.20	15.31	2.05	0.67	2.72
20	20		20.33	14.38	1.97	0.50	2.47
21	21	Ingalagere	16.51	11.73	1.46	0.40	1.86
22	22		17.22	15.82	1.24	0.37	1.60
23	23		17.35	23.38	2.04	0.90	2.94
24	24		19.10	15.32	2.39	0.76	3.15
25	25		19.60	27.22	1.18	0.47	1.65
26	26		18.26	16.48	1.25	0.33	1.58
27	27		17.71	14.67	1.39	0.36	1.74
28	28		18.06	15.75	1.34	0.49	1.83
29	29		17.22	14.32	1.37	0.36	1.72
30	30		18.12	20.32	1.87	0.69	2.56
LSD(0.05)			0.68	NS	NS	NS	NS
S. Em(±)			0.24	2.77	0.40	0.16	0.54
CV (%)			2.7	31.5	40.8	57.2	43.0

Seedling quality parameters of half sib families

Sturdiness quotient is inversely proportional to the seedling vigour. In general, the sturdiness quotients should be smaller than six (Jaenicke 1999). The seedlings with sturdiness ratio greater than six are basically tall, thin and etiolated, while a small quotient indicates sturdy plants with a greater chance of survival, especially on windy or dry sites. Other authors have reported similar results, where seedlings with quality indicators out of the acceptable ranges are likely not to perform well once they leave the nursery for on farms integration (Zida et al. 2008; Bayala et al. 2009 and Gregorio et al. 2005). However, in the present study sturdiness quotient more than six was not found. Perusal of results showed that, sturdiness quotient of different half sib families ranged from 3.39 (family 18) to 4.25 (family 24) for the observation period (Table 6).

Table 6. Seedling quality parameters of different half sib families

Sl. No.	Half sib family	Location	Sturdiness quotient	Quality index
1	1	Madahalli	4.12	0.40
2	2		4.41	0.32
3	3		4.10	0.35
4	4		4.02	0.35
5	5		4.33	0.57
6	6		4.01	0.31
7	7		4.09	0.44
8	8		4.61	0.42
9	9		3.97	0.29
10	10		3.74	0.41
11	11		4.07	0.43
12	12		4.81	0.36
13	13		3.96	0.48
14	14		3.69	0.54
15	15		3.54	0.48
16	16		3.41	0.43
17	17		3.87	0.39
18	18		3.39	0.20
19	19		3.91	0.40
20	20		4.04	0.32
21	21	Ingalagere	3.74	0.28
22	22		3.97	0.21
23	23		4.03	0.46
24	24		4.25	0.42
25	25		4.23	0.24
26	26		4.03	0.20
27	27		4.17	0.24
28	28		4.02	0.26
29	29		3.81	0.22
30	30		4.11	0.37

For Madahalli location, maximum SQ was found for family 12 (4.81) followed by family 8 (4.61) and family 2 (4.41) whereas least was found for family 18 (3.39). Data pertaining to Ingalagere location had shown range from 3.74 (family 21) to 4.25 (family 24). Maximum SQ was found for family 24 (4.25) followed by family 25 (4.23) and family 27 (4.17). Recorded data for family 24 (3.74) was minimum for Ingalagere location.

The field survival of seedlings can be

predicted with the help of Seedling Quality Index (SQI). Generally, higher the SQI value better is the field survival (Bayala et al. 2009). Results in the present study revealed that seedlings of family 5 (0.57) and family 14 (0.54) were found to have higher seedling quality index value compared to family 18 (0.20). It implies that the seedlings of family 5 and family 14 will have better field survival than family 18.

Dickson's quality index ranged from 0.20 (family 18 and family 26) to 0.57 (family 5). Highest Dickson's quality index was found to be 0.57 (family 5) followed by 0.54 (family 14) for Madahalli location. The least Dickson's quality index of Madahalli location families was 0.20 (family 18). Estimated Dickson's quality index of Ingalagere location varied from 0.20 to 0.46 (Table 6). In Ingalagere, maximum Dickson's quality index was found for family 23 (0.46) followed by 0.42 (family 24) and 0.37 (Family 30) whereas, minimum Dickson's quality index was found for family 26 (0.20) followed by family 22 (0.21).

Heritability and coefficient of variances of important traits

Estimated heritability values for different seedling parameters like seedling diameter and seedling height was found to be 0.63 and 0.78 respectively (Table 7).

Table 7. Broad sense heritability and coefficient of variances of different traits

Sl. No.	Growth traits	Heritability (H^2)	Phenotypic coefficient of variance (PCV)	Genotypic coefficient of variance (GCV)
1	Seedling diameter	0.63	40.89	32.57
2	Seedling height	0.78	51.64	45.65

Heritability values found in the present study was in the similar range to the values reported at nursery stage for Eucalyptus tereticornis (Surendran et al. 2002), Acacia mangium and A. auriculiformis (Varghese et al. 2002). PCV andGCV for seedling diameter were found to be (40.89 %, 32.57 %) and for seedling height (51.64 %, 45.65 %).Similar observations were reported by Divakara et al. (2010) and Raut et al. (2011) on the minimum magnitude of difference in PCV and GCV of seed traits.

Correlation analysis

Significant relationship between height and collar diameter of seedlings was observed (r = 0.52) which could be used for identifying good quality seedlings at nursery stage. This is in agreement with Gopalakrishnamurthy (2009) in *Nothapodytes nimmoniana*.

CONCLUSION

Simarouba glauca is one of the important oil yielding tree species and considerable variation is existing in the growth and biomass traits of seedlings at both the locations. The variability in seedling traits could be used for further tree improvement and domestication programme.

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