



Clonal variation for rooting traits in *Dalbergia sissoo*

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ABSTRACT: In the present study, the effect of clonal variability on the vegetative propagation and growth of plantlets in *Dalbergia sissoo* was evaluated. With the selection of high-performing clones, nurseries can enhance the efficiency and success rate of rooting, reduce production time and increase plant survival. The shoots from 15 different clones from the clonal hedge orchard maintained at Research Farm of the Department of Forestry and Natural Resources, Punjab Agricultural University, Ludhiana were collected in month of April to make cuttings for evaluating the variability in the rooting behaviour of *Dalbergia sissoo* clones. The vermiculite filled in trays (90 cc) were used as rooting medium. The cuttings of *Dalbergia sissoo* treated with 2000 ppm IBA were maintained in mist chamber conditions to produce rooting. The experiment was arranged in Factorial Completely Randomized Design (CRD) using four replications. Observations for various rooting traits were recorded at the end of experiment. Significant differences were observed among 15 clones of *Dalbergia sissoo* for rooting and growth traits. Clone 5 showed superior rooting (61.25 %) and may be suitable for large-scale propagation.

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1. INTRODUCTION

Dalbergia sissoo Roxb., commonly known as shisham, tahli, sissoo etc. is an indigenous timber tree species, belonging to the family Fabaceae, sub-family Faboideae (Saha *et al* 2013). Tahli is a large deciduous tree having thick, rough, grey bark and crooked stem attaining height upto 30 m and girth upto 2.4 m under favourable conditions. It is widely grown under agroforestry and farm forestry conditions, as the competition for nutrients and water with crops do not occur due to its deep root system. Farmers grow it on the boundaries of their fields and on agricultural lands in Punjab in combination with gram, cotton, maize, peas, mustard, rapeseed, wheat and sugarcane. It frequently found at elevation of 900 m, but it can also go as high as 1500 m (Shukla 2002). Its high quality sawn timber is perfect raw material for furniture manufacturing and building construction. The leaves are used as fodder and green manure. It grows as an ornamental roadside tree and is also used for medicinal purposes (Shah *et al* 2010).

Traditionally, *Dalbergia sissoo* is propagated by planting seedlings and suckers (Bari *et al* 2008). Owing to its nitrogen fixing nature, high commercial value, multifarious uses and its large scale mortality in northern region in the past years there is an urgent need

for undertaking large scale afforestation of this tree species. Elite plants selected from natural populations or obtained through breeding initiatives are multiplied through the widespread use of vegetative propagation in horticulture, forestry, and agriculture. Vegetative propagation is a mean of rapidly multiplying desirable genetic/clonal material while capturing the majority of the genetic potential. The majority of the genetic potential, including non-additive variance, is passed to the next plant when vegetative propagation is used (Libby 1974; Puri and Verma 1995). Moreover, tree population is extremely heterozygous and vegetative propagation facilitates the fastest possible utilisation of genetic gains. The proper environment, genetic component and the physiological status of cuttings are necessary for vegetative propagation to be successful (Afzal *et al* 2005). Clonal propagation techniques have been developed in *Dalbergia sissoo* to maintain uniformity in field plantations and increasing the production by producing genetically superior plants (Husen 2004). For the production of high quality timber and faster tree development, it is important to standardise clonal propagation technique through selection of elite clones from which the shoot cuttings are to be collected. Venilla *et al* (2022) standardised clonal propagation of *Pterocarpus indicus* Willd. an important and endangered tree species. Clones are abundant in nature and have long been employed as a tool for domestication, as well as in large scale forest operations. In *Dalbergia sissoo*, clonal variation was noted by Dhiman *et al* (1997) during macropropagation

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using leafy shoot cuttings. Many tree species have been found to exhibit genetic variation in their ability to root (Haissig and Riemenschneider, 1988). Various environmental factors such as hormones (particularly auxin), carbohydrates and mineral salts, all influence and govern the production of adventitious roots in *Dalbergia sissoo* (Kumar *et al* 2022). Carbohydrate content in cuttings is vital for rooting, and it was accumulated at the cuttings' base throughout the adventitious root development process (Bakshi and Kaur 2018). Although clonal propagation has been widely studied in various tree species, limited information is available on the clonal variability in rooting behaviour and early growth performance among different clones of *Dalbergia sissoo*. The lack of detailed, clone-specific data hinders the selection and recommendation of high-performing clones for large-scale nursery propagation and afforestation programs. For the production of high quality timber and faster tree development, it is important to select elite clones from which the shoot cuttings are to be collected. In light of this, this research paper reports the clonal variation in branch cuttings of *Dalbergia sissoo* at the nursery stage with regard to the rooting percentage, root length and number of roots.

2. MATERIAL AND METHODS

2.1 Location and climate of experimental site

The experiment was laid out in the mist chamber, Research Farm of Department of Forestry and Natural Resources, Punjab Agricultural University, Ludhiana, India. The region, which is in the central region of Punjab, is located at 247 metres above sea level and lies at 30°50" N latitude and 75°52" E longitude. A long wet season from July to early September and a long dry season from late September to early June characterize the subtropical to tropical climate. The warmest months are May and June, while the coldest months are December and January.

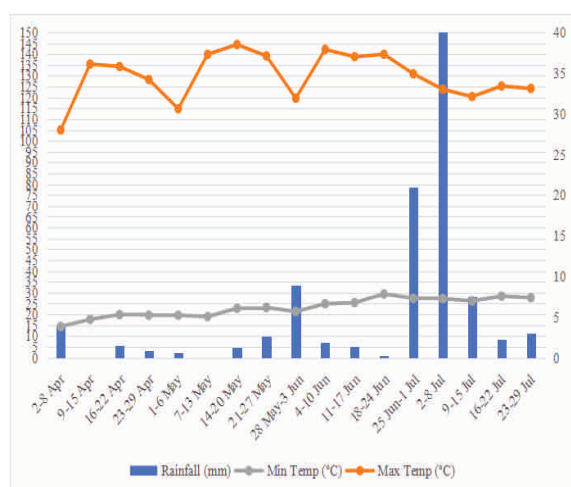


Fig 1: Standard weekly meteorological data recorded during the study period

2.2 Collection of Clonal material

Shoots from 15 different clones from the clonal hedge orchard maintained at Research Farm of the Department of Forestry and Natural Resources, Punjab Agricultural University, Ludhiana were collected in order to make cuttings for conducting the experiment. The details of these clones given in table 1.

Cuttings from 15 clones (maintained as clonal hedges) were collected and treated with IBA 2000 ppm. The vermiculite filled in trays (90 cc) were used as rooting medium. The experiment was arranged in Factorial Completely Randomized Design (CRD) using four replications. The planted cuttings were placed in mist chamber maintained with temperature of 35°C±2°C and relative humidity of 75±5 percent. Data on rooting percentage was collected at 10 days interval. The observations of morphological traits were recorded on randomly selected five rooted cuttings planted in vermiculite media.

a) Collar diameter (mm)

The diameter was measured at 2.5 cm above ground level (collar region) by using digital vernier caliper.

b) Roots per cutting

By uprooting the cuttings from the media, the number of roots formed was counted.

c) Root length (cm)

Plant cuttings were removed from the media to measure the root length using a measuring scale in centimetres.

d) Dry shoot biomass (g)

The shoots were placed in brown paper envelope and labelled properly. Thereafter it was placed in hot air oven at 40° C till a stable weight was achieved and recorded in grams.

e) Dry root biomass (mg)

The roots were placed in brown paper envelope and labelled properly. Thereafter it was placed in hot air oven at 40° C till a stable weight was achieved and recorded in grams.

2.3 Statistical analysis

Analysis of the data through standard statistical procedures was undertaken according to the guidelines defined for completely randomized factorial design. Analysis of variance, variability parameters and critical difference (CD) were calculated for the presentation and interpretation of the results of the present study (Panse and Sukhatme 1989). Analysis of Variance (ANOVA) was applied to the data obtained from rooting, root length, number of roots, dry shoot biomass and dry root biomass.

3. RESULTS

3.1 Rooting and growth traits

It is evident from the table 2 that rooting percentage varied significantly at 5 percent level among the 15 clones of the *Dalbergia sissoo*. The highest rooting response was observed in clone 5 which was 61.25 per cent after 88 days of planting and it was statistically similar with clone 1 (55.00 %) and clone

7 (53.13 %) The rooting percentages ranged from 8.75 to 61.25 percent with an average of 38.75 percent. Significant difference was noted between different clones for average number of roots per cutting, root length and dry biomass ($p < 0.05$). Clone 5 had maximum number of roots per cutting (18.50) which was statistically at par with clone 6 (16.81), clone 12 (16.50), clone 9 (16.44) and clone 8 (16.25). Clone 4 had minimum number of roots (12.31). The

Table 1: Details of *Dalbergia sissoo* clones used in the study

Code	Plus tree Number	Location	Latitude	Longitude	Altitude
1	30/97	Sidhwan Bet, Ludhiana, Punjab, India	30°52'N	75°22'E	244 m
2	68/97	Naraingarh farm, Patiala, Punjab, India	30°35'N	76°16'E	261 m
3	66/97	Nagar to Aur Road, Jalandhar, Punjab, India	31°03'N	75°55'E	274 m
4	62/97	Near Balachaur, Nawa Shehar, Punjab, India	30°35'N	76°16'E	261 m
5	G-5	Nepal	28°17'N	81°27'E	653 m
6	G-4	Nepal	27°53'N	82°44'E	660 m
7	47/97	Vill Kanech, Ludhiana, Punjab, India	30°49'N	75°60'E	282 m
8	201/15	Ballowal Saunkhri, Punjab, India	31°06'N	76°24'E	401 m
9	2/12	Mattewara No. 3, Punjab, India	30°99'N	75°99'E	261 m
10	23/12	Mattewara No. 4, Punjab, India	30°98'N	76°08'E	257 m
11	8/12	Kup Kalan Near Railway Station, Punjab, India	30°36'03" N	75°51'09.05" E	243 m
12	124/15	Azim Garh, Fazilka, Punjab, India	30°06'N	74°14'E	223 m
13	87/15	Harigarh link road, Sangrur, Punjab, India	30°24'46.84" N	76°04'06.70" E	247 m
14	9/13	Barnala to Bathinda Rd No. 9, Punjab, India	30°19'57.0" N	75°29'46.5" E	230 m
15	3/12	Vill. Banbhaura, Dist. Malerkotla, Punjab, India	30°28'00.72" N	75°57'25.59" E	246 m

Table 2: Variation among *Dalbergia sissoo* clones for rooting and growth traits

Clone	Collar diameter (mm)	Rooting percentage (%)	Roots per cutting	Root length of longest root (cm)	Dry shoot biomass (g)	Dry root biomass (g)
1	4.13	55.00	15.94	17.59	0.55	0.061
2	4.14	45.63	14.75	18.84	0.71	0.056
3	3.74	36.25	14.50	17.71	0.71	0.072
4	3.56	30.63	12.31	14.63	0.56	0.057
5	3.79	61.25	18.50	18.11	0.48	0.090
6	3.91	28.75	16.81	15.13	0.56	0.044
7	3.62	53.13	16.00	15.51	0.57	0.058
8	3.43	40.00	16.25	14.02	0.52	0.096
9	3.73	47.50	16.44	16.29	0.52	0.054
10	3.43	44.38	15.88	12.46	0.50	0.059
11	3.68	28.75	14.06	17.33	0.62	0.058
12	3.23	37.50	16.50	17.51	0.72	0.073
13	3.41	32.50	14.06	12.16	0.46	0.045
14	3.46	31.25	15.75	15.54	0.55	0.041
15	3.60	8.75	12.88	11.94	0.42	0.033
Mean	3.66	38.75	15.38	15.65	0.56	0.060
SE	0.05	1.83	0.28	0.39		
LSD 5%	NS	9.51	2.49	3.40	0.05	0.013

mean root length for *Dalbergia sissoo* clones was 15.65 cm. Clone 12 had maximum dry shoot biomass (0.72 g) which was statistically at par with clone 2 and clone 3 (0.71 g). Clone 15 had minimum dry shoot biomass (0.42 g) which was statistically at par with clone 13 (0.46 g). Maximum value for dry root biomass was noted in clone 8 (0.096 g) which was statistically similar to clone 5 (0.090 g). Minimum value was again recorded in clone 15 (0.033 g) which was statistically at par with clone 14 (0.041 g), clone 13 (0.045 g) and clone 6 (0.044 g). Different clones significantly influenced the level of total carbohydrates (Fig. 2). In the beginning total carbohydrate content was maximum in clone 5 (61.61 mg glucose/g DW) planted under mist chamber. The total carbohydrate content decreased on the last day of sampling viz after 80 days of planting.

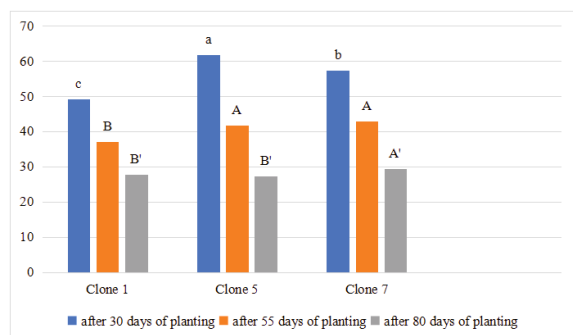


Fig 2: Effect of day of sampling and different clones in metabolic activities of leaf tissues during rooting in the cuttings of *Dalbergia sissoo*. Each bar represents mean (a) Total carbohydrates (mg glucose/g DW) at 2000 ppm IBA level

4. DISCUSSION

4.1 Rooting and growth traits

The variation in rooting percentage for different clones of *Dalbergia sissoo* occurred either due to genetic differences, environmental conditions and management practices. Findings from the study by Husen (2008) showed that variation does exist in shoot cuttings of different clones with respect to rooting response. The clone 5 might have certain genetic traits that make it more favourable for rooting, while the clone 15 may have genetic factors that contribute to lower rooting. The increased physiological age of the plus trees from which some of the clones derived may be connected to their poor rooting response. Factors like temperature and moisture also impact the success of rooting. Rooting of cuttings is a complex process involving biochemical, anatomical and ecophysiological factors controlling root initiation and development on stem cuttings (Uniyal *et al* 1993). The clonal variation for rooting was also reported in earlier studies (Singh and Bhatt 2009, Luna *et al* 2008, Chauhan *et al* 2009a). Apart from genetic differences

and environmental conditions, there could be other reasons for variation in root length, roots per cutting, shoot biomass and root biomass among different clones of *Dalbergia sissoo*. Factors like disease or pest may also be responsible for such variation in growth and rooting traits. The variation among clones for mean shoot and root biomass might be due to the differences in genetic potential among clones of *Dalbergia sissoo* Roxb. (Husen 2008), Luna *et al* (2008) also found huge variation among clones of *Dalbergia sissoo* Roxb. Clone 5 outperformed other clones likely due to a combination of genetic superiority, favourable hormonal balance, and physiological traits such as higher endogenous auxin levels, better carbohydrate reserves, and anatomical features conducive to root initiation and elongation. The current research also revealed that stored carbohydrates were used in shoot cuttings during adventitious root development. For such decrease it has been suggested that hydrolytic enzymes release into the rooting zone of cuttings stored carbohydrates, primarily starch and sugars, where they are used to supply the energy required for cellular differentiation and division. The variation in rooting traits among *Dalbergia sissoo* clones is a result of complex interactions between genetics, hormone regulation, biochemical composition, and anatomical features. Identifying clones with superior rooting potential is essential for efficient vegetative propagation and large-scale planting programs.

Table 3: Analysis of Variance table (ANOVA)

Source	Degree of freedom	Collar diameter (mm)			Rooting percentage (%)			Roots per cutting			Root length of longest root (cm)			Dry shoot biomass (g)			Dry root biomass (g)				
		M.S.	F	CI	M.S.	F	CI	M.S.	F	CI	M.S.	F	CI	M.S.	F	CI	M.S.	F	CI		
Treatment	14	0.27326	1.90	0.36	700.997	15.75**	6.36	10.377	3.39*	1.66	20.301	3.57*	2.27	0.03355	32.32*	0.001187	0.001187	0.001187	14.31**	0.028	
Error	15	0.14402			44.514			3.059			5.685										

*and ** denotes significance at 5 and 1 percent, respectively.

5. CONCLUSION

From the observations recorded and displayed in the form of tables, it is hereby concluded that significant differences were observed among 15 clones for rooting and growth traits. Clone 5 was found best with respect to rooting percentage (61.25 %) which was statistically at par with clone 1 (55 %) and clone 7 (53.13 %). The variability for rooting and growth traits may be exploited for attaining higher success in clonal multiplication of the elite clones and used to improve the efficiency of large-scale propagation. By selecting high-performing clones, nurseries can enhance rooting success, reduce production costs, and produce uniform, vigorous planting stock. The knowledge gained from this research is also crucial for the creation of vegetative multiplication gardens (VMGs) for the species, which would yield excellent propagation material with high rooting percentages for plantation initiatives. This will ultimately lead to higher survival rates in the field, improved plantation outcomes, and long-term gains in tree improvement and forestry programs.

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