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From the
Director's Desk

The ENVIS Centre on FGR-TIP brings to the readers latest information on various aspects of forest genetic resources and tree improvement in the form of articles, reports and documents to strengthen the field of forestry science. A large sector of the rural population are dependent on forest genetic resources for livelihood security and poverty alleviation. This makes it all the more important for us to collate information on FGRs through research being carried out by various organisations in the country. The newsletter provides details of the latest publications brought out in the areas of forest genetics and tree improvement worldwide. The ENVIS team sincerely looks forward to your suggestions and feedback and seeks your support and co-operation.

R.S. Prashanth
Director

In this issue

KNOW YOUR TREES - *Acrocarpus fraxinifolius* (PINK CEDAR)

Botanical Description

Kingdom	:	Plantae
Phylum	:	Tracheophyta
Class	:	Magnoliopsida
Order	:	Fabales
Family	:	Fabaceae
Subfamily	:	Caesalpinioideae
Genus	:	Acrocarpus
Species	:	*fraxinifolius*

Common Names

Pink Cedar, Acrocarpo, Australian ash, Indian ash, Kenya coffee shade, Mundani, Red cedar, Shingle tree (English); Mandania, Mandhani, Mundani (Hindi); Mun, Mundani (Manipuri); Tokphal (Marathi); Kalingi, Kurangadi, Mallam konnai, Mallaykone, Mallekone, Nelrai (Tamil); Karangan, Kurangadi (Malayalam); Belangi, Hantige (Kannada); Mundani Bengali (Bengali).

Mayahnin, Yetama (Burmese); Kuranjan (French); Madang Pariek, Delimas (Indonesian); Delimas (Javanese); Sino-Tibetan (Lao) Lazcar, Cedro Rosado (Spanish); Khang chang, Sadao chang, Khang khi mot (Thai).

Description

Acrocarpus fraxinifolius is a very large, lofty deciduous tree with a straight, cylindrical stem which is free of branches for upto 3/4 of is total height and massive buttressses at the base. The branches remain relatively small and are horizontally deployed. It is one of the tallest trees found in India, generally attaining a height of about 30 m and a girth of over 3 m. In the past, trees of rare heights and girths have been recorded. Colonel Beddome had reported that in southern India, trees are frequently 60 m high; one he measured was 8.23 m in girth above buttresses. Brandis (1885) had measured a tree in West Bengal which was 55.2 m in height with a clean bole of 33.5 m and 3.05 m in girth above the buttresses. A tree with 10.7 m clear bole and 3.8 m GBH giving a total out turn of 30.6 m^3 was reported from Kalimpong Forest Division (Sarkar, 1963).


Leaves

Picture Courtesy :
S. Muthumani, FCRI, Mettupalayam

The trees have thin, light grey bark with numerous lenticels. Although a legume, it apparently does not have nitrogen-fixing nodules. Leaves bipinnate, pinnae 3-4 pairs, leaflets 5-8 pairs, sessile, oblong, ovate and shortly acuminate. The leaves are bright red in colour when young giving the tree its characteristic appearance. Flowers about 3.0 cm long, dull red, arranged in dense erect simple racemes upto 30 cm long. Fruit 10-15 cm long, thin, dark-brown, dehiscent, winged, tapering at the base to the long stalk. Seeds upto 12-16, obovate, oblique compressed and 3.8-5.0 mm across.

Distribution

The species is indigenous to Western Ghats from South Kanara southwards mainly found on hill slopes upto 1200 m. In the eastern Himalayas, it is found in West Bengal, Bhutan, Sikkim, Assam and Meghalaya between 600-1200 m. In the southern India, it is fairly abundant in the Nilgiris, Coorg, North and South Kanara, Anamallis and Palni hills, Tirunelveli, Kerala and Andhra Pradesh (Kurnool district). It is absent from coastal plains of south India. In Assam, it occurs in Goalpara and Cachar. In West Bengal it is found in Kalimpong and Duars forests and in Meghalaya in Garo and Khasi hills at low elevations. In Coorg (Karnataka) the species has been raised as a high shade tree in coffee plantations. On a small scale, the species has been planted in Uttra Pradesh, Himachal Pradesh and Maharashtra. It is a tree of Southern tropical wet evergreen and southern tropical semi-evergreen forests in the sub-types West coast tropical evergreen forest ($1A/C_4$) and west coast Semi-evergreen forests ($2A/C_2$) respectively as distinguished by Champion & Seth (1968). Here it associates are *Artocarpus hirsutus, Bombax ceiba, Tetrameles nudiflora, Hopea parviflora, Lagerstroemia microcarpa, Valeria indica* and *Anthocephalus chinensis*.

In the East Himalayas, it is found in North Indian moist deciduous forests (3C) in the sub-type East Himalayan moist mixed deciduous forests ($3C/C_3b$) in association with Terminalia myriocarpa, Bombay ceiba. *Tetrameles nudiflora, Dvabanga grandiflora, Sterculia villosa* and *Sehima wallichii*. The species has been introduced in the high rainfall zone of Himachal Pradesh between 600-1200 m elevation (Ghildyal, 1989).

Ecology

A. fraxinifolius grows best in submontane areas in the humid and subhumid tropics with a short, dry spell. It is very sensitive to frost. In Thailand, it occurs in evergreen gallery forest and is more frequent in India and Myanmar. Regenerates primarily in small, burnt areas, on open patches where fresh soil has been exposed and along newly constructed roads. *A. fraxinifolius* is a pioneer and demands

light, but it can tolerate slight shade when young. It is most suitable for moderate altitudes with red soil and a moist climate.

Site Factors

i) Climate: In its natural habitat, the absolute maximum shade temperature varies from 350 to 42.5°C and the absolute minimum from 2.5° to 17.5°C. The summers are not very hot and the winters mild. The tree seems to like high rainfall areas, but it adapts itself to a large variation in rainfall ranging from 1900 to 5000 mm and above. Dry season in its habitat does not exceed 3-4 months; where dry period is longer; the tree is restricted to moister localities. In semi humid climates (with annual rainfall of 1500 mm and 4-5 dry months), it grows quickly for the first few years after planting, but then stagnates and dies (Lamprecht, 1989). It is sensitive to frost.

ii) Soil: It grows best in deep, well-drained, clayey-loamy soils with a pH of 4-7. In the Western Ghats, the soil over a large tract is chiefly derived from gneiss and is sandy loam, which is well-drained and porous. In the Eastern Himalayas, it is found on a variety of soils including red soils, brown soils and sandy loam deposits.

Phenology

Old leaves are shed during the cold season, new leaves appear during January in Karnataka and during March elsewhere immediately after recurrence of floral shoots. The young foliage is very handsome, fresh green with pink tips. Small reddish or orange flower appear in dense erect racemes during March in North India and during cold season in South India, when the tree is leafless. Fruits appear from December-February and ripen from April- June. Ripening pods turn brownish in colour and remain hanging from the branches for a fairly long time. The seeds remain intact, even if pod is separated from the tree; Birds get attracted which do rampant damage to the floral buds and young shoots. The fallen flowers are easily recognised from green petals, sepals and crimson stamens.

Silvicultural Characters

As it occurs in mixture with numerous other species, it is a moderate light-demander, though capable of standing some shade in youth. In the early stages, it prefers light shade and heavy weeding as opening of the canopy is considered harmful for regeneration, Raised in open, it is liable to wind damage. Experiments in Tamil Nadu have shown that the species can be successfully regenerated under a top canopy by clearing ground vegetation and also trees in the middle storey (Anon, 1986). It coppices vigorously.

Regeneration

i) Natural Regeneration

The seed has a hard seed-coat, thus imbibition is difficult, causing erratic germination. The seed may lie dormant on the forest floor for 0-10 months. Burning the weed growth and exposure of the mineral soil promote natural regeneration. Germination is epigeous. Primary root is moderately long, wiry, lateral roots moderate in number and length. Young stems are yellow to rusty tomentose. First 1-3 leaves with 3 pairs of leaflets, which increase to 6 pairs by the end of the first season. Lateral nerves 6-8 pairs (Balasubramanyan and Swarupanandan, 1986).

ii) Artifical Regeneration

Seed Collection and Storage: The tree fruits abundantly every year. Trees with fully exposed crowns bear more fruit. In West Bengal, best seed is reported to be obtained from the last week of April to the middle of May and in Karnataka from the end of February till the onset of rains. Mature pods are black in colour, they are collected by lopping branches or off the ground or by hand picking the pods, dried to split open or beaten, or crushed to separate the seed. One kilogram of fruits gives 125 g of cleaned seed. About 1100 fruits weigh one kg (Homfray, 1937). The seeds can be stored for a long time without detriment to viability. In Tamil Nadu, seeds stored in gunny bags or airtight tins for 19 months are reported to be as good as fresh. In West Bengal, however, seeds are not stored for long as they are said to be liable to insect attack.

The germination per cent has been variously reported ranging from 25 for Tamil Nadu and 75 for West Bengal. In Karnataka, Rai, (1976) obtained 90% germination after pretreatment with conc. H_2S0_4. Due to hard seed coat, germination is erratic and is spread over a year or more. In order to secure uniform and quick germination, the seed production areas are identified in West Bengal.

Pre-treatment of seed: Out of the 14 pre-sowing treatments of seed, Rai (1976) found that immersion in conc. H_2SO_4 for 10 minutes followed by washing and soaking in water for about 16 hours gave the best germination percent of 90.67. The second treatment with immersion in conc. H_2SO_4 for 5 minutes followed by washing and soaking in water for about 16 hrs gave 89.15% germination. Therefore treatment with conc. H_2SO_4 gives excellent germination. For this treatment the seed is taken in a pot and acid is poured in the pot to cover the seeds, stirring with a wooden rod continued

for about 10 minutes. Thereafter, the seed is thoroughly washed and soaked in large quantity of water for about 20 hours. Soaking of seed in moistened gunny bags for 15 days also registered 60% germination between 7 days to several months in triblets (Ghildyal, 1989).

Nursery Technique: The pre-treated seed is broadcast or sown in lines on raised germination beds. About 1 kg of seed is sufficient for a standard bed of 1.2 m x 12 m. It is desirable to provide overhead shade to germination beds. Watering is done twice daily till germination take place and then after every alternate day. Most of the germination is complete within 2-3 weeks but the period varies greatly from locality to locality. Once germination starts, seedling develops rapidly, shading and crowding the later germinated seedlings. The seedlings remaining in cotyledonary leaf stage for 2 to 3 weeks. It is desirable to prick out the seedlings at this stage to raised or sunken beds at a spacing of 7.5 to 10 cm. The establishment of pricked out seedlings is better in the shaded beds but to get hardy plants, shade is removed after the cotyledonary stage. It takes about 4 to 5 months to get a seedling of about 60 cm height whil is fit for planting out. The seedlings are sometimes attacked by defoliator of *Euremiablanida silhetana* which can be controlled by spraying an insecticide. Unjudicious watering may produce too moist conditions wherein the seedlings may get damping off. In raised beds pricked out seedlings have reported to show a remarkable shoot growth of 176.1 cm in 198 days (Rai, 1978). Planting of wild specimen taken from beneath selected parent trees is also successfully practised in Karnataka.

Silvicultural Operations

Direct Sowing: The species has been raised by direct sowing also. In West Bengal, direct sowing in lines or patches upto 900 m elevation proved successful, plants reaching 3.6-6.1 m in 2.5 years. Here, direct sowing is usually done in lines 1.8 m apart or in thalli 1.8 x 1.8 m. Mixed line sowing with *Chukrasia velutina* and *Toona ciliata* is also in practice. At Karian shola (Tamil Nadu) direct sowings under evergreen top canopy with a cover crop of *Tephrosia candida* were found to give 29% survival. The best date for sowing was found to be the 3rd of week of July. It is also suitable for broadcast sowing in burnt fuel coupes, as it is tolerant of shade and requires little help from weeds and climbers.

Planting Technique: Entire seedlings planted at the outbreak of monsoon rains give better results than direct sowing. In Maharashtra, entire transplanting of 9 months old seedlings than either direct sowing or stump cuttings gave 1.5-2.1 m height in one season.

Mixtures in Plantations: The species has been grown in mixtures in plantations of bhabar, hill and Duar tracts with other suitable species like sal, teak, *Duabanga grandiflora, Terminalia myriocarpa, Chukrasia velutina* and *Toona ciliata*.


Pink Cedar Plantation

Picture Courtesy :
S. Muthumani, FCRI, Mettupalayam

In sal taunga plantations, the species is planted at a spacing of 14.6 x 14.6 m by line sowings whereas in teak taunga the spacing is reduced to 7.3 x 7.3 m.

In Tamil Nadu, early attempts to raise the species in pure plantations failed due to pest infestations. Growing in mixture in plantations is advantageous due to the fact that this species is tall growing and intense light demander, therefore, has to be widely spaced, when other trees can be put inside.

Tending: As the species is tolerant of shade in its early stages and pushes its way through weeds easily, it requires little weeding and clearing. However, fencing is desirable against browsing and damage by sambhar and deer. Cutting of climbers is also advantageous for the crop. The first thinning must be performed when are 3-5 years old; since the trees require broad crown for optimum development, regular thinnings must continue until the stand is fully developed.

Growth And Yield

It is an extremely fast growing species. Plants left in nursery beds reached 6.1 m in one year. In Buxa (West Bengal), 5 year old plants gave 9.9 m mean height. Ring countings in West Bengal showed that the trees reach a diameter of 46.9 cm at the age of 40 and a diameter 64.6 cm at the age of 60 years.

As the species is grown in mixture with other species, no rotation has been fixed mixed plantations; a conversion period of 60 years is tentatively fixed in West Bengal.

Uses

Fodder : The foliage can be used as fodder.

Apiculture : *A. fraxinifolius* is a good source of nectar and a good bee forage.

Fuel : The wood is sometimes used for firewood in many places.

Timber : The sapwood is whitish; the heartwood is bright red to brownish-red with darker veins, making it very decorative. The wood is not very durable and is prone to attack by fungi and insects, but it impregnates well. It is heavy, moderately hard, and compact; specific gravity varies between 0.55 and 0.7 g/cm^3. It is easy to work with tools and is well suited for turnery, carving and polishing. The wood is used for interior trim, panelling, furniture and cabinet work. Within its native range it is also used for shingles, general construction, floors, stairways, doors, tea crates, beehive frames, and after being impregnated, for railway ties.

Gum or resin : The wood exudes a gum-like resin when the trees are felled.

Wood Properties

Wood of *A. fraxinifolius* has a density of 550-700 kg/m^3; containing an energetic value of 0 kcal/kg and its growing speed is medium. The wood's drying speed is quicer. The wood quality for timber is likeable.

Services

Erosion control : *A. fraxinifolius* has been recommended for reinforcing river banks and stabilizing terraces.

Shade or shelter : Ideal as a shade tree on tea and coffee plantations, for example as planted in Kenya and Uganda. Known to have been planted as a windbreak in Tanzania.

Reclamation : Very good for reforestation of open areas.

Soil improvement : Leaves are suitable for mulching.

Pests and Diseases

Young trees are susceptible to termite attack and in India, a grasshopper (*Atractomorpha crenulata*), and the caterpillar (*Eurema blanda*) defoliate seedlings in nurseries and young plantations. The tree is also a host for the wood borer (*Xylosandrus compactus*), a small Ambrosia beetle. *Ganoderma lucidum* causes trunk and root rot, wherever *A. fraxinifolius* is cultivated. Some insects feed on the sap of the living trees causing wilting of young shoots and foliage not appreciably. Defoliated plants are easily attacked by *Netria* spp. which attack the leading shoot and causes decay.

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Genetic analysis for different growth parameters in *Dalbergia sissoo* Roxb.

Introduction

The demand for wood and wood based products has continuously been on increase, and is likely to enhance further with increasing rate of literacy, liberalization of economic policies and advancement of utilization technology. The production of industrial round-wood in Asia-Pacific region has remained stable during past 25 years within the range of 250 to 300 million m^3 (Anon, 2010). The (FAO (2010) has published a detailed report on import of industrial round-wood in the region to indicate that demands for industrial round woods have grown from 43 (2000) to 67.5 million m^3 (2007). In India, demand for industrial round wood has been predicted to increase from 58 (2000) to 153 million m^3 (2020). Interestingly, out of total production of 68 million m^3 of wood, production from forests amount to only 12 million m^3 and rest wood comes from outside forest including imports (CFA, 2010).

Thus situation seems to be extremely alarming, and requires urgent measures so that either forest cover is increased substantially or productivity on per unit basis is enhanced multifold. Ironically, it may not be feasible to increase forest cover with limited land resources, and therefore possible option to bridge the gap between demand and supply is to only enhance productivity through planting genetically improved planting stocks to maximize returns per unit area (Kumar *et al.,* 2002). Though millions of seedlings are planted in India every year, productivity has however not been consummating with expected yield basically due to poor quality of planting stock (Pal, 1993). Significant improvement in yields has been achieved in many forest tree species through application of tree improvement followed by clonal propagation. The tree improvement and clonal forestry have complemented each other to a greater extent in exploitation of heterosis and its commercial deployment (Ahuja and Libby, 1993). The tree improvement programmes are basically directed towards identification of genetic variability, select desirable individuals and to utilize the variations for mass deployment.

The genus *Dalbergia* named after Swedish Botanist; Nicholas Dalberg (Parrotta, 1989; Ladipo, 1994), belongs to family Fabaceae and sub family Faboidae. It is a pantropical genus with 300 species distributed in different parts of tropical and sub-tropical regions and 34 species of genus are represented in India (Gaur, 1999). The genus *Dalbergia* basically consists of trees, shrubs and woody climbers, and highly valued timber species are considered to be *Dalbergia sissoo, D. latifolia, D. foliacea, D. melonoxylon, D. sericea* and *D. vulubilis*.

Dalbergia sissoo Roxb., popularly known as shisham, is one of the most important timber species of the genus Dalbergia. The species is found in Nepal, Bhutan, Bangladesh, Myanmar, Malaysia, Pakistan and Afghanistan. It is also widely distributed in tropical to sub-tropical Africa and Asia. The tree has been introduced in Java, Nigeria, Mauritius, Sri Lanka, Kenya, Northern Rhodesia, Palestine and Union of South Africa with varying degree of success. Troup (1921) detailed that shisham is indigenous to sub-Himalayan and Bhabar areas, and was introduced elsewhere. In India, it is distributed between latitude 21.17° N to 32.60° N, longitude 74.80° E to 93.43° E and altitude upto 900 m in Sub-Himalayan tracts. It also grows upto 1000 m asl along rivers and streams (Tewari, 1994). Natural forests of *D. sissoo* are common in sub-Himalayan tract either pure or in mixtures with *Shorea robusta, Acacia catechu, Terminalia tomentosa, Albizia procera, Anogeissus latifolia* etc. (Champion and Seth, 1968).

Shisham is used as an important raw material for making finest cabinet, furniture and veneer timbers, and wood is normally golden brown to dark brown in colour with medium coarse textured and fairly straight to somewhat interlocked grains (Rao and Purkayastha, 1972). Its density calculates to about 785 kg m^{-3} at 12 % moisture content. The wood of the species produces hard, heavy and strong timber with moderate shrinkage (Tewari, 1994). The heartwood of the species is highly durable timber (Class I) belongs to treatability class 'E' with practically no penetration from sides or ends (Tewari, 1994), however easy to work and finish (Limaye and Seaman, 1933, Sekhar and Bhatia, 1957).

The tree has excellent coppicing ability and stumps often produce masses of shoots. However, coppicing ability depends on vigour of individual stools and edaphic factors (Anon, 1983). Root suckers sprout up from lateral roots when exposed or cut. Though the species has number of promising attributes, it exhibits generally poor stem form (Bangarwa *et al.,* 1990) and forked bole which deteriorates its timber quantity and quality. However, a great variety of stem forms exists in its natural distribution zone, which indicates possibility of improvement through selection and multiplication. The variation between genotypes can easily be used as an estimate of total genetic variation and to calculate degree of genetic control for a particular trait.

Materials and methods

The nature and pattern of genetic variation among thirty six clones for growth parameters for *Dalbergia sissoo* was studied at three geographical locations to understand productivity and adaptability.

1. Selection of genotypes

A series of phenotypically superior trees were selected from distribution range of the species in India, and Nepal. The selected trees were propagated vegetatively through root suckers and about 350 propagated clones were established in the clonal bank.

The index method of selection (Cotterill and Dean 1986) was adopted for selecting thirty six genotypes for genetic evaluation (Table 1). During selection, it was ensured that experimental material represents maximum distribution range and wider genetic diversity was maintained. In germplasm banks, selection of superior genotypes was carried out by awarding appropriate weightage to different characters viz. height, collar diameter, stem straightness and incidence of disease as per 'Index Method of Selection' (Cotterill and Dean, 1986). The selected genotypes were multiplied clonally and sufficient stock was kept for field planting.

2. Experimental locations

The experimental sites were selected in the state of Punjab representing three agro-climatic zones of Punjab (Table 2). During establishment phase of trials, as far as possible uniform conditions were maintained so that human error could be reduced to the maximum possible.

3. Field studies

The environmental effect and genetic worth of various genotypes were studied through evolution trial at multi-geographical locations (MLT) to screen elite genotypes on the basis of G x E interactions. Some of the genotypes may do well in more than one ecological region where other might do well only in limited regions. Keeping this principal in view, multi-location trials of different clones were established at three locations, with three replications and nine ramets of each clone per replication uniformly.

4. Data collection

The following traits were studied in respect of all the clones established at different geographical locations, and periodic data at an interval of six months was recorded for analysis and interpretation (Table 3).

a. Height

Measurements on height of the plants were recorded in cm from ground level to the tip of the tree visible from ground. Height was measured using a measuring tape which was stretched to the tip of the tree with a bamboo pole.

b. Height at 1st branch

Height of thickest shoot was recorded in cm from ground level using a measuring tape which was stretched to the tip of the tree with a bamboo pole.

Table 1 - *Dalbergia sissoo* clones selected from different states

S.No.	Clone No.	Sources
1	1	Sabhalgarh, Chiriapur, Bijnor, Uttar Pradesh
2	2	Sabhalgarh, Chiriapur, Bijnor, Uttar Pradesh
3	3	Trilokpur, Gonda, Bijnor, Uttar Pradesh
4	4	Sabhalgarh, Chiriapur,Bijnor, Uttar Pradesh
5	9	Sabhalgarh, Pathri, Haridwar, Uttarakhand
6	10	Sabhalgarh, Pathri, Haridwar, Uttarakhand
7	12	Sabhalgarh, Pathri, Haridwar, Uttarakhand
8	14	Sabhalgarh, Pathri, Haridwar, Uttarakhand
9	19	Shah Mansurpur,Saharanpur, Uttar Pradesh
10	24	C.B.Gange, Barielly, Uttar Pradesh
11	33	Bhainsasur, Tulsipur,Gonda, Uttar Pradesh
12	36	Hasanpur, Tulsipur, Gonda, Uttar Pradesh
13	41	Hasanpur, Tulsipur, Gonda, Uttar Pradesh
14	43	Trilokpur,Tulsipur, Gonda, Uttar Pradesh
15	49	Trilokpur,Tulsipur, Gonda, Uttar Pradesh
16	51	Birpur, Bhambar,Gonda, Uttar Pradesh
17	57	Dinsia, Khalawala, Ambala, Haryana
18	66	Chihrauli, Yamunagar, Haryana
19	124	Kosi River Bank, Inerwa, Sarali, Nepal
20	128	Mahendragarh, Sarali, Nepal
21	168	Kanau, Chaur, Chila, Bariaj, Chila Rajaji, Chila Uttar Pradesh
22	174	Kanau, Chaur, Chila, Bariaj, Chila Rajaji, Chila Uttar Pradesh
23	192	Hasanpur 2, Tulsipur, Gonda, Uttar Pradesh
24	198	Hasanpur 2, Tulsipur, Gonda, Uttar Pradesh
25	201	Hasanpur 2, Tulsipur, Gonda, Uttar Pradesh
26	204	Hasanpur 2, Tulsipur, Northgonda, Uttar Pradesh
27	232	Birpur 4(near Limla Khonder), Bhambar, Gonda, Uttar Pradesh
28	235	Bankatwa 2, Gonda, Uttar Pradesh
29	237	Bankatwa 2, Gonda, Uttar Pradesh
30	243	Bankatwa 2, Gonda, Uttar Pradesh
31	247	Bankatwa 2, Gonda, Uttar Pradesh
32	5038	B.B.C 72-73 I/S, Sangrur, Punjab
33	5039	Pir Mashala, Compt.- II, Dera Bassi, Patiala, Punjab
34	5040	Amargarh-Chaunda Road, Km 6-7 L/S Sangrur, Punjab
35	5041	G.B.C 194-95 R/S Leharganga, Sangrur, Punjab
36	5042	Bir Mattewara Compt. 25, Ludhiana, Punjab

Table 2- Selected sites and respective agroclimatic zones of Punjab

S.No.	Name of location	Altitude	Longitude	Latitude	Temperature	Rainfall	Agroclimatic zone
1	Ludhiana	260 m	075°59'11.4"E	30°59'08.3"N	5.0°C to 39.0°C	948.0 mm	Hot semi-arid
2	Hoshiarpur	247m	075°49'02.3"E	31°33'33.0"N	14.1°C to 32.5°C	680.0 mm	Hot sub-humid
3	Patiala	249 m	076°24'01"E	30°19'36.0"N	7.1°C to 40.4°C	688.0 mm	Hot semi-arid

Table 3 : Pooled mean growth values for different parameters

Clone No.	Height (cm)	Height at 1st branch (cm)	Collar diameter (cm)	DBH	Stem straightness	Branching behaviour	Volume (cm^3)
1	394.73	149.08	57.37	42.30	2.91	3.07	0.13
2	438.47	157.99	62.70	47.35	2.80	2.86	0.15
3	432.76	172.04	65.25	49.26	2.95	2.75	0.16
4	404.16	158.60	61.47	45.43	2.76	2.81	0.14
9	356.42	152.30	51.15	37.19	2.90	2.91	0.11
10	414.47	168.60	56.69	41.57	2.92	2.78	0.13
12	257.71	110.52	37.31	20.91	2.67	2.63	0.05
14	413.80	161.83	61.31	44.29	2.91	2.72	0.14
19	414.58	169.58	62.34	46.13	2.94	2.84	0.15
24	430.92	170.04	61.76	44.68	2.92	2.84	0.15
33	427.77	177.37	63.92	46.33	2.88	2.95	0.15
36	434.60	169.76	68.05	49.13	2.85	2.81	0.16
41	477.21	180.62	68.70	50.89	2.76	3.06	0.18
43	410.90	173.32	58.21	42.86	2.91	2.74	0.13
49	419.95	172.39	62.31	45.53	2.80	2.87	0.15
51	388.71	165.35	53.66	38.91	3.03	2.99	0.12
57	365.87	159.73	51.36	38.57	2.85	2.72	0.11
66	230.40	108.62	30.23	17.12	3.07	2.97	0.04
124	438.34	159.65	59.07	45.80	2.88	2.84	0.14
128	398.49	167.70	60.51	43.75	2.89	2.91	0.13
168	382.01	151.60	55.34	39.48	3.00	3.08	0.11
174	351.59	137.22	48.27	37.06	2.93	2.92	0.09
192	303.92	122.15	44.00	27.67	3.04	2.76	0.08
198	375.13	149.43	52.53	37.01	3.09	3.09	0.11
201	429.38	165.65	60.51	45.03	2.91	2.64	0.16
204	204.75	104.83	28.27	16.21	3.03	2.80	0.03
232	293.98	116.99	40.78	26.41	2.96	3.00	0.07
235	401.40	153.02	57.18	39.91	3.02	2.82	0.13
237	398.93	166.10	61.95	45.96	2.95	2.86	0.14
243	126.31	46.27	17.87	11.92	1.02	1.14	0.04
247	366.03	150.90	51.30	36.35	2.98	2.79	0.10
5038	366.76	158.54	63.27	42.34	2.72	3.02	0.12
5039	306.05	139.87	45.06	30.85	3.09	3.12	0.08
5040	335.70	143.34	51.87	37.16	3.01	3.09	0.10
5041	320.70	132.17	52.17	38.58	2.63	2.65	0.10
5042	339.51	160.49	52.01	35.42	3.07	3.04	0.10
Average	**368.12**	**150.10**	**53.77**	**38.48**	**2.86**	**2.83**	**0.12**
Maxi	**477.21**	**180.62**	**68.70**	**50.89**	**3.09**	**3.12**	**0.18**
Mini	**126.31**	**46.27**	**17.87**	**11.92**	**1.02**	**1.14**	**0.03**

c. Collar diameter (CDM)

The collar diameter of the plant was measured in cm upto two decimal places at 10 cm above the ground level with the help of the digital electronic vernier caliper (Model: NSK max- cal- 269369).

d. Diameter at breast height (DBH)

Diameter at breast height was measured at 1.37 m height on the tree stem in cm upto two decimal places using digital electronic vernier caliper. In case of forking below this height, diameter of both the shoot was recorded and averaged later on.

e. Stem straightness

The stem straightness was awarded weightage through developing an index value in the scale of 1 to 5 as per following;

5 points : Straight bole
4 points : Straight with one bend
3 points : Straight with two bends
2 points : Crooked bole
1 point : Very crooked bole

f. Branching and crown behaviour

The branching behaviour, as index score from 1 to 5 was developed subjectively and the weightage was developed in following manner;

5 points : Lesser branches with narrow crown on the tip of the plant/ tree and thinner branches
4 points : Lesser branches with medium crown with thinner branches
3 points : Medium sized branches with medium crown
2 points : Thicker branches with more numbered and medium crown
1 point : Poor and thicker branches

g. Self pruning ability

The self pruning ability of different clones was also observed. Most of clones were found poor in self pruning ability and did not have clear cut distinguishness for the trait.

5. Analysis of variance

The growth data obtained at was analyzed for variance for different characters for all three geographical locations to understand G x E interactions (Table 4).

The pooled analysis depicted that variation due to clones for all the characters were highly significant except stem straightness. The variation due to environment was also found significant for all the characters. The variation due to environment + (clone x environment) was also found to be significant for all the characters except colar diameter and stem straightness, and pooled deviation also demonstrated significant results for all the characters except height.

6. Genetic analysis

The analysis of genetic parameters including phenotypic variance, genotypic variance and environmental variance for height, height at 1st branch, collar diameter, diameter at breast height, stem straightness, branching behaviour and volume were calculated for all the locations on pooled data (Table 5).

Discussion

During the course of investigations, a total of thirty six clones were evaluated on various growth parameters across three locations. The divergence analysis was carried out to estimate genetic diversity existing among the clones under evaluation. The results obtained from present investigation

Table 4. Pooled analysis of variance table (ANOVA)

		Mean sum of squares						
Source of Variations	**Df**	**Height**	**Height at 1st branch**	**Collar diameter**	**Diameter at breast height**	**Stem straight ness**	**Branching behavior**	**Volume**
Rep within Environment	6	16701.78**	1041.8	3433.44*	401.03**	0.14	0.18	0.01***
Clones	3	516501.95***	2144.89***	391.13**	283.13**	0.34	0.31**	0.00***
Environment + (Clone X Environment)	7	211204.49**	1097.59**	251.68	209.41*	0.18	0.19*	0.00**
Environments	2	112745.05***	8655.22***	1276.54**	2136.14***	1.19**	0.75**	0.03***
Clone X Environment	7	08303.33*	881.65*	222.40	154.36	0.15	0.17	0.00*
Pooled Deviation	3	64517.08	520.53***	160.20***	106.37***	0.20**	0.11***	0.00*
Pooled Error	2	102207.87	147.19	56.62	41.98	0.03	0.05	0.00
Total	107	12937.30	1440.16	297.30	233.52	0.23	0.23	0.00

Significance level: ***p<0.001, **p<0.01, *p<0.05

Table 5 – Genetic parameters for various growth characters

Characters	PCV%	GCV%	ECV%	Heritability (h^2)	Genetic advance (Gs)		Genetic gain	
					5 %	1%	5%	1%
Height	36.10	18.16	31.20	0.25	69.28	88.79	18.82	24.12
Height at 1st Branch	27.94	14.70	23.76	0.28	23.90	30.63	15.93	20.41
Collar diameter	38.06	17.07	34.01	0.2	08.48	10.87	15.77	20.21
Diameter at breast height	47.00	23.73	40.58	0.26	9.49	12.17	24.67	31.62
Stem straightness	19.32	8.39	17.41	0.19	0.22	0.28	7.50	9.61
Branching behavior	20.29	8.59	18.38	0.18	0.21	0.27	7.49	9.59
Volume	63.52	31.98	54.88	0.25	0.04	0.05	33.16	42.50

have therefore been discussed hereunder for appropriate interpretations.

The clones evaluated at three locations expressed, for various growth traits, to greater extent at Patiala followed by Ludhiana and the least expression was recorded at Hoshiarpur. Clone 41 was found to be the most promising clone over other clones. On the other hand, clone 243 was recorded with poor performance during the period of investigation. The growth performance therefore clearly indicates that at Patiala the clonal stock could express to the maximum level, whereas at Hoshiarpur the expression of genotypic worth was found to be poor. This may be attributed to edaphic and climatic differences between the sites. The results obtained are in agreement with the studies carried out by Rawat and Nautiyal (2007) who expressed role of climatic and edaphic factors in expression of genotypic worth in Dalbergia sissoo. Wu *et al.* (1997) also concluded that wide range of physiographic, soil and vegetative competition effects among the sites contribute in the expression of genetic worth of genotype through G x E interaction. Xu (1998) estimated that only about 8.33% of the growth variation attributed genetic variability among the 43 populations of Sitka spruce. Jun *et al.* (1998) found that there were no significant differences in stem height and diameter among different provenances of *Pinus tabuliformis*. Significant variation with respect to shoot length, collar diameter, number of leaves and total biomass was observed when variability studies were undertaken in 15 provenances of *Azadirachta indica* (Jain and Dhar, 2008). Nicodemus (2004) found significant levels of provenance variation in height, DBH, axis persistence, stem stem straightness, wood density, moisture content and bark thickness in 108 open-pollinated families representing 49 provenances of *Casuarina equisetifolia*. Significant variation for growth parameters were observed in a provenance trial of *Eucalyptus obliqua* (Brown *et al.,* 1976). In Brazil, variability studies were conducted in *Eucalyptus* to record sufficient variability between and among the populations (Dias and Kageyama, 1991).

Analysis of variance indicated statistically significant differences among the clones for all the traits studied. However, Patiala exhibited highest inter-clonal variation for height, collar diameter, DBH, branching behaviour, volume production and ranked second highest for height at 1st branch and stem straightness. These facts clearly indicate the effect of varying environmental conditions on expression of genotypic worth of different clones of *Dalbergia sissoo*. Kirkpatrick (1975) also stated the presence of distinct pattern of geographical variation in adult plants of *Eucalyptus globulus* whereas, to conclude high intra-clonal variation.

The analysis across locations depicted that variation due to clones and environment for all the characters was highly significant except stem straightness. Performance of genotypes in terms of height, height at 1st branch and volume was significantly affected by the interactions of environment which indicates that different clones have responded differently to changing environments. Similar findings were reported by Awang (1994) for height and DBH in *Acacia auriculiformis* provenances and Akande *et al.* (2009) for grain yield and reproductive characters in Glycine max. Nakitandwe *et al.* (2005) analyzed G x E effects to conclude that the proportion due to environments would be larger than of the proportion due to genotypes. The outcome of the analysis of present investigation suggested that different clones under evaluation had sufficient heterogeneity and the effect of clone x environment interaction was similar to other investigations. Clone x environment interaction was found larger than that of clonal effect for Populus species (Yu and Pulkkinen, 2003). The variance due to pooled deviation indicated considerable genetic diversity among the clones under investigations, which support the observation of Perkins and Jinks (1968). Such deviation may be of practical use to construct and test the utility of multiple regression models to know critically the complex mechanism of adaptation.

The genetic parameters are useful tools for predicting the amount of gain to be expected from clonal material. The variation between clones is commonly used as an estimate of total genetic variation and to calculate degree of genetic control for a particular trait (Foster and Shaw, 1988).

Genotypic coefficient of variation (GCV) indicates that range and magnitude of genetic variability exists among the traits in vicinity of phenotypic coefficient of variation (PCV). Burton (1952) suggested that the study of the genetic coefficient of variation together with heritability estimates could give appropriate estimate of genetic gain to be expected from selection. In the present study, environmental coefficients of variation (ECV) estimated for all the traits were higher than their respective GCV and indicated significant influence of environment on expression of different growth traits. Similar studies have been carried out by Ginwal and Mandal (2004) in *Acacia nilotica*. In fact, high heritability in conjunction with high GCV has been reported to be advantageous for practicing selection (Hanson *et al.,* 1956). According to Devagiri *et al.* (2004), ECV for all the seed and pod traits in *Dalbergia sissoo* were much less than that of their respective GCV and PCV. In present findings, highest PCV estimates were recorded for volume (63.51%) suggesting large amount of genetic variability for volume production followed by DBH (47.00%), CDM (38.06%) and height (36.10%) whereas, lowest to moderate PCV values were recorded for stem straightness (19.32%), branching behaviour (20.29%) and height at Ist branch (27.94%) thereby indicating narrow variability for these traits. Low value of GCV for height was reported by Singh (1993) in *Bambusa pallida* and by Sundararaju *et al.* (1995) in *E. tereticornis*. Surendran and Chandrasekharan (1984) from their findings recorded higher values of GCV for primary branches and also showed high heritability coupled with genetic advance for number of branches in *Eucalyptus tereticornis*.

Broad sense heritability is defined as ratio of total genetic variation to the phenotypic variation, and is of practical application in tree improvement particularly when clonal propagation is applied (Zobel and Talbert, 1984). Genetic advance provides information about the extent of genetic gain which is possible to achieve through selection, while heritability indicates how much of the phenotypic variability is heritable. Xiang *et al.* (2003) showed that additional and significant gain can be achieved by keeping entire non-additive component through vegetative propagation of the promising individual trees for promising full-sibs. Heritability estimates in broad sense will be reliable if accompanied by high genetic advance (Burton and Devane, 1953). High heritability accompanied by high genetic advance for several growth parameters have earlier been reported by Solanki et al. (1984) in *Prosopis cineraria* and Dhillon *et al.* (1995) in *Dalbergia sissoo*.

Among different traits studied, moderate heritability (0.25) coupled with high genetic advance with moderate genetic gain were exhibited by height. This signifies the fact that this trait contains good amount of heritable additive genetic component that can be exploited for further selection and improvement of this species. Subramanian *et al.* (1995) concluded that height, clear bole height, girth, diameter and basal area showed very moderate heritability and genetic advance in *Eucalyptus grandis*. Similar findings have earlier been reported for plant height and stem diameter by Sharma and Sharma (1995) in *Grewia optiva*. High heritability coupled with moderate genetic advance for height was assessed by Thakur (2007) in *Alnus nitida*. In *Dalbergia sissoo* heritability estimate for height, diameter and stem form have been reported by Vidakovic and Siddiqui (1968) and Vidakovic and Ahsan (1970). Giannini and Raddi (1992) reported higher range of heritability in plant height than diameter on clonal selection of *Cupressus sempervirens* and Borralho *et al.* (1992) in *Eucalyptus globulus*.

Height at 1st branch registered the maximum moderate value for broad sense heritability (0.28) with moderate genetic advance. The moderate genetic gain against high heritability shown by height at 1st branch, indicated that the expression of this character is possibly controlled by intra and inter-allelic interaction. Collar diameter had moderate heritability (0.20) accompanied by moderate genetic gain and low genetic advance may likely be due to non-additive gene action. Gera *et al.* (2001) reported that height and collar diameter exhibited high heritability (85.50% and 74.02%, respectively) with highest genetic gain (46.63% and 36.83%) in *Tectona grandis*. Gera *et al.* (2000) while working on *Dalbergia sissoo* showed low heritability for collar diameter, internodal length and survival. During present investigations, moderate heritability was associated with low genetic advance for DBH, indicating that additive gene effects are important in determining this character. High heritability coupled with high genetic advance for diameter at breast height and height in poplar was observed by Singh *et al.* (2001), Singh *et al.* (1996) and Tewari *et al.* (1999). Shelbourne and Low (1980) also report a moderately high average individual heritability of 0.19 for diameter of *Pinus radiata*. Pichot and Cross (1989) while working on estimation of genetic parameters in *Populus deltoides* found that heritability estimates for diameter were higher in comparison to plant height at the age of two years. Wilcox and Farmer (1967) observed opposite trend in *P. deltoides*.

The importance of stem straightness is recognized by the solid wood product. The stem straightness exhibited moderate heritability coupled with low genetic advance and gain. Hodge *et al.* (2002) demonstrated that stem straightness seems to have low heritability (h^2<0.10), with low to moderate additive variance (5%<GCV<10%) in *Bombacopsis quinata*. The results of present finding showed that more work is needed to determine the economic value of improvement in this trait due to moderate inheritance pattern with low genetic advance. In *Dalbergia sissoo* stem straightness is reported to be under considerable genetic control (Vidakovic and Ahsan, 1969).

Branches contribute significantly to trunk thickeness and are also point of crown size, which is linked to changes photosynthetic fixation of CO_2 / unit of land area. The branching behaviour showed low genetic advance with moderate heritability (0.18) to exhibit that this trait expressed low / moderate inheritance pattern with low genetic control. Singh (2006) reported high heritability for proleptic and sylleptic branch in *Populus deltoides*. Crown and branch form of white spruce showed high heritability (Shelebourne, 1969). Wilcox and Farmer (1968) estimated intermediate range of heritability for number of branches. Volume recorded a moderate broad sense heritability (0.25) coupled with high genetic gain and low genetic advance which may be attributed to the action of additive and non-additive genes. Genetic gain could also possibly be increased by employing an appropriate method of indirect selection (Lin and Zsuffa, 1993).

Conclusion

The investigation was carried out to evaluate comparative performance of 36 clones of *Dalbergia sissoo* for growth parameters under different environmental conditions with a purpose to understand the genotypic worth of various clones. Selections for the programme were carried out in diverse conditions of both India and Nepal, adopting index method. Further, plus trees were propagated clonally and established in vegetative multiplication garden for creation of juvenility. Thereafter, the clone were multiplied in mist chamber and established at three geographical locations. Though clone 41 was found to be most promising clone showing highest growth rate, clones 124, 24, 36 and 1 were reported to be stable over the location. Clone 33, 36, 41 registered maximum index values which suggests that these clones have well adapted to the environmental conditions. It is recommended that clone 41, which originated from Gonda (Uttar Pradesh, India) may well be used for large-scale clonal deployment.

Based on analysis of various genetic parameters including variability, genetic divergence, heritability, genetic advance and genetic gain for growth characteristics, clones exhibited greater productivity and adaptability. In this way, the practical application of tools of genetic improvement for screening of productive and adaptive clones has amply been demonstrated.

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ENVIS ACTIVITIES

SECAS exhibition at Karur Railway Station

Science Express climate Action Special (SECAS) train flagged of on 17th February 2017 from Delhi Safdarjung is an innovative mobile science exhibition mounted on 16 AC coaches custom-built for Department of Science & Technology (DST), Department of Biotechnology (DBT), Ministry of Environment, Forest and Climate Change (MoEF&CC), Vikram A Sarabhai Community Science center (VASCSC) and Wildlife Institute of India (WII) by Indian Railway. It aims to create awareness among various sections of society, especially students, as to how climate change can be combated through mitigation and adaptation. The train is scheduled to travel across the country about 8 months, halting at 74 locations covering 19,000 km.

FGR-TIP ENVIS had put up a stall at karur in Tamil Nadu, one of the Station of the Train. More than 5000 people visited our stall including school/college students, teachers, parents and general public. The ENVIS team explained about the concept of ENVIS, various centres under MoEF&CC, focal point, and importance of conserving existing forest genetic resources to mitigate the fluctuating climate condition. The school children were supplied with various knowledge products such as environmental quiz booklets and name slips with tree passport information.

ABOUT IFGTB

Institute of Forest Genetics and Tree Breeding (IFGTB), Coimbatore is a National Research Institute under the Indian Council of Forestry Research and Education. IFGTB envisions a wood secure society. The Institute primarily aims to carry out research to improve productivity of forest tree species through conventional breeding programmes and biotechnological interventions. The major areas of research include tree improvement , breeding, planting stock improvement, marker assisted selection, genomics, clonal propagation, agroforestry systems, climate change research, integrated disease and pest management, seed handling and testing, eco restoration and conservation.

ABOUT ENVIS

ENVIS established by the Government of India, in 1982 has been on providing environmental information to decision makers, policy planners, scientists and engineers, research workers, etc. all over the country. It is a comprehensive decentralized information system on environment involving effective participation of institutions / organisations in the country actively engaged in work relating to different subject areas of environment. A large number of nodes, known as ENVIS Centres, have been established in the network to cover the broad subject areas of environment with a Focal Point in the Ministry of Environment, Forest and Climate Change.

INSTRUCTIONS TO CONTRIBUTORS

Dear Author/ Subscriber/ Contributor,

We invite contributions to the ENVIS Newsletter issues! The ENVIS Centre at IFGTB focuses on Forest Genetic Resources and Tree Improvement. It aims to act as a window for quality scientific publications and a forum for presenting your thinking on the challenges in the fields of FGRs and tree improvement. The ENVIS Newsletter, Van Vigyan, a quarterly publication, publishes original research articles, reviews, reports, research highlights, news-scan etc., related to the thematic area of the ENVIS Centre. Original research and review articles, notes, research and meeting reports are invited for the newsletter. Details of forthcoming conferences / seminars / symposia /trainings / workshops also will be considered for publication in the newsletter. Articles may be sent in Times New Roman (with font size 12) in double spacing with a maximum of 5-6 typed pages. Photographs/line drawings and graphs need to be of good quality with clarity for reproduction in the newsletter. Only electronic submission will be accepted.

Details may be sent to: ifgtb@envis.nic.in.

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