INTER-CLONAL VARIATION IN *DALBERGIA SISSOO* ROXB. WITH RESPECT TO GROWTH PERFORMANCE, SURVIVAL AND PHENOLOGICAL CHARACTERISTICS IN DIFFERENT CLIMATIC ZONES

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Introduction

Variations and their manifestation within a tree species are due to heredity and environment. Growing progenies under unform site and climatic condition reduces the proportion of environmental variations facilitating selections for genetic variations (Faulkner, 1975). *Dalbergia sissoo* shows a great degree of variation both within and between populations for growth rate and stem form (Vidakovic and Siddiqui, 1968; Vidakovic and Ahsan, 1970; Dogra, 1981; Bangarwa *et al.,* 1994).

Flowering phenology within a clonal plantation can potentially alter the quantity as well as genetic quality of fruits (Sedgley and Griffin, 1989). There seems to be a direct association between the extent of flowering synchrony and fruit production among the constituent clones in the plantation. Krishnaswamy and Mathuda (1954), Sheikh (1989), Bangarwa (1993) and Bangarwa *et al.* (1994) studied the phenological characteristics of *Dalbergia sissoo* in north Indian conditions.

Keeping the above facts in view the present study was undertaken to determine the inter-clonal variation in *Dalbergia sissoo* with respect to growth performance, survival and phenological characteristics in different climatic zones. Selections for clonal variations are made for growth rate, site adaptability, pest resistance and productivity (Landsberg and Wright, 1989). These differences make the proper selection of clonal material, which is critically important in the success of any plantation programme.

Material and Methods

The planting materials of *Dalbergia sissoo* from more than 300 candidate plus trees were collected from the entire range of its distribution in India and multiplied at vegetative multiplication garden at New Forest, Dehra Dun. Out of these, few promising clones were selected and multiplied vegetatively by taking 3-4 cm long softwood cuttings with at least 1-2 leaves from the coppice shoots and providing them with basal dipping in 1000 ppm IBA. The rooted cuttings were then transferred to polythene bags containing a mixture of soil, sand and FYM in a standard ratio. After one year of growth, clones were transplanted to the fields for

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laying out clonal plantation trials in different climatic zones of northern India (Table 1). The trials were laid out in Randomized Block Design with three replications each of nine ramets with spacing of 6 m x 6 m. Six clones were selected for the present studies which were common to all sites. The details of the clones and their parental trees are given in the Tables 2 and 3.

Growth parameters were recorded at quarterly basis for two years w.e.f. November 1998 to March 2001 and survival per cent was recorded during the month of March, 2001. Height and collar diameter are presented as height and collar diameter increment by subtracting the initial mean data with the respective quarterly data. Phenological characteristics viz. time of flowering, pod and seed setting were recorded for all the clones. The data recorded were subjected to statistical analysis using SPSS statistical package to quantify the variation among clones at different sites. For better interpretation of the significant results, critical differences were calculated by Scheffe's method at 5% probability level (Scheffe, 1959).

Results

Height Increment : Table 4 reveals that all clones registered a steady increase in height increment at all the sites and significant inter-clonal variation was observed significant at $P \leq 0.05$. Clone C192 attained the maximum height increment followed by clones C066, C019, C034 and C087 in that order, while clone C083

Table 1

Details of the experimental sites.

Site Characteristics	Lachhiwala, Dehra Dun (Uttarakhand)	Lalkuan, Haldwani (Uttarakhand)	Bithmera, Hisar (Haryana)	Pandhori Mindo Mind, Hoshiarpur (Punjab)
A. Geographic Details:				
1. Latitude	30° 11' 60" N	29° 10' 00" N	29° 33' 00" N	31° 31' 60" N
2. Longitude	78° 07' 00" E	79° 31' 00" E	75° 55' 00" E	75° 54' 60" N
3. Altitude (m)	512	423	216	290
B. Soil Characteristics :				
1. pH	8.00	6.42	7.40	6.45
2. E.C. (mS)	0.26	0.29	0.24	0.09
3. Organic Carbon (%)	0.27	0.46	0.49	0.10
4. Available Nitrogen (kg/ha)	137.90	188.20	150.50	125.40
5. Available Phosphorus (kg/ha)	48.40	63.80	70.60	73.20
6. Available Potassium (kg/ha)	22.40	78.40	156.80	23.50
7. Calcium (ppm)	170.00	230.00	320.00	120.00
8. Magnesium (ppm)	122.00	174.00	185.00	195.00

Table 2

Geographical details of the Dalbergia sissoo clones.

Clone	State	Circle	Division	Range	Beat	Compt.
C019	Uttarakhand	Haridwar	Haridwar	Khanpur	Shahman-soorpur	-
C034	Uttar Pradesh	Gonda	North Gonda	Tulsipur	Bhain-sasur	2
C066	Haryana	Yamuna Nagar	Yamuna Nagar	Chhichrauli	-	-
C083	Rajasthan	Hanumangarh	Hanumangarh	Hanuman-garh	--	12 A Kola
C087	Rajasthan	Hanumangarh	Hanumangarh	Hanuman-garh	--	12 A Kola
C192	Uttar Pradesh	Gonda	North Gonda	Tulsipur	Hasnapur	2

Table 3

Details of the parental trees of Dalbergia sissoo clones.

Clone	Age (yrs.)	Total Ht. (m)	GBH (cm)	Clean Bole (m)
C019	50	34.00	178.00	15.00
C034	45	22.00	122.00	12.00
C066	40	15.20	120.00	9.00
C083	47	14.00	105.00	8.50
C087	47	13.00	110.00	8.00
C192	48	25.00	111.00	15.00

exhibited the minimum height increment at Lachhiwala (Dehra Dun).

Clone 034 outperformed all other clones at Lalkuan (Haldwani) and Bithmera (Hisar) and clone 066 at Pandhori Mindo Mind (Hoshiarpur) for maximum height increment. On the other hand, clone 019 at Lalkuan, clone 083 at Bithmera and clone 087 at Pandhori Mindo Mind attained minimum height increment, the performance of the other clones was in the order: C 192 > C066 > C 083 > C087 at Lalkuan, C 192 > C 066 > C 019 > C087 at Bithmera and C 192 > C034 > C083 at Pandhori Mindo Mind.

The effect of the site on inter-clonal variation in height increment was also found significant at $P \leq 0.05$. Generally, all the clones attained the maximum height increment at Bithmera followed by Lalkuan, Pandhori Mindo Mind and Lachhiwala in that order.

Collar Diameter Increment : Collar diameter increment increased throughout the period of study from November 1998 to March 2001. Significant inter-clonal variation was recorded in collar diameter increment at $P \leq 0.05$ (Table 5).

Clone C192 attained the maximum collar diameter increment whereas clones C066, C019, C034 and C087 were statistically at par at $P \leq 0.05$; while minimum value was recorded for clone C083 at Lachhiwala (Dehra Dun). Clone

Table 4

Inter-clonal variation in height increment (m) at different sites.

Site	Clone	Month							Mean
		March 1999	July 1999	Nov. 1999	March 2000	July 2000	Nov. 2000	March 2001	
Lachhiwala	C019	0.05	0.34	0.84	0.91	1.15	1.37	1.53	0.88
(Dehra Dun,	C034	0.17	0.34	0.61	0.72	1.04	1.24	1.32	0.78
Uttarakhand)	C066	0.09	0.39	0.75	0.93	1.36	1.62	1.75	0.98
	C083	0.09	0.21	0.39	0.60	0.69	0.84	0.91	0.53
	C087	0.16	0.35	0.56	0.73	0.85	0.97	1.04	0.67
	C192	0.41	0.69	1.03	1.18	1.51	1.95	2.08	1.26
	Mean	0.16	0.39	0.70	0.84	1.10	1.33	1.43	0.85
Lalkuan	C019	0.10	0.27	0.46	0.58	0.81	1.01	1.11	0.62
(Haldwani,	C034	0.22	0.85	1.84	2.03	2.82	3.23	3.43	2.06
Uttarakhand)	C066	0.15	0.45	0.76	0.91	1.22	1.56	1.71	0.97
	C083	0.13	0.31	0.54	0.76	0.95	1.34	1.46	0.78
	C087	0.12	0.29	0.50	0.66	0.87	1.10	1.23	0.68
	C192	0.30	0.55	0.96	1.15	1.61	2.20	2.41	1.31
	Mean	0.17	0.45	0.84	1.02	1.38	1.74	1.89	1.07
Bithmera	C019	0.48	1.61	2.57	2.91	3.50	3.97	4.29	2.76
(Hisar,	C034	0.43	1.79	2.92	3.33	4.28	5.02	5.51	3.33
Haryana)	C066	0.34	1.45	2.48	2.86	3.71	4.44	4.69	2.85
	C083	0.36	1.30	2.05	2.50	3.29	3.95	4.31	2.54
	C087	0.45	1.39	2.22	2.79	3.59	4.19	4.62	2.75
	C192	0.39	1.46	2.33	2.79	3.64	4.50	5.15	2.89
	Mean	0.41	1.50	2.43	2.86	3.67	4.34	4.76	2.85
Pandhori	C019	0.12	0.33	0.52	0.64	0.93	1.20	1.35	0.73
M. Mind	C034	0.18	0.48	0.74	1.04	1.45	1.82	2.13	1.12
(Hoshiarpur,	C066	0.17	0.52	0.83	1.04	1.70	2.55	3.13	1.42
Punjab)	C083	0.07	0.24	0.44	0.53	0.81	1.16	1.30	0.65
	C087	0.07	0.19	0.31	0.36	0.58	1.03	1.09	0.52
	C192	0.14	0.54	0.86	1.09	1.46	1.79	2.13	1.14
	Mean	0.13	0.38	0.62	0.78	1.15	1.59	1.86	0.93

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	Mean of Clones	C019 1.25	C034 1.82	C066 1.55	C083 1.12	C087 1.15	C192 1.65

	Mean of Sites	Lachhiwala 0.85	Lalkuan 1.07	Bithmera 2.85	Pandhori M. Mind 0.93

	Mean of	Lachhiwala	Lalkuan	Bithmera	Pandhori M. Mind
	Clone C019	0.88	0.62	2.76	0.73
	x Site C034	0.78	2.06	3.33	1.12
	C066	0.98	0.97	2.85	1.42
	C083	0.53	0.78	2.54	0.65
	C087	0.67	0.68	2.75	0.52
	C192	1.26	1.31	2.89	1.14

Critical Differences

Treatment	CD at 5%	Treatment	CD at 5%	Treatment	CD at 5%
Clone	0.21	Site	0.17	Clone x Site	NS

NS = Non-significant

C034 attained the maximum collar diameter increment followed by clone C192. Clones C083 and C087 showed poor collar growth, which were statistically at par with clones C019 and C066 at P≤ 0.05 at Lalkuan (Haldwani). Clone C019 attained the maximum collar diameter increment followed by clones C087 and C034. Clone C192 recorded the minimum value for collar growth, which was statistically at par with clone C083 at P≤ 0.05 at Bithmera (Hisar). Clone C034 showed the maximum collar diameter increment followed by clone C066. Clones C087 and C083 showed the minimum collar growth rate at Pandhori Mindo Mind (Hoshiarpur).

Statistical analysis reveled that the effect of site on inter-clonal variation in collar diameter increment was non-significant at P≤ 0.05. Generally, all the clones attained the maximum collar diameter increment in the order : Bithmera>Pandhori Mindo Mind> Lachhiwala>Lalkuan.

Survival: Data pertaining to survival of clones at different sites are presented in Table 6. Significant inter-clonal variation was observed in survival at P≤0.05. Maximum survival was recorded for clone C066 followed by clones C087, C192 and C019. Clones C083 and C034 exhibited low survival at Lachhiwala (Dehra Dun). Hundred per cent survival was recorded for clone C019 at Lalkuan (Haldwani) followed by clones C066 > C087 > C083 > C192 in that order and were statistically at par with each other at P≤0.05. Clones C034 had the minimum survival. Clone C087 recorded the maximum survival and clones C083, C192, C019 and C034 ranked second with respect to survival and were statistically at par at P≤0.05. Clone C066 had minimum survival at Bithmera

Table 5

Inter-clonal variation in collar diameter increment (cm) at different sites.

Site	Clone	Month							Mean
		March 1999	July 1999	Nov. 1999	March 2000	July 2000	Nov. 2000	March 2001	
Lachhiwala	C019	0.20	0.69	1.61	1.94	2.32	2.80	3.09	1.81
(Dehradun,	C034	0.25	0.68	1.17	1.62	1.87	2.35	2.63	1.51
Uttarakhand)	C066	0.35	0.90	1.48	1.83	2.40	3.02	3.49	1.92
	C083	0.18	0.37	0.66	1.06	1.28	1.66	1.79	1.00
	C087	0.29	0.68	1.11	1.67	1.93	2.17	2.37	1.46
	C192	0.64	1.18	1.87	2.21	3.04	3.87	4.28	2.44
	Mean	0.32	0.75	1.32	1.72	2.14	2.64	2.94	1.69
Lalkuan	C019	0.18	0.43	0.80	1.06	1.37	1.71	1.87	1.06
(Haldwani,	C034	0.43	1.32	2.94	3.37	4.49	5.18	5.66	3.34
Uttarakhand)	C066	0.16	0.49	0.89	1.03	1.39	1.80	2.01	1.11
	C083	0.15	0.38	0.83	1.09	1.19	1.53	1.71	0.98
	C087	0.14	0.38	0.68	0.93	1.22	1.66	1.85	0.98
	C192	0.45	0.74	1.31	1.52	2.04	2.76	3.11	1.70
	Mean	0.25	0.62	1.24	1.50	1.95	2.44	2.70	1.53
Bithmera	C019	0.92	2.59	4.16	4.74	5.45	6.09	6.51	4.35
(Hisar,	C034	0.54	2.12	3.08	3.53	4.16	4.78	5.02	3.32
Haryana)	C066	0.47	1.28	2.43	2.83	3.61	4.22	4.61	2.78
	C083	0.43	1.24	1.87	2.32	2.95	3.62	3.91	2.33
	C087	0.76	1.93	3.01	3.89	5.00	6.21	7.23	4.00
	C192	0.29	0.84	1.48	1.93	2.47	2.96	3.27	1.89
	Mean	0.57	1.67	2.67	3.21	3.94	4.65	5.09	3.11
Pandhori	C019	0.24	0.67	1.07	1.40	1.96	2.50	3.01	1.55
M. Mind	C034	0.50	1.44	2.27	2.34	4.13	5.32	5.56	3.08
(Hoshiarpur,	C066	0.34	0.89	1.40	1.94	3.18	4.58	5.61	2.56
Punjab)	C083	0.12	0.39	0.66	0.91	1.25	1.68	2.15	1.02
	C087	0.10	0.31	0.51	0.68	0.85	1.18	1.35	0.71
	C192	0.30	0.87	1.49	2.03	2.69	3.40	3.83	2.09
	Mean	0.27	0.76	1.23	1.55	2.34	3.11	3.59	1.83

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Mean of Clones		C019 2.19	C034 2.81	C066 2.09	C083 1.33	C087 1.79	C192 2.03
Mean of sites		Lachhiwala 1.69		Lalkuan 1.53		Bithmera 3.11	Pandhori M. Mind 1.83
Mean of Clone x site		Lachhiwala		Lalkuan		Bithmera	Pandhori M. Mind
	C019	1.81		1.06		4.35	1.55
	C034	1.51		3.34		3.32	3.08
	C066	1.92		1.11		2.78	2.56
	C083	1.00		0.98		2.33	1.02
	C087	1.46		0.98		4.00	0.71
	C192	2.44		1.70		1.89	2.09

Critical Differences

Treatment	CD at 5%	Treatment	CD at 5%	Treatment	CD at 5%
Clone	0.59	Site	NS	Clone x Site	1.16

NS = Non-significant

(Hisar). In case of Pandhori Mindo Mind (Hoshiarpur), clone C019 recorded maximum survival followed by clones C192, C066 and C087, which were statistically at par at $P \leq 0.05$. Clone C083 exhibited minimum survival.

Effect of sites on inter-clonal variation in survival was observed significant at $P \leq 0.05$. Generally, maximum survival of clones was observed at Bithmera followed by Lalkuan, Lachhiwala and Pandhori Mindo Mind in that order. The two-factor interaction effect between the clone and site was also found significant at $P \leq 0.05$.

Phenological Characteristics : A perusal of Table 7 reveals that clone differed significantly in phenological characteristics viz. occurrence of flowering, pod and seed setting at different sites. In case of clonal plantation trial, Lachhiwala (Dehra Dun), early flowering and pod setting clones were C087, C083 and C034 whereas clones C019, C066 and C192 were late in flowering and pod setting. Early seed setting clone was C034, whereas no seed setting was observed in clones C083 and C087.

In case of clonal plantation trial, Lalkuan (Haldwani), early flowering and pod setting clones were C083, C034, C087 and C019 whereas clone C066 and C192 were late in flowering and pod setting. Early seed setting clones were C083, C034, C087, while clone C019 was late in seed setting.

In case of clonal plantation trial Bithmera (Hisar), early flowering and pod setting clones were C034, C087, C019 and C083 while late in clone C192. Early seed setting clones were C083, C087, C066 and C192 whereas late seed setting clones were C019 and C034.

Table 6

Inter-clonal variation in survival (%) at different sites.

Site	Clone						Mean
	C019	C034	C066	C083	C087	C192	
Lachhiwala (Dehra Dun, Uttarakhand)	74.07 (65.29)	74.04 (60.14)	100.00 (90.00)	62.96 (52.71)	92.59 (76.97)	92.59 (76.97)	82.70 (70.35)
Lalkuan (Haldwani, Uttarakhand)	100.00 (90.00)	66.66 (55.59)	96.30 (83.48)	92.59 (76.97)	96.30 (83.48)	81.48 (64.70)	93.21 (79.27)
Bithmera (Hisar, Haryana)	92.59 (76.97)	92.59 (76.97)	85.19 (71.72)	96.30 (83.48)	100.00 (90.00)	96.30 (83.48)	93.83 (80.44)
Pandhori Mindo Mind (Hoshiarpur, Punjab)	88.89 (74.09)	66.67 (54.70)	77.78 (62.32)	59.26 (50.59)	77.78 (67.41)	85.19 (71.21)	75.93 (63.39)
Mean of Clones	88.89 (76.59)	74.99 (61.85)	89.82 (76.88)	77.78 (65.94)	91.67 (79.46)	88.89 (74.09)	

Mean of Sites	Lachhiwala	Lalkuan	Bithmera	Pandhori Mindo Mind
	82.70 (70.35)	93.21 (79.27)	93.83 (80.44)	75.93 (63.39)

Critical Differences

Treatment	CD at 5%	Treatment	CD at 5%	Treatment	CD at 5%
Clone	11.25	Site	9.18	Clone x Site	22.50

Note: Values in parenthesis are arc-sine transformation means and these outside are original means.

In case of clonal plantation trial, Pandhori Mindo Mind (Hoshiarpur), early flowering, pod and seed setting clones were C034, C087, C083, C019 and C066 while late recorded in clone was C192.

The effect of the sites on inter-clonal variation in phenological characteristics was significant at $P \leq 0.05$. The two-factor interaction effect between the clone and site was also observed significant.

Discussion

Growth characteristics presented in terms of increment in height and collar diameter is in fact, a net result of accumulation of photosynthates, which is highly useful and valid tool for predicting the growth performance of the plants. A clone derived from the candidate plus tree through vegetative means is expected to perform as of the mother plant. Clonal

Table 7

Inter-clonal variation in some phenological characteristics at different sites.

Site	Clone	Phenological Characteristics		
		Occurrence of flowering (Day)	Occurrence of pod setting (Day)	Occurrence of seed setting (Day)
Lachhiwala	C019	79.67	92.00	142.33
(Dehra Dun,	C034	73.67	89.67	135.67
Uttarakhand)	C066	80.00	92.33	141.67
	C083	72.00	85.67	--
	C087	71.33	81.67	--
	C192	81.00	91.33	140.33
	Mean	76.28	88.78	140.00
Lalkuan	C019	77.33	90.33	139.00
(Haldwani,	C034	73.00	93.00	132.00
Uttarakhand)	C066	81.33	95.00	136.67
	C083	71.33	90.67	128.33
	C087	74.33	90.67	132.33
	C192	80.00	91.33	135.67
	Mean	76.22	91.83	134.00
Bithmera	C019	70.33	82.67	132.33
(Hisar, Haryana)	C034	68.67	80.67	132.67
	C066	73.00	82.33	130.67
	C083	70.33	85.33	128.33
	C087	68.67	81.33	129.00
	C192	74.00	91.67	130.67
	Mean	70.83	84.00	130.61
Pandhori Mindo Mind	C019	72.33	85.67	131.67
(Hoshiarpur, Punjab)	C034	71.00	87.67	129.67
	C066	73.00	90.33	133.67
	C083	72.00	90.00	132.00
	C087	71.00	89.00	133.67
	C192	75.67	95.67	137.33
	Mean	72.50	89.72	133.00

Contd...

Critical Differences

Parameters	Treatment	CD at 5%	Treatment	CD at 5%	Treatment	CD at 5%
Occurrence of flowering	Clone	1.31	Site	1.07	Clone x Site	2.62
Occurrence of pod setting	Clone	1.28	Site	1.05	Clone x Site	2.56
Occurrence of seed setting	Clone	1.48	Site	1.21	Clone x Site	2.95

propagation transfers and utilizes both additive and non-additive gains, which are the reason for promoting clonal propagation in forestry (Fielding, 1963; Thulin, 1969; Libby, 1977; Campinhos and Ikemori, 1980). The physiological importance of seasonal periodicity of growth in trees has been well documented for tropical and temperate species (Kramer and Kozlowski, 1960).

Significant inter-clonal variation was recorded in growth performance at different sites. This variation in growth performance of clones may be attributed to inherent genetic factors as well as the effect of environmental conditions. Dunlap and Barnett (1983) and Pathak *et al*. (1984) have also reported that the genetic and environmental factors influenced the growth performance of plants. Clones from the states of Uttar Pradesh, Uttarakhand and Haryana were performing better than the clones from the state of Rajasthan. Presumably, clones from these states (UP, UA and HR) were easily adapted due to being originated in the similar eco-climatic conditions than the clones from the state of Rajasthan.

Generally, all clones performed better at Bithmera (Hisar) than at the other sites. The edapho-climatic conditions of this site seem to provide the congenial environment for growth performance of the clones. Dormling (1979), Sorensen (1979) and Rehfleldt and Wycoff (1981) reported that plants raised from different provenances often display different pattern of growth. Sniezko and Stewart (1989) also suggested that variation in growth characteristics of the plants is essentially genetic in nature if grown in identical environmental conditions. Nautiyal *et al*. (2003) also found the significant inter-clonal variation in height and collar diameter of *Dalbergia sissoo* clones under Dehra Dun conditions. Other studies pertaining to the growth performance of *D. sissoo* provenances also support the present investigation (Rehman and Hussain, 1986; Devagiri, 1997; Singh, 1998; Sagta and Nautiyal, 2001).

Significant inter-clonal variation in survival was recorded at different sites. On an average maximum survival was recorded for clone C066 followed by clone C087, while clones C019 and C192 were closely related to each other in survival. Minimum survival was recorded for clone C034. This may be due to the fact that clone C066 had more potential in adaptation at various sites than the others.

However, clone from the Rajasthan origin showed the moderate survival in

comparison to the others possibly due to the facts that plants from the xeric environmental conditions are well adapted to tide over the harsh conditions. Mathur (2003) also recorded maximum survival for the clones from Rajasthan origin under water stress conditions. Clones growing in common nursery conditions, when shifted to the different sites, are likely to express interaction with prevailing site conditions leading to different response. The resultant variation in survival of clones may be partly due to both environment and genetic make up. The studies of Johari and Chew (1987), Devagiri (1997), Singh (1998), Sagta and Nautiyal (2001) also support the present investigation.

Clonal plantations are intended to supply abundant amounts of genetically superior seeds for commercial plantations as well as for further tree improvement programme. Hence, clonal plantations have vital links between commercial plantations and tree improvement programme. One of the most important aspects in a clonal plantation is the flowering synchrony among the clones for random mating among the constituent clones and hence the genetic gain in the resultant progeny (Gunaga *et al*., 1999). Any factor adversely affecting the seed production in clonal plantation would be a hindrance for logical end of tree improvement programme (Griffin, 1984). Variation in flowering phenology within a clonal plantation can potentially alter the quantity as well as genetic quality of fruits (Sedgley and Griffin, 1989). Differences in phenological characteristics obtained in different clones at various sites in the present study may be due to the genetic make up of clones as well as due to the variation in edapho-climatic conditions of the sites. Clones were behaving in a mixed manner with respect to phenological characteristics. Clones C083, C087 and C034 showed early occurrence of flowering, pod and seed setting at the major sites, while late occurrence in clones C019, C066 and C192. It may be reiterated that plants from the hot drier areas produce early and more seeds as an adaptive mechanism towards supporting their regeneration in such harsh conditions. However, no seed setting was observed in clones (C083 and C087) from the state of Rajasthan at Lachhiwala (Dehra Dun). This might be due to poor performance of these clones and ultimately photosynthates may not be available for further seed setting. The studies of Kumar (1992); Rawat *et al*. (1992); Palupi and Owens (1998); Gunaga and Vasudeva (2002) on clonal variation in some phenological characteristics of *Tectona grandis* support the present findings.

Conclusion

In conclusion, clone C192 out performed at all the sites viz. Lachhiwala (Dehra Dun), Lalkuan (Haldwani), Bithmera (Hisar) and Pandhori Mindo Mind (Hoshiarpur) and suited for adaptation to a wide range of agro-climates. On the other hand, some of clones were site specific viz. C192 and C066 at Lachhiwala (Dehra Dun); C034 and C192 at Lalkuan (Haldwani); C192 and C034 at Bithmera (Hisar) and C066 and C192 at Pandhori Mindo Mind (Hoshiarpur). Accordingly, various clones of *Dalbergia sissoo* are recommended for plantations at different sites for optimization of their productivity.

Clones C083, C087 and C034 showed early occurrence of flowering, pod and seed setting at the major sites, while late occurrence in clones C019, C066 and C192.

This indicates that on the basis of early and late occurrence of phenological events, clones can be inter-bred for getting the more genetic gain in the resultant progeny.

SUMMARY

Clonal plantation trials of *Dalbergia sissoo* were laid out on four different sites viz. Lachhiwala (Dehra Dun), Lalkuan (Haldwani), Bithmera (Hisar) and Pandhori Mindo Mind (Hoshiarpur) to investigate inter-clonal variation with respect to growth performance, survival and phenological characteristics. Clone C192 (Tulsipur, North Gonda, UP) exhibited excellent performance at all sites and suited for adaptation to a wide range of agro-climatic conditions. On the other hand, some of clones were site-specific viz. C066 (Chhichrauli, HR) at Lachhiwala (Dehra Dun) and Pandhori Mindo Mind (Hoshiarpur), C034 (Tulsipur, North Gonda, UP) at Lalkuan (Haldwani) and Bithmera (Hisar). Accordingly these clones of *Dalbergia sissoo* are recommended for plantations at different sites for optimization of their productivity. Flowering, pod and seed setting were early in clones C083, C087 (Hanumangarh, RJ) and C034 (Tulsipur, North Gonda, UP) and late in clones were C019 (Haridwar, UA), C066 (Chhichrauli, HR) and C192 (Tulsipur, North Gonda, UP) at major sites. Thus, clones can be interbred for optimal genetic gains in the resultant progeny on the basis of early and late occurrence of phenological events.

विभिन्न जलवायु प्रदेशों में बढ़वार सक्रियता, अतिजीविता और ऋतुजैविकी विशेषताओं के सम्बन्ध में *डलबर्गिया सिस्सु* राक्स० में मिलती अन्तरकृतकीय विभिन्नता

आर०एस० रावत व एस० नौटियाल

सारांश

डलबर्गिया सिस्सु के कृन्तकीय रोपवन परीक्षण चार विभिन्न स्थलों अर्थात् लच्छीवाला (देहरादून), लालकुआं (हल्द्वानी), बिठमेड़ा (हिसार) और पंढोरी मिण्डो मिंड (होशियारपुर) में बढ़वार सक्रियता, अतिजीविता और ऋतु–जैविकीय विशेषताओं की दृष्टि से अन्तरकृन्तकीय विभिन्नता अन्वेषित करने के लिए स्थापित किए गए। कृन्तक सी 192 (तुलसीपुर, उत्तरी गोंडा, उ०प्र०) ने सभी स्थलों पर अत्युत्तम सक्रियता प्रदर्शित की और वह कृषिवानिकी की विस्तृत दशाओं के अनुकूल बन सकने के उपयुक्त पाया गया। इसके विपरीत कुछ कृन्तक स्थल विशिष्ट पाए गए उदा० सी 066 छिछरौली (हरियाणा), लच्छीवाला (देहरादून) और पंढोरी मिण्डो मिंट (होशियारपुर) के लिए; सी 034 तुलसीपुर (उत्तरी गोंडा, उ०प्र०) लालकुआं (हल्द्वानी) और बिठमेड़ा (हिसार) के लिए। तदनुसार *डलबर्गिया सिस्सु* के इन कृन्तकों को इनकी उत्पादकता को इष्ठतम बनाने के लिए विभिन्न स्थलों पर रोपवनों के लिए अभिस्तावित किया जाता है। पुष्पन, फलियां आना और बीज बैठना मुख्य स्थानों पर कृन्तक सी 083, सी 087 (हनुमान गढ़, राजस्थान) और सी 034 (तुलसीपुर, उत्तरी गोंडा, उ०प्र०) में जल्दी तथा कृन्तक सी 019 (हरिद्वार, उत्तराखण्ड), सी 066 (छिछरौली, हरियाणा) और सी 192 (तुलसीपुर, उत्तरी गोंडा, उ०प्र०) में देर से हुआ। इस तरह ऋतुजैविकीय घटनाओं के जल्दी या विलम्ब से होने के आधार पर प्रतिफलन सन्तति में इष्टतम आनुवांशिक लाभ प्राप्ति के लिए कृन्तकों का अन्तर्प्रजनन भी कराया जा सकता है।

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