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Candidate Plus Tree Selection of S*alix alba* – A Multipurpose Tree Species

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ABSTRACT

Candidate plus tree selection is considered as an important and preliminary step in tree improvement programme of a particular species. The candidate plus trees of Salix alba were selected from twenty places across the two selected districts (Ganderbal and Bandipora) of Kashmir valley following comparison tree method. Tree characteristics used were height, DBH, volume, bole height and crown diameter with mean of 12.5m, 28.7cm, 0.53m^3, 5.4m and 3.4m respectively. The superiority percentage of these selected candidate plus trees of Salix alba over their respective check trees ranged from 20.2 % to 44.0 % in height, 35.9% to 55.0% in DBH and 150.4% to 201.2% in volume respectively. The selected candidate plus trees will be used for future tree improvement programmes based on their clonal and progeny performance.

Key words: *candidate plus trees, Salix alba, selection, superiority percentage.*

INTRODUCTION

The *Salix* species are eco-friendly, multipurpose, fast growing and are widely used for plantation world over. These are being cultivated for a variety of end uses viz. baskets, cricket bats, hurdles, furniture, plywood, paper and pulp, rope making etc.[1, 2]. The arborescent willow species are able to grow on various types of soil, even compacted, swampy, acidic or alkaline, provided the roots have sufficient moisture. Thus these are most suitable for the biological control of soil erosion, siltation, nutrient recycling, phytoremediation, carbon sequestration and filtering of sewage polluted water[3]. *Salix alba* is a moderate to a large deciduous tree with ascending branches and spreading but light crown, attaining a height of 20-25 m and a diameter of 60 cm. Under its native habitat, trees are known to attain a height of 30 m and I m in diameter. The bark is reddish green or brown, smooth in younger trees, fissuring longitudinally with age. Leaves are long lanceolate, acuminate silky, grayish green, silvery white underneath, finely serrated, petiole about 1 cm; shoots are first silky then olive green and very supple. Flowers male and female in separate catkins. Fruits ovoid-conic capsules. Seeds minute, yellow, ovoid with silky hairs which help in dispersal[4]. The growth of *Salix alba* can be compared with a good clone of poplar. In order to diversify the plantation of tree species with integration of agriculture crops, willow is most eco-friendly and farmer's choice.

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The cricket bat and artificial limbs industry is solely dependent on the wood of *Salix alba* and there is ready made market for willow based wood industry[5]. White willow is primarily utilized for cricket bats and polo balls, fruit boxes, artificial limbs, match-wood, honey-comb frames, tool handles, fibre-boards, agricultural implements, boats etc. used as a fence post, it is as durable as oak[4]. Tender shoots are woven into baskets and ropes. Dried inner bark is powdered and made into bread. Decoction of tender twigs is given as a beverage, also employed as an adulterant to tea. Bark yields tannin (5-7 %) and salicin; utilized as haemoptysis in rheumatism, diarrhea and dysentery[6]. The tree is extensively planted in cold deserts along with other *Salix species* for conservation and reclamation of soil in catchment areas, to prevent erosion along stream banks; as live-fence for check dams, on roadside avenues for recreation and agro-forestry. Candidate plus tree (CPT) selection is considered as an important and preliminary step in tree improvement programme of a particular species[7]. The yield of a tree is affected by many associated characters, and thus it is a highly complex trait to be used for selection. Moreover, selection based on single trait may not be very effective to screen elite genotypes in many tree species[8]. However selection based on yield and its associated characteristics results in higher expected response[9]. In multi-trait selection method, each trait plays an important role and all the individuals are ranked according to one scoring system. The phenotypes selected through this methodology are expected not only to have desired qualities but will also have genetically divergent base for future genetic and breeding programmes.

MATERIAL AND METHODS

A detailed survey of two districts of Kashmir valley was conducted pertaining to the selection of candidate plus trees (CPT's) of *Salix alba*. The two districts selected were Ganderbal and Bandipora owing to the more abundance of *Salix alba* in these districts. In order to cover these two districts in holistic manner, ten sites from each district were selected for this purpose. From each site, five candidate plus trees were selected following comparison tree method wherein candidate tree is compared with surrounding five check trees for the selected characteristics viz; height, DBH, volume etc. (Table-1). The CPT's were measured for height and diameter in relation to five comparison trees. The volume of CPT's along with check trees was determined as per the formula; V = BA x H x FF, where, BA=Basal area of the tree; H=Height of the tree; FF=Form factor of the tree. Tree measurements/values of five check trees are averaged, totaled and then compared with that of the candidate tree. The method of minimum selection standards developed by[10] was strictly followed for selection of the plus trees. The superiority percentage of the CPT's was calculated following[11]. Only those CPT's, which had qualified the minimum selection standards of superiority percentages for height (more than 20%), diameter (more than 35%) and volume (more than 150%), over comparison trees were recognized as Plus trees.

RESULTS

The candidate plus trees (CPT's) of *Salix alba* were selected following comparison tree method via. conducting an extensive survey of two districts (Ganderbal and Bandipora) of Kashmir valley. The details recorded regarding these CPT's of *Salix alba* viz. source, height (m), DBH (cm), bole height (m) and crown diameter (m) have been presented in Table-2. From this table, it is clearly evident that the tree height ranges from 9.9m to 14.8m. The maximum tree height (14.8m) was recorded for CPT-76 whereas the minimum tree height (9.9m) was recorded for CPT-18. The mean tree height was recorded as 12.5m. The DBH ranged from 20.5cm to 37.2cm. The maximum DBH (37.2cm) was recorded for CPT-11

whereas the minimum DBH (20.5cm) was recorded for CPT-57 and CPT-76. Mean DBH was recorded as 28.7cm. Tree volume was calculated maximum ($0.98m^3$) for CPT-11. Minimum tree volume ($0.24m^3$) was recorded for CPT-24. Mean tree volume was recorded as $0.53m^3$. Similarly the bole height of these CPT's ranged from 4.3m for CPT-51 to 6.8m for CPT-76 with mean value of $5.4m^3$, whereas crown diameter recorded maximum (4.5m) for CPT-28 and minimum (2.5m) for CPT-18, CPT-45, CPT-63 and CPT-91 with mean value of 3.4m. The superiority percentage of the selected CPT's in terms of height, DBH and volume over their respective check trees has been worked out and presented in Table-3. All the selected CPT's have fulfilled the criteria laid down by Pitcher and Dorn (1967) for their selection. These trees on an average had indicated 28.9 %, 43.1 % and 163.6 % superiority in height, DBH and volume respectively, over their respective comparison trees (Table-3). The superiority percentage of height ranged from 20.2 % to 44.0 % in case of CPT-51 and CPT-49 respectively. Lowest superiority percentage in DBH was recorded as 35.9 % in case of CPT-70 and highest superiority percentage in DBH was recorded as 55.0 % in case of CPT-53. CPT-89 registered highest superiority percentage (201.2 %) while CPT-37 showed lowest superiority percentage (150.4 %) in volume.

DISCUSSION

Plus tree selection among even-aged stands is a basic tool for tree improvement[12, 13]. With the intensification of forest farming, tree improvement programmes have become an integral part of the forest management. As a result of which, the seed stands or seed production areas have been recommended for immediate gain[7, 14] in this regard. The plus trees selected through minimum selection standards method, therefore form the base for any breeding programme. A careful selection of plus trees is necessary through which efforts should be made for the maximum use of genetic variations[15, 16]. Such trees can be used either for progeny testing, vegetative multiplication or directly as seed sources[17]. In the present investigation, 100 CPT's of *Salix alba* were selected from two districts on the basis of check tree method. The data with regard to candidate plus trees (CPT's) of *Salix alba* selected from two districts of Kashmir valley via. conducting an extensive survey following comparison tree method has been presented under Table-2 and 3. The tree height, DBH, volume, bole height and crown diameter varied from 9.9m-14.8m, 20.5cm-37.2cm, $0.24m^3$-$0.98m^3$, 4.3m-5.4m and 2.5m-4.5m respectively. Mean superiority percentage of these CPT's over the check trees in height, DBH and volume was 28.9%, 43.1% and 163.6% respectively. Plus tree selection has been carried out in a number of tree species for different end uses. Fifty-three candidate plus trees (CPTs) of *Pongamia pinnata* were selected from different locations in Orissa, India, on the basis of their seed and pod characteristics to identify suitable seed source with high oil content for production of quality planting seedlings for use in afforestation programs[18]. [19] reported plus tree selection in *Eucalyptus* hybrid by considering volume production as the characteristic of highest economic interest for growth parameters. [20] ported plus tree selection in *Melia azaderach* following base line method from various agro-climatic conditions of Punjab, India. Similarly candidate plus tree selection was reported in *Madhuca indica* which were evaluated for various seed germination and seedling traits following progeny testing[21]. Similar results were reported by[22] for *Pinus roxburghii*. Studies conducted with regard to CPT selection have been reported in *Pongamia pinnata*[23, 24, 25, 26] Argan tree[27], Shisham[28], *Jatropa*[29], *Terminalia chebula*[30], *Prosopis juliflora*[31], and *Bambusa bambos*[32] which are in line with the present findings.

Table-1: Candidate Tree Report

Species……. Candidate tree number……

Location……... Date…….

Tree measurements

Characteristics	Comparison Trees					Total	Average	Candidate Tree	Superiority %
	1	2	3	4	5				
DBH (cm)									
Height (m)									
Volume (m^3)									
Straightness									
Crown									
Disease/ insect damage									

Table-2: Characteristics of the selected CPT's of *Salix alba*

CPT's	Site (District)	Height (m)	DBH (cm)	Volume (m^3)	Bole height (m)	Crown diameter (m)
CPT-1	Shalbugh (Ganderbal)	13.2	29.7	0.58	6.0	4.2
CPT-2		13.7	27.9	0.54	6.4	3.9
CPT-3		12.7	31.4	0.63	5.7	4.4
CPT-4		12.2	27.2	0.45	5.3	3.7
CPT-5		13.2	25.5	0.43	5.7	3.0
CPT-6	Dab (Ganderbal)	11.9	28.8	0.50	5.4	4.0
CPT-7		11.4	29.8	0.51	5.2	3.7
CPT-8		12.3	33.5	0.69	5.8	4.1
CPT-9		12.5	30.5	0.58	5.6	3.9
CPT-10		11.6	35.1	0.72	5.4	4.3
CPT-11	Haran (Ganderbal)	14.0	37.2	0.98	6.2	4.2
CPT-12		14.5	35.0	0.89	6.1	4.2
CPT-13		13.8	31.7	0.70	5.9	3.9
CPT-14		13.7	29.3	0.59	5.4	3.7
CPT-15		13.6	24.9	0.42	5.8	3.3
CPT-16	Chandun (Ganderbal)	10.3	26.6	0.37	4.6	2.8
CPT-17		11.9	27.2	0.44	5.2	3.0
CPT-18		9.9	22.2	0.24	4.5	2.5
CPT-19		11.2	25.8	0.38	4.7	2.9
CPT-20		11.6	31.4	0.58	5.0	3.1
CPT-21	Gundrehman (Ganderbal)	12.3	28.6	0.51	5.9	3.6
CPT-22		10.4	27.2	0.39	4.5	3.2
CPT-23		11.6	28.2	0.46	5.2	3.4
CPT-24		10.1	21.7	0.24	4.4	3.0
CPT-25		12.6	28.9	0.53	5.2	3.6
CPT-26	Sehpora (Ganderbal)	13.2	34.9	0.81	6.0	4.2
CPT-27		13.8	34.2	0.82	6.2	4.4
CPT-28		14.4	35.8	0.93	6.1	4.5
CPT-29		13.3	34.8	0.81	5.7	4.2
CPT-30		13.5	32.5	0.72	5.4	4.0
CPT-31	Dagpora (Ganderbal)	12.3	29.7	0.55	4.9	4.1
CPT-32		12.5	35.5	0.79	5.3	4.0
CPT-33		13.2	30.5	0.62	5.8	3.6
CPT-34		12.9	24.2	0.38	5.7	3.0
CPT-35		13.2	23.4	0.36	5.4	2.6
CPT-36	Wakura (Ganderbal)	14.7	25.9	0.50	5.7	4.4
CPT-37		14.4	23.5	0.40	6.2	3.2
CPT-38		13.8	25.9	0.47	5.8	3.7

CPT-39		14.1	31.3	0.70	5.3	4.2
CPT-40		14.5	24.8	0.45	6.1	3.9
CPT-41	Tulmulla (Ganderbal)	12.1	32.9	0.66	5.3	4.1
CPT-42		11.6	31.2	0.57	5.1	3.5
CPT-43		11.3	22.5	0.29	4.6	3.0
CPT-44		11.0	28.3	0.44	4.6	2.9
CPT-45		10.7	27.2	0.40	4.7	2.5
CPT-46	Butwana (Ganderbal)	10.9	25.5	0.36	4.5	2.6
CPT-47		11.5	21.1	0.26	5.3	3.1
CPT-48		11.1	24.4	0.33	5.1	2.9
CPT-49		11.7	29.2	0.50	4.8	3.4
CPT-50		11.8	25.2	0.37	5.2	3.9
CPT-51	Aloosa (Bandipora)	11.9	27.4	0.45	4.3	3.4
CPT-52		10.7	29.5	0.47	4.9	2.8
CPT-53		11.7	31.2	0.57	5.1	3.2
CPT-54		10.9	31.7	0.55	4.7	4.0
CPT-55		10.3	36.3	0.68	4.4	4.3
CPT-56	Ashtangoo (Bandipora)	12.6	23.4	0.35	5.8	2.7
CPT-57		13.1	20.5	0.28	5.4	3.2
CPT-58		12.9	24.8	0.40	6.2	3.0
CPT-59		13.3	28.9	0.56	5.1	3.5
CPT-60		13.6	27.2	0.51	5.2	3.4
CPT-61	QuilMuqaam (Bandipora)	11.1	25.0	0.35	4.5	3.0
CPT-62		11.9	25.8	0.40	5.4	2.8
CPT-63		10.2	25.5	0.33	4.7	2.5
CPT-64		10.6	23.6	0.30	4.6	3.0
CPT-65		11.5	24.2	0.34	5.2	3.3
CPT-66	Zaalwan (Bandipora)	14.2	29.5	0.62	6.2	3.6
CPT-67		14.5	33.6	0.83	6.3	3.7
CPT-68		13.8	35.1	0.86	5.8	3.9
CPT-69		13.6	33.6	0.77	5.4	4.1
CPT-70		13.7	32.1	0.71	5.7	4.1
CPT-71	Ajas (Bandipora)	13.1	24.8	0.41	5.5	3.9
CPT-72		12.2	30.6	0.58	5.6	3.7
CPT-73		12.9	28.3	0.52	5.3	3.0
CPT-74		12.9	28.6	0.53	5.9	2.6
CPT-75		12.4	23.4	0.34	5.4	2.7
CPT-76	Kaimbachoo (Bandipora)	14.8	20.5	0.31	6.8	3.3
CPT-77		13.8	27.8	0.54	6.3	3.2
CPT-78		13.7	25.1	0.43	6.3	2.9
CPT-79		14.0	31.1	0.68	5.8	3.5
CPT-80		14.2	21.9	0.34	6.2	2.9
CPT-81	Hajin (Bandipora)	11.1	31.2	0.54	5.1	2.8
CPT-82		10.3	31.9	0.53	4.7	3.2
CPT-83		11.6	31.7	0.58	5.3	3.4
CPT-84		11.3	28.6	0.46	5.2	3.7
CPT-85		11.9	25.7	0.39	4.9	3.8
CPT-86	Sonawari (Bandipora)	13.6	22.8	0.36	6.2	3.4
CPT-87		12.9	29.4	0.56	5.7	3.3
CPT-88		12.8	25.1	0.40	5.8	2.7
CPT-89		13.2	27.2	0.49	5.5	2.8
CPT-90		13.5	32.7	0.72	6.3	3.0
CPT-91	Saderkote (Bandipora)	10.4	31.2	0.51	4.8	2.5
CPT-92		10.8	25.5	0.35	4.6	2.8
CPT-93		10.9	27.5	0.41	4.5	3.2
CPT-94		11.4	33.6	0.65	5.2	3.5
CPT-95		11.2	35.0	0.69	5.1	3.7
CPT-96	Sumbal (Bandipora)	13.1	27.1	0.48	5.7	2.9
CPT-97		13.3	29.9	0.60	5.8	3.9
CPT-98		14.0	34.5	0.84	6.5	3.8
CPT-99		13.6	31.2	0.67	6.2	3.4
CPT-100		13.8	35.9	0.90	6.0	3.7
Mean		12.5	28.7	0.53	5.4	3.4
Range	**Minimum**	9.9	20.5	0.24	4.3	2.5
	Maximum	14.8	37.2	0.98	6.8	4.5

Table-3: Superiority of selected CPT's of *Salix alba* over check trees

CPT's	Height (m)	Av. of 5 check trees	Superiority %	DBH (cm)	Av. of 5 check trees	Superiority %	Volume (m^3)	Av. of 5 check trees	Superiority %
CPT-1	13.2	9.5	38.5	29.7	21.3	39.2	0.58	0.22	168.2
CPT-2	13.7	10.1	35.4	27.9	20.5	36.5	0.54	0.21	152.3
CPT-3	12.7	9.3	37.2	31.4	22.6	39.1	0.63	0.24	165.4
CPT-4	12.2	8.6	42.3	27.2	19.9	36.8	0.45	0.17	166.3
CPT-5	13.2	9.5	39.3	25.5	18.0	41.5	0.43	0.16	179.0
CPT-6	11.9	9.3	28.4	28.8	20.1	42.9	0.50	0.19	162.3
CPT-7	11.4	8.9	27.8	29.8	21.2	40.4	0.51	0.20	152.0
CPT-8	12.3	9.8	26.0	33.5	23.7	41.2	0.69	0.28	151.2
CPT-9	12.5	9.9	26.0	30.5	21.5	42.0	0.58	0.23	154.1
CPT-10	11.6	9.3	24.9	35.1	24.7	42.0	0.72	0.29	152.0
CPT-11	14.0	10.4	34.6	37.2	27.1	37.4	0.98	0.38	154.1
CPT-12	14.5	10.6	36.2	35.0	25.1	39.6	0.89	0.34	165.5
CPT-13	13.8	10.3	34.4	31.7	22.8	38.9	0.70	0.27	159.1
CPT-14	13.7	9.8	39.1	29.3	20.8	41.1	0.59	0.21	177.0
CPT-15	13.6	9.9	37.8	24.9	17.4	43.0	0.42	0.15	181.6
CPT-16	10.3	8.3	23.9	26.6	18.4	44.6	0.37	0.14	159.2
CPT-17	11.9	9.5	25.7	27.2	18.8	44.8	0.44	0.17	163.8
CPT-18	9.9	7.8	26.6	22.2	14.7	50.7	0.24	0.08	187.6
CPT-19	11.2	8.9	25.6	25.8	17.9	44.2	0.38	0.14	161.1
CPT-20	11.6	9.3	24.9	31.4	21.5	46.0	0.58	0.22	166.2
CPT-21	12.3	10.2	21.1	28.6	19.3	48.3	0.51	0.19	166.1
CPT-22	10.4	8.6	21.5	27.2	18.8	44.8	0.39	0.15	154.8
CPT-23	11.6	9.5	21.9	28.2	19.2	47.0	0.46	0.18	163.5
CPT-24	10.1	8.2	22.9	21.7	14.8	46.6	0.24	0.09	164.1
CPT-25	12.6	10.2	23.8	28.9	19.7	46.8	0.53	0.20	166.9
CPT-26	13.2	10.9	20.7	34.9	23.4	49.2	0.81	0.30	168.9
CPT-27	13.8	11.3	22.5	34.2	23.6	45.0	0.82	0.32	157.8
CPT-28	14.4	11.9	21.1	35.8	24.6	45.7	0.93	0.36	157.2
CPT-29	13.3	10.9	21.8	34.8	23.7	46.7	0.81	0.31	162.2
CPT-30	13.5	11.1	21.5	32.5	22.1	47.2	0.72	0.27	163.3
CPT-31	12.3	9.8	26.0	29.7	19.6	51.5	0.55	0.19	189.2
CPT-32	12.5	9.8	27.7	35.5	24.1	47.5	0.79	0.29	177.6
CPT-33	13.2	10.3	28.5	30.5	21.5	42.0	0.62	0.24	159.3
CPT-34	12.9	10.2	26.2	24.2	16.9	43.5	0.38	0.15	160.0
CPT-35	13.2	10.4	26.5	23.4	16.1	45.2	0.36	0.14	166.9
CPT-36	14.7	10.9	34.7	25.9	18.4	40.8	0.50	0.19	166.9
CPT-37	14.4	10.5	36.8	23.5	15.9	48.4	0.40	0.13	201.2
CPT-38	13.8	10.2	36.1	25.9	18.1	43.2	0.47	0.17	179.0
CPT-39	14.1	10.3	37.1	31.3	22.9	36.4	0.70	0.27	155.2
CPT-40	14.5	10.6	35.8	24.8	18.2	36.5	0.45	0.18	153.0
CPT-41	12.1	9.5	27.0	32.9	22.6	45.7	0.66	0.24	169.5
CPT-42	11.6	9.6	20.6	31.2	21.4	45.9	0.57	0.22	156.9
CPT-43	11.3	9.2	22.8	22.5	15.0	50.3	0.29	0.10	177.2
CPT-44	11.0	8.9	23.7	28.3	19.3	46.7	0.44	0.17	166.2
CPT-45	10.7	8.7	22.9	27.2	18.7	45.6	0.40	0.15	160.5
CPT-46	10.9	8.2	32.3	25.5	18.4	38.7	0.36	0.14	154.5
CPT-47	11.5	8.3	39.1	21.1	14.6	44.8	0.26	0.09	191.9
CPT-48	11.1	7.8	41.2	24.4	17.7	37.8	0.33	0.12	168.2
CPT-49	11.7	8.1	44.0	29.2	21.4	36.6	0.50	0.19	168.8
CPT-50	11.8	8.5	38.6	25.2	17.5	43.9	0.37	0.13	187.2
CPT-51	11.9	9.9	20.2	27.4	18.7	46.8	0.45	0.17	159.0
CPT-52	10.7	8.9	20.8	29.5	19.6	50.7	0.47	0.17	174.4
CPT-53	11.7	9.6	21.5	31.2	20.1	55.0	0.57	0.19	191.8
CPT-54	10.9	8.9	21.9	31.7	22.1	43.4	0.55	0.22	150.7
CPT-55	10.3	8.4	22.9	36.3	24.2	50.0	0.68	0.25	176.6
CPT-56	12.6	9.3	35.8	23.4	16.3	43.1	0.35	0.12	177.9
CPT-57	13.1	9.6	36.6	20.5	14.6	40.5	0.28	0.10	169.8
CPT-58	12.9	9.3	37.9	24.8	17.9	38.4	0.40	0.15	164.1
CPT-59	13.3	9.7	37.3	28.9	20.9	38.4	0.56	0.21	163.1
CPT-60	13.6	10.1	35.5	27.2	19.7	38.2	0.51	0.20	158.8

CPT-61	11.1	8.9	24.6	25.0	16.8	48.8	0.35	0.13	176.0
CPT-62	11.9	9.5	25.7	25.8	18.1	42.8	0.40	0.16	156.4
CPT-63	10.2	8.3	22.4	25.5	17.8	43.1	0.33	0.13	150.8
CPT-64	10.6	8.6	23.8	23.6	16.5	43.1	0.30	0.12	153.6
CPT-65	11.5	9.1	25.9	24.2	17.1	41.7	0.34	0.13	152.8
CPT-66	14.2	10.6	34.4	29.5	20.9	41.3	0.62	0.23	168.5
CPT-67	14.5	10.6	36.6	33.6	24.2	38.9	0.83	0.31	163.6
CPT-68	13.8	10.3	34.8	35.1	25.7	36.5	0.86	0.34	151.1
CPT-69	13.6	9.9	36.9	33.6	24.7	36.1	0.77	0.30	153.5
CPT-70	13.7	10.0	36.8	32.1	23.6	35.9	0.71	0.28	152.7
CPT-71	13.1	10.9	20.3	24.8	17.2	44.5	0.41	0.16	151.1
CPT-72	12.2	10.1	21.1	30.6	21.2	44.4	0.58	0.23	152.5
CPT-73	12.9	10.7	20.3	28.3	19.5	45.2	0.52	0.20	153.6
CPT-74	12.9	10.7	20.7	28.6	19.7	45.3	0.53	0.21	154.7
CPT-75	12.4	10.2	21.9	23.4	16.1	45.2	0.34	0.13	157.1
CPT-76	14.8	11.5	28.5	20.5	14.2	44.3	0.31	0.12	167.7
CPT-77	13.8	10.8	28.2	27.8	19.2	45.0	0.54	0.20	169.7
CPT-78	13.7	10.6	29.1	25.1	17.4	44.2	0.43	0.16	168.3
CPT-79	14.0	10.9	28.1	31.1	22.1	40.6	0.68	0.27	153.4
CPT-80	14.2	11.2	26.9	21.9	15.4	42.4	0.34	0.13	157.1
CPT-81	11.1	9.1	21.5	31.2	21.0	48.7	0.54	0.20	168.6
CPT-82	10.3	8.5	21.0	31.9	22.1	44.4	0.53	0.21	152.4
CPT-83	11.6	9.4	23.2	31.7	22.1	43.4	0.58	0.23	153.3
CPT-84	11.3	9.2	22.8	28.6	19.8	44.5	0.46	0.18	156.4
CPT-85	11.9	9.6	24.0	25.7	17.8	44.3	0.39	0.15	158.3
CPT-86	13.6	10.3	32.1	22.8	16.4	39.2	0.36	0.14	156.0
CPT-87	12.9	9.8	31.4	29.4	20.9	40.4	0.56	0.22	159.1
CPT-88	12.8	9.8	30.1	25.1	17.5	43.3	0.40	0.15	167.2
CPT-89	13.2	10.1	31.1	27.2	19.7	38.2	0.49	0.20	150.4
CPT-90	13.5	9.9	35.7	32.7	24.0	36.0	0.72	0.29	150.9
CPT-91	10.4	8.5	22.9	31.2	21.3	46.6	0.51	0.19	164.2
CPT-92	10.8	8.8	22.4	25.5	17.5	45.9	0.35	0.14	160.6
CPT-93	10.9	8.9	21.9	27.5	18.6	47.6	0.41	0.15	165.7
CPT-94	11.4	9.4	21.5	33.6	23.4	43.7	0.65	0.26	150.7
CPT-95	11.2	9.1	23.2	35.0	24.2	44.6	0.69	0.27	157.8
CPT-96	13.1	9.7	35.7	27.1	19.4	39.9	0.48	0.18	165.4
CPT-97	13.3	9.8	35.4	29.9	21.5	38.9	0.60	0.23	161.3
CPT-98	14.0	10.2	37.3	34.5	25.1	37.3	0.84	0.32	158.8
CPT-99	13.6	10.1	35.0	31.2	22.6	38.0	0.67	0.26	157.2
CPT-100	13.8	10.0	38.5	35.9	26.4	36.0	0.90	0.35	156.2
Mean	12.5	9.7	28.9	28.7	20.1	43.1	0.53	0.20	163.6

REFERENCES

1. Verwijst, T., Willows: an underestimated resource for environment and society. *Forestry Chronicle* **77**(2): 281-285 (2001).
2. Kuzovkina, M.A., Wieh, M., Romero, M.A., Charles, J., Hurt, S., Mclvor, I., Karp, A., Trybrush, S., Labrecque, M., Teodorera, T.I., Singh, N.B., Smart, L.B. and Volk, T.A., *Salix*: Botany and global horticulture. *Horticulture Reviews* **34**: 447-489 (2008).
3. Zalesny, R.S. JR. and Bauer, E.O., Selecting and utilizing *Populus* and *Salix* for landfill covers: Implications for leachate irrigation. *International Journal of Phytoremediation* **9**: 497-511 (2007).
4. Luna, R.K., Plantation trees. Publishing Corporation. IBD, Dehradun, pp 640-645 (1995).
5. Saini, B.C., Sharma P., *Salix* - a multipurpose tree for future agro-forestry. *ENVIS For. Bull*. **1**(1): 18-20 (2001).
6. CSIR., Plants for reclamation of wastelands. CSIR, New Delhi (1990).
7. Zobel, B.J. and Talbert, J.T., *Applied forest tree improvement*. John Wiley and Sons, New York (1984)..
8. Cotternill, P.P. and Dean, C.A., Index selection for applied breeding. CSIRO, Melbourne, pp. 137 (1986).

9. Baker, R.J., Selection indices in plant breeding. Press Inc., Boca Raton, Florida, pp. 218 (1986).
10. Pitcher, J.A. and Dorn, D.E., A new form for reporting hardwood superior tree candidates. **In**: Proceedings of Fifth Central States Forest Tree Improvement Conference (Ed. Kriebel, H.B.) Wooster, Ohio, U.S.A., pp. 7-12 (1967).
11. Wright, J.W., *Introduction to Forest Genetics*, Academic Press, New York. pp. 463 (1976).
12. Shiv Kumar, P., Guidelines for selection of plus trees. *Vananusandhan* **5**(1): 18-20 (1988).
13. Emmanuel, C.J. S.K. and Bagchi, S., Teak plus tree selection in South India. Trends in tree science (Eds. Khosla, P.K. and Sehgal, R.N.), ISTS publication, Solan (H.P.), pp. 268-271 (1988).
14. Quijada, M., Seed stands. Forest Tree Improvement. **In**: A report on the FAO/DANIDA training course. FAO Publication, Rome. pp,112-115 (1985).
15. Sidhu, D.S., Method of plus tree selection for raising first-generation population for a tree breeding programme. *Indian Forester* **122**(6): 476-484 (1996).
16. Sharma, C.M., Ghildiyal, S.K. and Nautiyal, D.P., Plus tree selection and their seed germination in *Pinus roxburghii* from Garhwal Himalaya. *Ind. J. For.* **24**(1): 48-52 (2001).
17. Ghildiyal, S.K., Provenance testing in *Pinus roxburghii* from Western-central Himalaya. D.Phill. Thesis, Department of Forestry, H.N.B. Garhwal University, Srinagar Garhwal Uttarakhand, India (2003).
18. Sahoo, D.P., Rout, G.R., Das, S., Aparajita, S., and Mahapatra, A.K., Genotypic variability and correlation studies in pod and seed characteristics of *Pongamia pinnata* (L.) Pierre in Orissa, India. *International Journal of Forestry Research* **1**: 1-6 (2011).
19. Sidhu, D.S., Selection of plus trees and their progeny testing in *Eucalyptus* hybrid. *Indian Forester* **119**(9): 744-752 (1993).
20. Dhillon, G.P.S., Sidhu, D.S., Singh, B. and Singh, A., Genetic variation among open pollinated progenies of *Melia azaderach* under nursery and field conditions. *Indian Forester* **135**(1): 84-88 (2009).
21. Wani, M.S. and Ahmad, L., Estimation of field environment variability for germination and seedling traits in *Madhuca indica* Gmel. *American Journal of Experimental Agriculture* **3**(2): 361-373 (2013).
22. Ghildiyal, S.K., Sharma, C.M. and Gairola, S., Additive genetic variation in seedling growth and biomass of fourteen *Pinus roxburghii* provenances from Garhwal Himalaya, India. *Journal of Science and Technology* **2**(1): 37-45 (2009).
23. Kaushik, N., Kumar, S., Kumar, K., Beniwal, R.S., Kaushik, N. and Roy, S., Genetic variability and association studies in pod and seed traits of *Pongamia pinnata* (L.) Pierre in Haryana, India. *Genet Resour Crop Evol.* **54**:1827–1832 (2007).
24. Raut, S.S., Narkhede, S.S., Bhave, S.G., Rane, A.D. and Gunaga, R.P., Identification of candidate plus trees and seed source variability in *Pongamia pinnata* (L.) Pierre. *Journal of Tree Sciences* **29**(1,2): 1-6 (2010).
25. Rao, G.R., Korwar, G.R., Shanker, A.K. and Ramakrishna, Y.S., Genetic associations, variability and diversity in seed characters, growth, reproductive phenology and yield in *Jatropha curcas* (L.) accessions. *Trees* **22**:697–709 (2008).
26. Divakara, B.N. and Das, R., Variability and divergence in *Pongamia pinnata* for further use in tree improvement. *Journal of Forestry Research* **22**(2): 193−200 (2011).
27. Aitaabd, N., El ayadi, F., Msanda, F. and El mousadik, A., Genetic variability of Argan tree and preselection of the candidate plus trees. *Not. Bot. Hort. Agrobot. Cluj*. **38**(3): 293-301 (2010).
28. Yadav, M.K., Dhillon, R.S. and Singh, V.P., Plus tree selection and progeny testing in Shisham (*Dalbergia sissoo*

Roxb.). *Legume Research* **28**(1): 55 – 58 (2005).

29. Rao, G.R., Shanker, A.K., Srinivas, I., Korwar, G.R. and Venkateswarlu, B., Diversity and variability in seed characters and growth of *Pongamia pinnata* (L.) Pierre accessions. *Trees* **25**: 725–734 (2011).
30. Navhale, V.C., Sonone, N.G., Jangam, P.S., Jadhav, S.T. and Bhave, S.G., Genetic variability and selection of candidate plus trees in chebulic myrobalan (*Terminalia chebula* retz.). *Electronic Journal of Plant Breeding* **2**(1): 157-163 (2011).
31. Goel, V.L., Dogra, P.D. and Behl, H.M., Plus tree selection and their progeny evaluation in *Prosopis juliflora*. *Indian Forester* **123**(3): 196-205 (1997).
32. Raj, M.A.J., Paramathma, M. and Kumaravelu, G., Correlation and path coefficient analysis in *Bambusa bambos* (L.) Voss. *Indian Forester* **132**(9): 1077-1082 (2006).