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Original scientific paper

ESTIMATION OF GENETIC PARAMETERS OF NEWLY INTRODUCED TREE WILLOW CLONES IN HIMACHAL PRADESH, INDIA

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Willows being multipurpose species are well recognized in short rotation forestry world over. 200 clones of different species and hybrids were procured from twenty countries over the period of three years. These were subjected for nursery screening and further 18 promising clones were planted in March, 2006 at university main campus Nauni, Solan, Himachal Pradesh. The five years growth performance was evaluated and clone J-799 has given maximum plant height (19.33 m) which is at par with the clone NZ-1140 (16.33 m) followed by SI-63-007 (14.30 m). As regards with diameter at breast height and volume index, clone J-799 registered first rank followed by NZ-1140 and 131/25 recording 16.50 cm and 0.554 m^3, 15.30 cm and 0.386 m^3 ;15.30cm and 0.368m^3, respectively. Bole straightness was recorded maximum in clone J-795 that is at par with clones J-194, PN-721 and 131/25 followed by clones J-799, SI-63-007, NZ-1140 and SI-64-017.

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Heritability in broad sense for bole straightness (46.36%) and genetic gain of the volume index (67.95%) was found highest. Genotypic, phenotypic and environment coefficients of variations were recorded maximum (0.995) for volume index character. Genetic correlation coefficient was highest (0.921) between plant height and volume, while phenotypic correlation coefficient was highest between diameter at breast height and volume index. On the basis of five year growth performance, five clones namely J-799, NZ-1140, 131/25, SI-63-007 and PN-731 are found suitable for lower and mid-hills of Himachal Pradesh.

Key words: genetic correlation; genetic gain heritability; tree willow, volume index

INTRODUCTION

Willows are ecofriendly, multipurpose, fast growing and are widely used for plantation world over. The genus *Salix* comprises of about 350 – 500 species worldwide (ARGUS, 1997), some of which have been cultivated for a variety of end uses viz., baskets, cricket bats, hurdles, furniture, plywood, paper and pulp, rope making etc. (VERWIJST, 2001;KUZOVKINA *et al*.,2008). Due to its wide geographic adaptation and fast growth, it has a significant economic value. The genus is distributed over wide ecological and climatic zones ranging from North America to China, excluding Australasia (TRYBUSH *et al.,* 2008). 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 (ZALESNY *et al*., 2007).

In India, there are about 31 indigenous and 4 exotic species of willows (SAINI and SHARMA, 2001), but majority of them are not suitable for industrial use or high bio-mass production except *Salix tetrasperma*, and *S. acmophylla* which meet limited requirements of industrial uses. One of the most important characters required by entrepreneurs is bole straightness followed by clear bole height and diameter. About 800 bat manufacturing factories have come up in Kashmir valley, Jallandhar, Delhi, Meerut, covering an annual turnover of Rs. 500 crores and generating employment for 15,000 peoples engaged in sawing, shaping and finishing the blades around 10 million bats are produced every year in India (ANONYMOUS, 2009). Therefore one should give utmost importance for bole straightness of *Salix* species along with volume production. Arborescent species of willow like *Salix alba*, *S. humboltiana*, *S. excelsa*, *S. acmophyla*, *S. daphnoides*, *S. fragilis*, *S. nigra*, *S. matsudana*, *S. amygdaloides*, *S. jessoensis* and *S. tetrasperma* and their inter and intra specific hybrids/clones are able to grow by vegetative propagation on a large variety of edaphic, ecological and hydrological conditions and are better adapted in monoculture as well as in agroforestry systems under short rotation forestry. Most of the arborescent species of *Salix* are confined to hilly region of the country except *S. tetrasperma* which is occurring right from tropical to temperate regions of India. Wide natural distribution, particularly of *Salix tetrasperma* in Pakistan, India, China,

Malaysia, Mynmar, Philippines, Thailand, Vietnam (ZHENFU *et al*.,1984) and upper Egypt (AL-SHERIF *et al*., 2009), considerable level of genetic variation, relative ease of hybridization and vegetative propagation has made it attractive for genetic improvement. It was further emphasized that a systematic research work should be carried out on screening of genetic resource of indigenous species, import of various clones/species/hybrids/strains, etc. clonal testing, hybridization and development of new clones matching to different sites with regard to specific enduses.

In *Salix*, programmes in genetics and breeding of tree form willows were started first. Examples of important achievements are reported by RAGONESE and ALBERTI (1965) from Argentina, KRSTINIC (1979) from Yugoslavia and MAY (1982) from Italy. However well planned genetic and breeding studies were undertaken recently and encouraging results were reported by ERIKSSON *et al.* (1984), GULBERG (1988) and ZSUFFA (1988). In tree breeding programmes, scoring systems to assess stem straightness and branching are widely used as selection criteria. For example, COOPER and FERGUSON (1981) in cotton wood and BURDON *et al.,* (1992a) and KUMAR (2004) in *Pinus radiata* used 1 to 9 scoring system for evaluating bole straightness. A scale of 1-6 was used for *Populus* species (ZEPS *et al.,* 2010) Sitka spruce (LEE, 1992; MACDONALD *et al.,* 2009), *Eucalyptus cladocalyx* (CALLISTER *et al.,*2007) and in *E.dunii* (ARNOLD *et al.,*2004). While, ISIK and TOPLU (2004) used four point score, where 4 was most straight in poplar clones. 1 to 3 score was used by HODGE and DVORAK (1999) in *Pinus tecunumanii* whereas 3 was considered most straight. HAI *et al.,* (2008) used a score of 1 to 5 considering 5 as perfect straight for *Acacia auriculiformis* in Vietnam.

The essential purpose of tree improvement is to develop a suitable clones/variety that eventually brings about economic returns and related benefits to growers. An efficient and practical means of screening the genetic resources is essentially required (LUNA and SINGH, 2009). Knowledge of variances and heritability within and between clonal populations is important in various breeding decisions, which include whether try to breed for a trait and how to breed for it. Further, the heritability at the juvenile stage is probably higher than at the mature stage because the environment is mostly homogenous in early tests. This means that efficiency of early testing measured as genetic gain per unit of time may be higher than that of later testing (ERIKSSON *et al.,* 1993). High genetic variances due to clones are reflected in high broad sense heritability, provides an estimate of the proportion of the variation within a population that is due to genetic differences among individuals.

Keeping in view the ever increasing demand of willow wood for multifarious uses particularly for sports good manufacturing entrepreneurs, household timber, constituted wood etc., selected promising clones developed by various research organizations through out the world, were procured and introduced at university campus followed nursery screening for three times. A field trial of 18 superior clones (Table 1) is raised in the university field. The objectives of the present study are to compare the growth parameters of selected promising clones in field condition as well as to estimate the genetic parameters of clones of *Salix*

species. The main emphasis was given on traits such as diameter growth, plant height, straightness, less branches, narrow crown etc. Other potential traits of processed wood like veneer, plywood, furniture and strength properties will be analysed.

MATERIALS AND METHODS

Location of site and experimental design

The experimental plantation was raised at Naganji field area of the Department of Tree Improvement and genetic Resources, Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan (HP) in March, 2006. The field site is located at an elevation of 1200 m above mean sea level in the north-west of Himalaya and lies between 30°51'N latitude and 76°11'E longitude. The experimental area is hilly, marked with elevations, depressions and has a gentle slope towards the south-eastern aspect. The area experiences a wide range of temperature with a minimum of 1°C in winters to a maximum of 33°C and sometimes more (upto 35°C) during May and June as the hottest months where January and February are the coldest months of the year. The annual rainfall ranges between 800-1300 mm with maximum downpour during the monsoon season (July - September). The one year growth entire transplants were treated as per standard package of practices before out-planting. The pits of 45cm x 45cm x 60cm size were prepared at 3m x 3m spacing and plantation was done in randomized block design with three replications.

Table 1 Description of Salix clones grown in the field trial.

Sr no.	Clone	Species/hybrid	Source Country (Plant material procured)	Origin/developed
1.	J-799	*S. matsudana x S. alba*	UK	China
2.	PN-731	*S. nigra*	New Zealand	USA
3.	V-99	*Salix* x *rubens*	Croatia	Croatia
4.	NZ-1179	*S. matsudana x S. alba*	UK	UK
5.	SE-63-016	*S. jessoensis*	Italy	Japan
6.	NZ-1040	*S. matsudana x S. alba*	New Zealand	New Zealand
7.	*S. alba* (Kashmiri willow)	*S. alba* cv. *caerulea*	UK	UK
8.	NZ-1002	*S. matsudana x S. alba*	New Zealand	New Zealand
9.	PN-722	*S. matsudana*	New Zealand	New Zealand
10.	NZ-1140	*S. matsudana* x *S. alba*	UK	UK
11.	SI-64-017	*S. alba*	Italy	S. Italy
12.	131/25	*S. Babylonica x S. alba*	UK	Argentina
13.	J-194	*S. matsudana x S.arbutifolia* X *S. matsudana*	UK	China
14.	PN-721	*S. matsudana x S. alba*	New Zealand	New Zealand
15.	SI-63-007	*S. alba*	Italy	S. Italy
16.	J-795	*S. matsudana x S. alba*	UK	China
17.	NZ-1130	*S. matsudana x S. alba*	New Zealand	New Zealand
18.	SE-69-002	*S. matsudana*	Italy	Italy

Assessment of the traits

The observations were recorded in the last week of December 2010. Height of the plant was measured in meter with the instrument Abeney level, while diameter at breast height was measured at a height of 1.37 cm with caliper to the nearest centi meter. Volume index was calculated by multiplying by square of diameter with height as its relative index as also used in *Populus* species (YU *et al.,* 2001; KUMAR and SINGH, 2001; CEULEMANS *et al.,* 1992 and LI *et al.,* 1998, GUO and ZHANG, 2010). A subjective score was assigned to each tree for bole straightness (1 to 5). This type of scale has been also used by HODGE and DVORAK(1999) in *Pinus tecunumanii*, ISIK and TOPLU (2004) in *Populus nigra*, CALLISTER (2007) in *Eucalyptus*, ZEPS *et al.,* (2010) and HAI *et al.,* (2008) in *Acacia auriculiformis*.

Statistical analysis

Analysis of variance was conducted for all the traits to detect significant differences among the clones with the model for a randomized block design is

$Y_{ij} = \mu + R_i + T_j + E_{ij}$

where

Y_{ij} = Any observation for j^{th} treatment in ith block
μ = The general overall mean
R_i = effect of i^{th} replication
T_j = The effect of j^{th} treatment
E_{ij} = Random error associated with Y_{ij} observation.

Genotypic, phenotypic, environmental variances and coefficients of variability, genetic and phenotypic correlations were worked out as per SINGH (2006).

Genotypic, Phenotypic and environmental variances were calculated as:

$$PCV(\%) = \frac{\sqrt{Vp}}{\overline{X}} \text{ X } 100 ; \qquad Vp = \text{Phenotypic variance}$$

$$GCV(\%) = \frac{\sqrt{Vg}}{\overline{X}} \text{ X } 1\,0\,0 ; \qquad Vg = \text{Genotypic variance}$$

$$ECV(\%) = \frac{\sqrt{Ve}}{\overline{X}} \text{ X } 100 ; \qquad Ve = \text{Environmental variance}$$

PCV = Phenotypic Coefficient of Variability
GCV = Genotypic Coefficient of Variability
ECV = Environmental Coefficient of Variability
$\overline{X}$ = Population mean of character

Genotypic correlation (r_g)= G $Cov_{xy}/(Vg_x.Vg_y)^{1/2}$
Phenotypic correlation (r_p)= P $Cov_{xy}/(Vp_x.Vp_y)^{1/2}$
Where, G Cov_{xy} and P Cov_{xy} = Genotypic and Phenotypic covariance between x and y characters, respectively.
Vg_x and Vp_x = Genotypic and Phenotypic variance of x character
Vg_y and Vp_y = Genotypic and Phenotypic variance of y character

Heritability in broad sense, genetic advance at 5 percent intensity and Genetic advance was calculated as suggested by JOHNSON *et al.,* (1955).

$$h^2_{b.s} = \frac{Vg}{Vp} \times 100$$

Where,
$h^2_{b.s}$ = Heritability (broad sense)

$$\text{Genetic Advance (GA)} = \left[\frac{Vg}{Vp}\right] \times \left(\sqrt{Vp}\right) \times K$$

K = Selection differential at 5 per cent selection intensity. The value of K = 2.06 (ALLARD, 1960).
Genetic gain was worked out following the method suggested by JOHNSON *et al.* (1955) as under:

$$\text{Genetic Gain (\%)} = \frac{GA}{\overline{X}} \times 100$$

and genotypic coefficient of variability (GCV),

RESULTS AND DISCUSSION

Plant height, diameter at breast height, volume index and bole straightness are the important morphometric traits which indicate the growth and development of plant. Perusal of Table-2 disclosed that all the morphological traits varied significantly. The clone J-799 recorded highest plant height (19.33 m), diameter at breast height (16.50 cm) and volume index (0.554m^3). The clone NZ-1140 (16.33 m) placed at par with J-799 for height growth followed by the clones SI-63-007 (14.33 m), PN-731(13.47 m), J-795 (13.40 m) and J-194 (13.10 m). The clones NZ-1140 (15.30 cm), 131/25 (15.30 cm) and SI-63-007 (14.50 cm) shows diameter growth at par with clone J-799. Similarly for volume index clones NZ-1140 (0.386 m^3) and 131/25 (0.368 m^3) shows at par with clone J-799. However, clone SE-63-016 recorded lowest height (8.17m), diameter (5.77 cm) as well as volume index (0.046 m^3). Such a significant variation may be attributed to their distinct genetic constitution of the clones and their performance in given set of climatic and edaphic conditions.

In consonance with the present study on morphometric data THARAKAN *et al.,* (1998) found statistically significant differences between clones of *Populus* and

Salix for height, diameter, growth, leaf area and biomass production. Similarly, TUNCTANER (2002) evaluated 53 willow clones in Turkey and found clones of *S. excelsa* registered better in growth performance than even poplar check clone. Highly significant differences in mean tree height, basal diameter and volume were observed between parental species of poplar and hybrids by CEULEMANS *et al.,* (1992). They further noticed that superiority of hybrids in said characters were more prominent as the years progressed. Highly significant differences among *Populus nigra* clones for diameter and height (ISIK and TOPLU 2009) and for volume index in *P. deltoides* hybrids of two year (OZEL *et al.,* 2010) and three years (GUO and ZHANG, 2010) old plants are reported.

Table 2 Growth data of Five year old willow plants

Sr No.	Clone	Plant Height (m)	Diameter at Breast Height (cm)	Volume Index (m^3)	Straightness
1.	J-799	19.33	16.50	0.554	4.33
2.	PN-731	13.83	13.47	0.257	3.75
3.	V-99	12.67	9.87	0.139	3.75
4.	NZ-1179	10.00	9.83	0.144	3.92
5.	SE-63-016	8.17	5.77	0.046	3.47
6.	NZ-1040	11.83	10.87	0.141	3.40
7.	Kashmiri willow	9.83	9.53	0.113	3.08
8.	NZ-1002	12.33	12.20	0.184	3.72
9.	PN-722	07.50	7.71	0.053	3.90
10.	NZ-1140	16.33	15.30	0.386	4.25
11.	SI-64-017	12.67	9.43	0.133	4.10
12.	131/25	13.83	15.30	0.368	4.58
13.	J-194	13.10	13.60	0.297	4.73
14.	PN-721	11.20	10.77	0.130	4.40
15.	SI-63-007	14.30	14.50	0.304	4.27
16.	J-795	13.40	9.57	0.133	4.90
17.	NZ-1130	12.50	10.20	0.212	3.40
18.	SE-69-002	10.50	8.27	0.079	4.07
Mean		12.41	11.26	0.204	4.00
	SE	2.35	2.84	0.112	0.40
	CD(0.05)	4.79	5.77	0.29	0.61

Under Agroforestry system *Salix alba* clone recorded 19 meter plant height in six years growth in a *tarai* belt of Uttrakhand, India which is one of the most fertile soils of the country clubbed with better moisture regime and growth period (SAINI and SHARMA, 2001). However, the present study reveals same growth pattern in J-799 clone in five years in an ordinary field along the nallah (small stream) without any integration of agriculture crops with limited (seven months) growth period that can be compared with any good clone of Poplar in India.

Significant differences were reported in height and diameter among clones of 13 years old *Salix alba* (ORLOVIĆ *et al.,* 2006) and 14 years old clones of willow (TOPLU *et al*., 2008). JIANG *et al*., (2010) obtained a large significant differences

among 27 poplar hybrids obtained from *Populus deltoides* x *P. ussureinsis* assessed with *Populus* x *beijingensis* at an age of 4 for height and diameter at breast height. DHILLON *et al.,* (2010) found significant differences among *Populus deltoides* clones for diameter at breast height, height and volume in 5 year old plants grown in central plain region of Punjab, India. Similar genetic variation for height and diameter under field conditions in poplar clones have been reported by NELSON and TAUER (1987), TOKY *et al*., (1996), PURI *et al*., (2001), SINGH *et al*., (2001) and SIDHU and DHILLON (2007).

Straightness in *Salix* species plays an important role in determining the worth of its wood in the wood based industries. Same table reveals that J-795 (4.90 score) is most straight and is at par with J-194 (4.73), 131/25 (4.58) and PN-721 (4.40). Significant differences in this trait among 14 years old *Salix* (TOPLU *et al.,* 2008) and 2 years age poplar clones (IRIK and TOPLU, 2004), three years clones of *Acacia auriculiformis* (HAI *et al.,*2008) and in *Pinus radiata* (BURDON *et al.,*1992a) was noticed accordingly.

J-799 J-795 J-194

Fig 1. Height, Diameter at Breast Height and Bole straightness in some *Salix* clones at an age of Five

Genetic values

The genetic parameters furnished in Table 3 revealed high variability among the *Salix* clones. Phenotypic coefficient of variation (PCV) is greater than genotypic coefficient of variation (GCV) for all growth parameters, which varied from 14.28 percent and 11.32 percent in bole straightness to 85.04 percent and 52.96 percent in volume index, respectively. DHILLON *et al.,* (2010) also recorded phenotypic coefficient of variation more than genotypic coefficients of variation that

were highest for character volume than height and diameter at breast height in 5 years old poplar clones. Genotypic coefficient of variation for diameter at breast height is higher than height growth supported by the findings in *Populus deltoides* clones recorded subsequently at 5, 6 and 8 years old plantation (DHILLON *et al.,* 2010), 8 years old *Pinus radiata* (BURDON *et al.,*1992b) and 4 years old clones of *Acacia auriculiformis* (HAI *et al.,*2008).

In the present findings the heritability estimates (broad sense) were used to estimate the heritable portion of variation. Broad sense individual heritabilities of the traits ranged from 29.55 percent in diameter at breast height to 46.36 per cent in bole straightness. The result shows the scope for improvement in these characters through clonal selection and control breeding. The outcome of the present study exhibited higher heritability for height (37.53 %) than diameter at breast height (29.55 %) as also recorded by DHILLON *et al.,* (2010) and MOHN and RANDALL (1971) in *P. deltoides* clones, RONNBEY-WASTLJUNG and GULLBERB (1999) in *Salix viminalis* and GIANNINI and RADDI (1992) in *Cupressus sempervirens*. Higher heritability was found for tree height and stem straightness in comparison to others traits in hybrids of poplars (ZEPS *et al.,* 2010). HODGE and DVORAK (1999) found straightness to be the most heritable of the quality traits at the ages of 5 and 8 years in *Pinus tecunumanii*.

Table 3 Genetic Factors of five year old Salix clones

Sr No.	Clone	Plant Height (m)	Diameter at Breast Height (cm)	Volume Index (m^3)	Straightness
1.	Genetic Variance	4.86	4.86	0.012	0.20
2.	Environmental Variance	8.09	11.59	0.018	0.26
3.	Phenotypic Variance	12.95	16.45	0.03	0.48
4.	Genotypic Coefficient of Variation	17.69	19.58	52.96	12.48
5.	Phenotypic Coefficient of Variation	28.87	36.02	85.04	18.32
6.	Environmental Coefficient of Variation	22.82	30.23	66.53	13.42
7.	Heritability	37.53	29.55	38.79	46.36
8.	Genetic Advance	2.78	2.468	0.139	0.67
9.	Genetic Gain	22.32	21.92	67.95	17.50

In the present study, the genetic gain was recorded highest (67.95 %) for volume index and lowest (17.50 %) in bole straightness. Heritability estimates in broad sense are reliable if accompanied by high genetic gain (BURTON and DE VANE, 1953). JOHNSON *et al.,* (1955) reported that heritability estimates along with expected genetic gain are more useful and realistic than the heritability alone predicting the resultant effect for selecting the best genotype. The findings reported are in

agreement to ZEPS *et al.,* (2010) on poplar hybrids*;* SINGH *et al.,* (2001) on *Populus deltoides* and CALLISTER *et al.,* (2007) in *Eucalyptus cladocalyx*.

Correlation studies

The phenotypic and genotypic correlation coefficients (Table 4) gave positive and significant associations with all the traits. However, phenotypic correlation coefficients of straightness with other traits were not found significant. The genotypic correlations, in general, were higher than phenotypic correlations for all the characters, suggesting a good index of selection for these traits. Maximum positive and significant phenotypic correlation coefficient was found for diameter at breast height with volume index (0.921) followed by plant height with diameter at breast height (0.869). The genotypic correlation coefficient was recorded maximum (0.995) for plant height with volume index followed by diameter at breast height and volume index (0.965). These correlations indicate that improvement of one character will be accompanied by the improvement in another. Diameter was found positively correlated with bole straightness in poplar clones (ISIK and TOPLU, 2004). The results from the present investigation for relationships are corroborated by similar findings reported by MOHN and RANDALL(1971), RANDALL and COOPER (1973), NELSON and TAUER (1987), PANDEY *et al.,* (1993), JIANG *et al*., (2010) and DHILLON *et al.,* (2010) on *Populus* species. Similar genotypic correlation coefficient between tree height and bole straightness was recorded in 8 years old *Pinus radiata* (BURDON *et al.,*1992c), 3 years old clones of *Acacia auriculiformis* (HAI *et al.,*2008) and 5.5 years old *Eucalyptus* clones (CALLISTER *et al.,* 2007).

Table 4 Phenotypic(P) and Genotypic(G) correlation coefficients

		Height	DBH	Volume Index	Straightness
Height	P	1	0.869**	0.854**	0.220
	G	1	0.881**	0.995**	0.789**
DBH	P		1	0.921**	0.129
	G		1	0.965**	0.750**
Volume Index	P			1	0.119
	G			1	0.763**

**. Correlation is significant at the 0.01 level (2-tailed).
DBH = Diameter at Breast Height

CONCLUSIONS

There are significant differences among clones for plant height, diameter at breast height, volume index and bole straightness. With respect to morphological traits namely plant height, diameter at breast height and volume index the clones namely J-799, NZ-1140, 131/25, J-194, and SI-63-007 are found superior to the rest of the clones. While in terms of bole straightness clone J-795 is considered best which is at par with J-194 and 131/25. Broad sense heritability of bole straightness was found maximum showing good scope of improvement of this character that can

be primarily taken into further breeding programme. These promising clones selected based on the present study are to be further tested under multi-location trials in order to study the genotype x environment interaction at different sites for analysis of suitability of clones on one hand and can be used for intra and inter specific control breeding (hybridization) for producing more productive clones on the other.

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UTVRĐIVANJE GENETIČKIH PARAMETARA NOVIH INTRODUKOVANIH KLONOVA VRBE U HIMACHAL PRADESH, INDIA

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I z v o d

Vrba kao vrsta koja ima višestruku namenu je dobro prepoznata u svetu kao vrsta kratkih perioda rotacije u šumarstvu. Introdukovano je 200 klonova iz dvadeset zemalja u period u dužem od tri godine. Vršena je karakterizacija i 18 najboljih klonova je zasađeno u Martu 2006. U univerzitetskom glavnom kampu Nauni, Solan, Himachal Pradesh.Ocenjivane su osobinne porasta u toku pet godina. Klon J – 799 je imao najveći rast biljke (19.33 m) koji je u paru sa klonom NZ – 1140 (16.33 m) a visina klona SI – 63 – 007 je bila 14.30 m. Za diametar stabla u visini krune i indeksa volumena redosled u rangu je klon J – 799, zatim NZ – 1140 i 131/25 kod kojih su dobijene vrednosti 16.50 cm i 0.554m^3, 15.30 cm i 0.386m^3 i 15.30 cm I 0.368m^3. Pravost stable je bila maksimalna kod kolna J – 795 koji e u paru sa klonom J – 194, PN – 721 I 131/25 a zatim klonovi J – 799, SI – 63 -007, NZ – 1140 I SI – 64 – 017. Najviši stepen naslednosti u širem smislu je utvrđen za pravost stable (46.36%) i genetičku dobit indeksa volumena (67.95%). Genotipski, fenotipski i ekološki koeficijenti variranja su utvrđeni kao najviši (0.995) za osobinu indeksa volumena. Najviši koeficijent genetičke korelacije (0.921) je utvrđen između visine i volumena biljke, dok je fenotpski koeficijent korelacije utvrđen između diametra stabla u visini krune i indeksa volumena.

Na osnovu petogodišnjih osobina rasta, pet klonova : J – 799, NZ – 1140, 131/25, SI – 63 – 007 I PN – 731 su odabrani kao podesni za niže I brežuljke srednje visine u Himachal Pradesh oblasti.

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