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Principal Component Analysis of Growth and Biomass Characteristics for Different Progenies of *Ulmus villosa* Brandis

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The present study was carried out in order to find out the most important character contributing towards genetic variability in 30 *Ulmus villosa* progenies on the basis of principal component analysis. Principal Component Analysis (PCA) was carried out taking 10 important parameters, proved useful in extracting the most important factors. Three principal components contributed 84.62% of total variance. First principal component contributed 40.97% of total variation whereas the second component accounted for 24.93% variation and the third explains 18.72 % of variation. In the first PCA high loadings for traits such as shoot fresh weight (0.853), shoot dry weight (0.843), collar diameter (0.764) and plant height (0.736) represented those which are important for selection and further improvement of the species. The study revealed that maximum weightage should be given to fresh shoot weight due to its maximum variable loading for the initial selection of progenies for the biomass improvement of the species.

Key Words: Biomass, Growth, PCA, Progenies, *Ulmus villosa*

Introduction

The elms (*Ulmus* L.) are represented by approximately 35 species distributed throughout the temperate regions of the Northern Hemisphere and into the subtropics of Central America and Southeast Asia, including six species in eastern North America (Pooler and Townsend, 2005). There are five species of *Ulmus* found in India, of which four species namely *U. wallichiana*, *U. villosa*, *U. pumila* and *U. chumlia* are from North Western Himalaya and *U. lanceifolia* from North-Eastern regions of the country. Himalayan elms are the source of best fodder and quality timber. *U. wallichiana* is lopped for fodder which causes the depletion of regeneration. It is already categorized as vulnerable species in Red Data Book (www.iucnredlist.org). *Ulmus villosa* Brandis, commonly known as marinoo in India, is a small to medium sized deciduous tree belonging to family Ulmaceae (Melville and Heybroek, 1971). It is one of the more distinctive Asiatic elms and a species capable of remarkable longevity (Singh, 1991). It grows up to 20-30 m in height at elevations from 1200 m to 2500 m with a scattered distribution in the north western Himalayas. It finds greater favor on account of its multiplicity of uses and fast growth habit. It is a multipurpose agroforestry tree species producing fodder, fuel and timber. Inspite of its immense popularity and multiplicity of its uses, less attention has been paid on the improvement of this species (Melville and Heybroek, 1971). It is considered one of the most important agro-forestry trees in the Kashmir region. It also has a great potential outside its natural range for use on degraded land (Singh 1982; Bhardwaj and Mishra 2005). It is moderately susceptible to Dutch Elm Disease (DED) (Santamour 1979) and has been introduced in Europe and North America as an ornamental tree and for breeding purposes. DED is caused by certain fungi (*Ophiostoma* spp) and is one of the most serious diseases known to trees that has ravaged elm populations all over Europe. This poses a challenge for future conservation of *elm*, which in turn necessitates more knowledge about the distribution of variation in adaptive traits in the species.

Principal component analysis is a multivariate statistical technique which helps to reduce the data with large number of correlated variable into a substantially smaller set of new variables through linear combination of variables that account most of the variation present in the original variables. Since the aim of principal component analysis is to replace the original set of variables with few variables as possible, naturally in doing so some information contained in the original variables has to be sacrificed. But principal component has an advantage that this lost information is kept to minimum. Kaiser (1958)

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suggested the dropping of those principal components of the correlation matrix with eigen value less than one. He argued that the components with variance less than one contain less information. Hence keeping these points in view the present study was carried out in order to find out the most important character contributing towards genetic variability in marinoo progeny on the basis of principal component analysis.

Materials and Methods

Well matured seeds were collected in the month of April, 2011 from five mother trees (15-25cm DBH) each at six sites (Table 1). The progenies were then raised under nursery conditions in the experimental field. The experiment was conducted at the main campus of Dr. YS Parmar University of Horticulture and Forestry at Majhgaon experimental area. The area is situated at 30˚50' N latitude and 76˚11 E longitude at an elevation of 1100 m above mean sea level on north eastern aspect. On an average the area receives an annual rainfall of 1150 mm most of which is concentrated during monsoon rains.

The observations on morphometric traits of progenies *viz*; plant height, collar diameter, number of branches , number of leaves, petiole length, root length, leaf area, shoot fresh weight, shoot dry weight, root fresh weight and root dry weight were recorded by selecting five plants randomly in each treatment of replication and then taking the average value for each character (Table 2). The data so obtained were subjected to the principal component analysis (PCA) as per the Kaiser (1958). For principal component analysis of the data SPSS software, version 10.0 was used.

Results and Discussion

The range of mean values with respect to these characters among different progenies is given in Table 2.

Since it was difficult to conceive 10 dimensions (number of characters on which measurements was recorded) therefore, principal component analysis was employed for data reduction. The factor pattern and summary of principal component analysis on the gathered data has been revealed in Table 3. It was observed that three out of ten components had eigen value greater than unity and as such these components are retained in further analysis. These components explained a sufficient amount of variation (84.62%) of the total variation.

Table 1. List of different seed sources

Abb.	Site/ Seed Source	Location
S_1	Jadh (800 m)	Mandi (H.P)
S_2	Jugahan (800 m)	Mandi (H.P)
S_3	Jhidi (1,089 m)	Mandi (H.P)
S_4	Jagoti (1,824 m)	Shimla (H.P)
S_5	Katouch (1,900 m)	Shimla (H.P)
S_6	Andhra(2,200 m)	Shimla (H.P)

Table 3 revealed that the first principal component (λ_1= 4.29) explains 40.97 percent of the total variability in the data set. The variable loadings for first principal component are highest for four characters, indicating that maximum weight was attached to shoot fresh weight (0.853) followed by shoot dry weight (0.843), collar diameter (0.764) and height (0.763), respectively. The second principal component (λ_2= 2.61) explains 24.93 percent of total variation. The variable loading for second component was observed highest in petiole length (0.692) followed by leaf area (0.684) and number of leaves (0.594), respectively. The third principal component (λ_3= 1.96) explains 18.72 per cent of total variation. Maximum loading was observed in root fresh weight (0.806) followed by root dry weight (0.780) and root length (0.745). Principal component analysis provides an insight into a complex relationship between different characters in a biological system. It reflects the importance of the largest contributor to the total variation. In the current study the three components accounted for 84.62 percent of whole variability (Table 3). Tunctaner (2002) reported five principal components on the basis of 14 traits studied in willow clones. Similar types of findings were reported by Singh and Huse (2004). Singh (2006) recorded cumulative variability of 56 % from three principal components in *Populus deltoides* clones. Isik and Toplu (2004) reported three PCA which accounts 90% of the overall variation in *Populus nigra* in which first component includes height, diameter and apical dominance. Gupta (2006) in *Salix* clones also reported maximum variable loading for the shoot fresh weight and recommended the same for the selection along with other components.

The results of the present study indicated that the maximum weightage should be given to shoot fresh weight (having maximum variable loading) for the

Table 2. Mean values for growth and morphometric traits in 30 progenies of *Ulmus villosa*

Site/ tree	Diameter (mm)	Plant height (cm)	Leaf area (cm^2)	No. of leaves	Petiole length (mm)	Root length (cm)	Fresh shoot weight (g)	Dry shoot weight (g)	Fresh root weight (g)	Dry root weight (g)
S_1T_1	4.05	53.67	8.14	127.67	3.00	17.31	9.82	5.76	3.36	1.66
T_2	4.05	58.63	7.20	109.00	3.80	29.83	21.67	12.74	8.74	4.39
T_3	3.62	49.31	7.78	92.33	2.70	18.28	7.75	4.05	3.92	1.69
T_4	5.22	67.28	14.40	150.00	2.50	24.93	18.34	9.92	6.28	2.78
T_5	4.56	57.83	9.20	112.67	3.40	19.36	17.85	9.74	8.41	5.28
S_2T_1	5.90	91.25	10.16	142.00	2.70	32.72	17.79	11.06	5.79	3.93
T_2	6.04	84.44	8.95	132.00	3.00	33.58	20.15	11.95	10.72	6.99
T_3	6.37	82.63	8.67	151.33	3.00	29.33	17.09	12.2	6.78	4.38
T_4	6.66	81.27	9.84	191.67	3.00	32.40	23.01	13.69	10.81	7.51
T_5	5.49	80.03	14.07	154.00	2.80	28.93	22.74	12.96	9.21	5.44
S_3T_1	6.62	89.33	10.40	197.00	3.30	34.78	25.22	16.73	10.31	4.85
T_2	5.70	94.33	9.74	175.00	3.80	35.17	21.49	12.46	8.75	4.39
T_3	5.38	77.67	8.61	219.33	3.70	30.63	20.73	12.86	8.96	3.43
T_4	**7.51**	**96.09**	10.66	**243.00**	2.20	26.12	14.93	7.94	6.51	3.69
T_5	5.67	86.29	10.35	143.00	4.00	31.40	14.69	8.75	5.62	3.04
S_4T_1	5.27	68.87	9.72	119.33	4.00	18.70	17.02	11.61	6.63	3.64
T_2	7.44	83.83	10.77	176.00	3.30	31.80	23.12	14.09	10.16	5.23
T_3	5.69	73.60	9.48	125.00	3.70	**40.40**	11.27	6.13	5.53	2.54
T_4	6.06	78.82	**20.20**	147.00	3.80	32.45	23.37	15.85	8.97	5.24
T_5	7.33	87.82	15.88	229.00	**4.17**	30.70	**38.38**	**26.19**	10.75	6.23
S_5T_1	4.68	88.27	10.42	163.67	3.30	26.17	26.22	17.07	13.08	**7.72**
T_2	4.37	62.67	7.36	88.00	2.70	26.55	9.86	5.42	3.56	1.67
T_3	5.70	62.98	11.90	116.00	3.80	26.61	19.4	13.21	7.79	3.64
T_4	6.40	84.33	11.05	114.00	2.90	32.27	18.06	9.93	6.93	3.2
T_5	6.85	62.39	10.32	126.67	3.70	29.79	27.54	16	8.86	4.45
S_6T_1	6.81	85.42	13.29	195.67	2.70	35.44	19.36	11.44	8.17	4.35
T_2	4.42	66.77	9.25	154.67	3.70	23.42	17.02	11.83	5.28	2.86
T_3	4.30	71.92	7.30	115.67	3.00	31.10	26.1	16.49	**13.46**	6.73
T_4	5.04	62.76	9.41	166.00	3.00	31.40	26.14	16.28	9.88	5.02
T_5	3.80	58.99	8.24	116.00	3.60	24.10	12.8	5.02	4.35	1.77

Table 3.`Three principal components of 10 parameters of *Ulmus villosa*

Characters	Principle components		
	I	II	III
Height (cm)	0.736	-0.459	0.136
Collar diameter (mm)	0.764	-0.537	-0.081
Leaf area (cm^2)	0.543	0.684	0.284
Number of leaves	0.516	0.594	0.039
Petiole length	0.179	0.692	0.18
Root length	0.649	-0.326	0.745
Shoot fresh weight(g)	0.853	0.448	0.04
Shoot dry weight (g)	0.843	0.452	0.099
Root fresh weight(g)	0.54	0.43	0.806
Root dry weight (g)	0.65	0.342	0.780
Eigen value	4.29	2.61	1.96
Percent of variability	40.97	24.93	18.72
Cumulative percent of variability	40.97	65.9	84.62

selection along with other characters, since it is the largest contributor towards total genetic variability in marinoo.

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