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Variability Studies in Seedling Growth and Biomass Characteristics in Half-sib Progenies of *Ulmus villosa* Brandis in Kashmir

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ABSTRACT: The present investigation aims to assess the extent of variation existing among half sib progenies of *Ulmus villosa* Brandis for seedling growth and biomass traits and selection of the best mother tree for future afforestation programs in Kashmir. Seeds were collected from 15 mother trees across five districts of Kashmir: Anantnag, Pulwama, Budgam, Kulgam and Srinagar and were grown under open nursery conditions. Significant variations were observed among all the progenies for all growth and biomass characteristics. On the basis of performance progenies of Bijbehara-Anantnag exhibited superior performance for growth and biomass characteristics such as seedling height (32.20 cm), collar diameter (10.20 cm), total leaf area per plant (20.10 cm²), root length (12.01 cm), number of branches (25.00), number of leaves (48.66), plant percent (85.47%), survival percentage (81.32), sturdiness quotient (4.95) and Dickson's quality index (0.94). Biomass analysis indicated that Bijbehara-Anantnag also yielded the highest fresh shoot weight (22.42 g) and dry shoot weight (11.46 g) and fresh root weight (9.86 g) and dry root weight (5.50 g). Genetic analysis indicated moderate to high heritability and positive correlations between seedling and biomass characteristics, highlighting the influence of both environmental and genetic factors. These findings provide valuable insights into the selection of superior mother tree for seed collection, paving the way for tree improvement programs, sustainable propagation, and conservation efforts for this important tree species.

Keywords: Ulmus villosa, half-sib progeny, variability, Kashmir.

INTRODUCTION

The UT of Jammu and Kashmir forests spread over an area of 29066 sq km including the trees outside the forests, which is 55% of the total geographical area of UT (Anonymous, 2019). The valley of Kashmir falls under temperate zone and the forests consist mostly of evergreen coniferous and broad leaved tree species occupying an area of 8128sq km (Anonymous, 2015). Lying in the western extremity of the Himalayan mountain chain, the UT of Jammu and Kashmir is the home of best natural temperate coniferous and broadleaved species. However the situation of the forest resources in Jammu and Kashmir is not different from the national scenario. With the increase in population of both human as well as livestock these forests are under great pressure due to open grazing, heavy exploitation and excessive biotic dependence. Through a nation-wide study FSI has done estimation of dependence of people living in the villages close to forests for fuel wood, fodder and small timber in quantified terms for each state and UT of the country. The combined estimated quantities of these three produce for the UTs of Jammu and Kashmir and Ladakh have been reported as 12,98,816 tonnes, 1,40,17,803 tonnes and 19,763 cum respectively (Anonymous, 2019). Hence in order to reduce dependence on forests and at the same time fulfill the growing demand of population for forest products, there is a need to grow and exploit suitable fast growing tree species outside the conventional forests area. *Ulmus villosa* Brandis, commonly known as the cherry bark elm, is a promising multipurpose tree species that can grow to a height of 20–30 meters. It is typically found at elevations ranging from 800 to 2500 meters, with a scattered distribution across the northwestern Himalayas, extending from Hazara in Pakistan and Afghanistan to Kashmir and eastward to Kullu in Himachal Pradesh, India. It is a fast-growing and versatile tree species from the *Ulmaceae* family. It stands out among Asiatic elms due to its unique characteristics and exceptional longevity (Sodhi *et al.*, 2023). Growing up to a height of 25m, the tree is rather lightly and pendulously branched, the bark smooth with distinctive horizontal bands of lenticels, although it eventually becomes very coarsely furrowed. The oblong-elliptical-acute leaves are <11cm long and 5cm broad. The wind pollinated apetalous flowers appear in spring and are particularly densely clustered, the white hairs covering the perianth and ovary contrasting with the purplish anthers. The samara are elliptic, <12mm long and densely hair on both sides (Singh, 1982). This species holds significant potential for agroforestry, especially on degraded lands, due to its rapid growth and adaptability to various soil types. It provides valuable timber for light construction, fodder, medicinal bark, and ropes (Thakur & Thakur 2016). The species finds its prominence among hill farmers on the account of multifarious end uses (Lone *et al*., 2016). In Kashmir, it also enjoys the status of a sacred tree (Anonymous, 2022).

Trees are genetically diverse organisms. In many tree species, substantial genetic differentiation is found between populations and between single trees within populations (Muona, 1990). All differences among trees are the result of three things, *viz.*, different environment in which tree is growing, the genetic differences among trees and interaction between tree genotype and environment in which they grow. Environmental factors in combination with genetic and physiological factors play important role in determination of plant potential for seed quality. Variations are essential for adaptation and improvement. The amount of variation determines the potential for improving species through breeding programmes. Determining the amount, cause and nature of variation present in the species of interest is the first step towards any improvement work. In order to establish priorities for the conservation and improvement of tree genetic resources understanding of the diversity among and between tree populations is required.

Despite its economic importance, *Ulmus villosa* Brandis, has received limited research attention, particularly regarding its genetic improvement (Thakur *et al*., 2014). The species potential for genetic variability remains largely unexplored. The basic objective of any tree improvement programme is to select a better seed source for propagation (Zobel and Talbert 1984). Provenance or seed source testing is the initial step of a tree improvement programme, which helps to determine the nature and extent of variability present in a species as well as to select the best planting material for higher productivity (Bhat and Chauhan 2003). Hence, estimating the genetic variability existing in *U. villosa* through progeny evaluation is a prerequisite for isolating elite genotypes/progenies which are much desired for mass propagation and achieving maximum gain in the productivity. Assessment of quantitative traits contributing towards high biomass or timber production as well as gaining an insight to the complex traits association and extracting traits with highest contribution towards the genetic variability in the population can be effective towards selection and obtaining higher genetic gain in each cycle of any tree improvement programme (Sodhi *et al*., 2023).

This study aims to screen out the best germplasm of *Ulmus villosa* through progeny evaluation by analysis of seedling growth traits, biomass characteristics and genetic traits, this study seeks to provide a comprehensive understanding of the species and its genetic potential and its adaptability to different ecological conditions. These insights are pivotal for identifying superior genotypes, ensuring sustainable utilization, and enhancing the productivity of this valuable species (Graudal & Kjaer 2000).

MATERIAL AND METHODS

The research was conducted in 2021-2022 at Division of Forest Biology and tree Improvement, Faculty of Forestry, SKUAST-K, Benhama, Ganderbal, Kashmir. The study site is situated in the Kashmir Valley, India, characterized by a temperate climate with four distinct seasons: winter, spring, summer, and fall. The experimental field, located at an altitude of 5,850 feet above mean sea level (amsl), exhibits undulating terrain with a southern aspect. The average annual precipitation is approximately 690mm, primarily occurring as rain and snow from December to April. Meteorological data for the experimentation period were obtained from the meteorological observatory in Ganderbal. The average precipitation during the experimentation period was 357.1 mm (November-December) and 885.1 mm (January-October) in 2021 and 2022, respectively. Temperature varied from -8°C to 20.05°C (minimum) and 1.5°C to 34.5°C (maximum), while relative humidity ranged from 34% to 100% (maximum) and 21% to 100% (minimum) during the growing season.

A systematic random sampling approach was employed across five districts of Kashmir— Anantnag, Pulwama, Budgam, Kulgam, and Srinagar where middle-aged *Ulmus villosa* trees with approximately uniform dimensions were selected using the check tree method. Three sites in each district mentioned in Table -1 were selected for seed collection. Seeds collected from various mother trees were meticulously cleaned and sown in polybags (25cm by 7cm) containing uniform mixture of sand, soil, and farmyard manure (FYM) in 1:2:1 ratio for raising progenies. Sowing was done on April 23, 2022, in a poly house, with three replicates per mother tree. The experimental design followed a completely randomized design (CRD). Weeding and irrigation were performed as necessary throughout the growing season. Observations on growth and biomass parameters were recorded at the conclusion of the growing season *i.e*. October - November 2022. Five plants from each progeny were randomly selected in each replication and average values were recorded for each progeny. For recording observations on biomass parameters five plants that were selected for seedling growth parameters were uprooted carefully and separated with the help of scissors for weighing. Data obtained from the observations were subjected to analysis of variance using R statistical software. Critical difference, phenotypic coefficient of variation, genotypic coefficient of variation, heritability, genetic advance, genetic gain, and correlation were determined to assess the variability and relationships among the studied traits.

RESULTS AND DISCUSSION

The study investigated the impact of different genotypes on various growth parameters and biomass characteristics of seedlings across different geographical locations. Notably, significant variations were observed in growth and biomass traits among progenies, indicating the presence of inherent variability among different genotypes.

Seedling growth characteristics. Significant variations were exhibited among all the raised progenies for all the growth traits observed. On the basis of overall performance, progenies of Bijbehara, Anantnag performed best in for most of the growth traits such as seedling height (32.20 cm), collar diameter (10.20 mm), number of branches (25.00), number of leaves (48.66), average leaf area (20.10 cm^2),root length (12.01cm), shoot vigor index (745.01), root vigor index (2409.17) and survival (81.32%) Average minimum seedling height, number of branches, number of leaves, root length, survival, shoot vigor index and root vigor index was recorded in Toolipora-Kulgam with the values 10.21cm,16.11,32.33,6.94 cm, 65.32%, 254.86 and 809.45 respectively. However minimum average collar diameter of 3.90 mm was recorded in Harwan- Srinagar site. Minimum average leaf area (8.42 cm^2) was recorded in Shalimar-Srinagar. The maximum average internodal length was recorded in seedlings of site Mattan-Anantnag (4.20 cm) and minimum average internodal length was recorded in site Mirgund-Budgam (2.24 cm).

Since seeds were collected from different mother trees and were planted under similar nursery conditions, the variability observed for seedling growth characteristics may be attributed to genotypic differences among different progenies. Further, the variation present among different progenies for various seedling growth parameters could be ascribed to the fact that this species has scattered distribution over a wide range of edapho climatic conditions. Mayavel *et al*. (2023) conducted a provenance variability study in *Azadirachta indica* to assess its various attributes to produce high-quality planting stocks. Significant variations were noted for all the studied characters and the results are in agreement with the present study. Zhang *et al.* (2022) carried out an experiment to study within-and between-population variation in seedling traits of *Juglans mandshurica*. The results revealed that all seed traits varied significantly among families within the population. The results are in consonance with the findings of Singh (2019) in *Dalbergia sissoo*, Kumar (2018) in *Terminalia arjuna*, and Ravindra (2018) in *Azadirachta indica* as they reported significant variation in growth traits among different progenies in their studies. Similarly Fornah *et al*. (2017) reported considerable variation among seedling growth characters among seed sources of *Gmelina arborea* in a study Sierra Leone under nursery conditions.

Biomass characteristics. A significant variation was also observed in biomass characteristics in all the raised progenies such as average fresh and dry shoot weight, average fresh and dry root weight and root shoot ratio as clearly visible in Table 2. Seedlings raised from Bijbehara, Anantnag site exhibited highest value for average fresh shoot weight (22.42g), average dry shoot weight (11.46g), average fresh root weight (9.86g) and average dry root weight (5.50g). Variation in root shoot ratio was also significant, maximum root shoot ratio was calculated as 0.68 in site Shalimar- Srinagar, followed by 0.65 in Wanpora-Kulgam. Minimum root shoot ratio 0.29 was recorded in site Khudwani-Kulgam.

Since during our investigation seeds were collected from fifteen mother trees from different seed sources and were sown under uniform environmental conditions *i.e.*, in the same experimental field during the same season, therefore, we can infer that the variation in growth characters may be due to genotypic differences amongst the different progenies . Our results are in line with the studies conducted by Binu and Santoshkumar (2023) who evaluated the seedling progeny of over twenty-five (25) trees of *Melia dubia*. The best performance came from the offspring of two Tholpetty trees. Seed source variation studies by Sodhi *et al*. (2023) in *Ulmus villosa* Brandis concluded that significant variation was observed among all the seed sources studied hence, S5 (Nauni, district Solan) and S1 (Suket, district Mandi) were found the progenies that performed best for seedling and biomass attributes. These findings are also in agreement with the results obtained by Kumar *et al*. (2021), during their study on *Celtis australis,* Kumari *et al*. (2016) on *Ulmus villosa*, Kiran *et al*. (2016) on *Ulmus villosa* as they revealed significant variation between biomass traits in their studies and provide an opportunity for selecting superior planting material to improve species productivity. Similarly Thakur and Thakur (2016) reported considerable variation among biomass traits in *Ulmus villosa* in a study conducted at Himachal Pradesh under nursery conditions.

Findings from Table 3 showed significant differences in sturdiness quotient, Dickson's quality index and plant percent. Maximum value for sturdiness quotient, Dickson's quality index and plant percent was worked out to be 4.95, 0.94 and 85.47% respectively in progeny of Bijbehara-Anantnag, followed by Mattan-Anantnag with that of 4.80, 0.91 and 85.32% respectively. Minimum value for sturdiness quotient, Dickson's quality index and plant percent was observed in Toolipora-Kulgam with 1.33, 0.54 and 53.21% respectively. Since sturdiness quotient expresses the vigor of seedlings, and Dickson's quality index indicate the seedling quality index, the above results reveal that the seedlings obtained from Bijbehara-Anantnag are comparatively of good quality and can perform better in field conditions. According to Dickson *et al.* (1960) seedlings grown in natural substrates have the best and the highest sturdiness quotient or a good Dickson's quality index, which is a highly developed morphological index to predict field performance.

Banach *et al.* (2023) in *Quercus robur*, Rajesh *et al.* (2019) in *Santalum album* and Kumar (2016) in *Acacia nilotica* reported the same outcome for Dickson's quality index, sturdiness quotient, and plant percent. In view of Kumaran and Surendran (1999), *Pongamia pinnata* shows variation in all the progenies under his study for sturdiness quotient, Dickson's quality index, and plant percent.

Table 1: Average seedling growth parameters of half sib progeny of *Ulmus villosa* Brandis.

Mother Trees		Seedling height (cm)	Collar diameter (mm)	No. of branches per plant	No. of leaves per plant	Av total Leaf area/ plant (cm^2)	Root length (cm)	Internodal length (cm)
District	**Site**							
Kulgam	Khudwani	25.20^{e}	7.53^{j}	20.01^{g}	45.33^{i}	12.36^{n}	9.62^{m}	3.52^{d}
	Toolipora	10.21^{m}	7.26^{f}	16.11^{fg}	32.33^{i}	10.42^{m}	6.94^{d}	3.33^{e}
	Wanpora	20.26^{j}	4.11^{k}	18.21^{g}	41.66^{h}	14.68^{o}	11.52^{e}	2.38^{k}
Srinagar	Shalimar	14.51^{l}	4.33^{jk}	16.60^{a}	35.33^{fg}	8.42^{k}	11.02^{h}	2.65^{k}
	Harwan	16.16^{k}	3.90^{l}	17.36^{cde}	38.33^{b}	9.20^{i}	11.23^{g}	2.76^{j}
	Lalbazar	20.22^{j}	4.04^{i}	17.66^{bcd}	40.01^{de}	10.64^{j}	11.09^{g}	4.00^{a}
Anantnag	Bijbehara	32.20^{a}	10.20^{a}	25.00^{a}	48.66^{a}	20.10^{a}	12.01^{a}	3.69^{c}
	Mattan	31.50^{b}	9.76^{b}	23.00^{bc}	47.33^{b}	11.34^{f}	11.89^{b}	4.20^{a}
	Anchidora	29.23^{c}	9.23^{d}	21.33^{de}	47.00^{cd}	13.26^{c}	11.72^{c}	3.08^{f}
Pulwama	Barsoo	27.26^{d}	8.66^{c}	20.70^{e}	46.83^{gh}	10.58^{h}	11.42^{f}	3.98^{b}
	Batpora	25.26^{e}	7.66^{e}	20.33^{b}	46.50^{ef}	13.61^{b}	10.72^{j}	2.89^{i}
	Kakapora	23.53^{g}	6.47^{h}	19.83^{f}	43.33^{b}	12.12^{d}	10.83^{i}	3.04^{h}
Budgam	Wahabpora	24.60^{f}	6.50^{g}	19.90^{fg}	44.00^{c}	16.91^{g}	10.69^{k}	3.10^{g}
	Mirgund	23.20^{h}	4.41^{j}	19.80^{bcde}	43.13^{b}	11.54^{e}	9.87^{l}	2.24^{l}
	Narbal	22.11^{i}	4.23^{jk}	18.75^{a}	42.00^{de}	12.70^{l}	9.75^{m}	3.01^{h}
C.D.($p \leq 0.05$)		**0.22**	**0.26**	**1.46**	**1.12**	**0.20**	**0.21**	**0.23**

***Values sharing same letter are statistically non-significant at 5%**

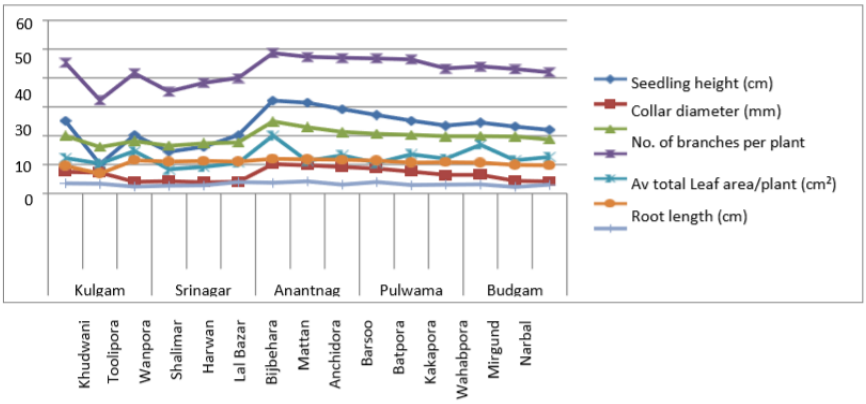


Fig. 1. Average seedling characteristics of *Ulmus villosa* Brandis.

Table 2: Average biomass characteristics of seedlings of *Ulmus villosa* Brandis.

Mother trees		Shoot weight fresh (g)	Shoot weight dry (g)	Root weight fresh (g)	Root weight dry (g)	Root Shoot Ratio
District	**Site**					
Kulgam	Khudwani	20.87^{e}	9.96^{c}	6.63^{g}	2.96^{f}	0.29^{h}
	Toolipora	16.56^{m}	6.13^{h}	5.74^{c}	2.84^{c}	0.46^{b}
	Wanpora	18.68^{k}	7.70^{g}	8.75^{k}	5.02^{l}	0.65^{k}
Srinagar	Shalimar	17.72^{c}	6.21^{b}	7.73^{j}	4.23^{k}	0.68^{n}
	Harwan	18.29^{f}	7.21^{c}	8.25^{g}	4.67^{h}	0.64^{i}
	Lal Bazar	18.43^{n}	7.46^{j}	8.07^{l}	4.36^{m}	0.58^{j}
Anantnag	Bijbehara	22.42^{i}	11.46^{e}	9.86^{a}	5.50^{a}	0.47^{c}
	Mattan	22.33^{j}	11.33^{d}	9.47^{e}	5.33^{e}	0.47^{f}
	Anchidora	21.93^{d}	10.70^{c}	9.13^{d}	5.15^{b}	0.48^{d}
Pulwama	Barsoo	21.71^{a}	10.63^{a}	8.61^{e}	4.73^{g}	0.44^{m}
	Batpora	21.56^{b}	10.20^{b}	7.40^{h}	3.60^{j}	0.35^{l}
	Kakapora	19.73^{k}	9.20^{f}	7.52^{f}	3.75^{fg}	0.40^{e}
Budgam	Wahabpora	19.99^{h}	9.46^{g}	7.16^{h}	3.18^{i}	0.33^{g}
	Mirgund	19.25^{g}	9.06^{d}	7.03^{i}	3.06^{l}	0.33^{n}
	Narbal	19.07^{l}	8.90^{i}	6.93^{b}	3.01^{d}	0.33^{a}
C. D.($p \leq 0.05$)		**0.19**	**0.20**	**0.19**	**0.05**	**0.35**

***Values sharing same letter are statistically non-significant at 5%**

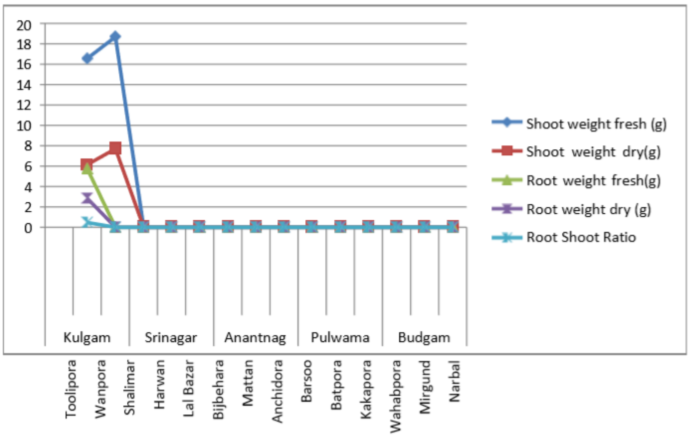


Fig. 2. Average Biomass characteristics of half sib progenies of *Ulmus villosa.*

Table 3: Survival, vigor, sturdiness quotient, Dickson's quality index and plant percent of *Ulmus villosa* seedlings.

Mother Trees		Survival (%)	Shoot vigor index	Root vigor index	Sturdiness Quotient	Dickson's Quality index	Plant %
District	**Site**						
Kulgam	Khudwani	78.82^{j} (8.87)	538.84^{c}	942.05^{m}	4.16^{a}	0.84^{h}	66.73^{h} (8.16)
	Toolipora	65.32^{k}(8.08)	254.86^{h}	809.45^{n}	1.33^{l}	0.54^{a}	53.21^{j}(7.29)
	Wanpora	67.93^{c}(8.24)	317.97^{de}	1914.86^{d}	1.92^{b}	0.70^{i}	58.41^{d}(7.64)
Srinagar	Shalimar	66.24^{f}(8.13)	264.31^{g}	1643.25^{g}	1.40^{g}	0.62^{ef}	55.92^{l}(7.47)
	Harwan	66.64^{i} (8.16)	277.97^{fg}	1867.86^{j}	1.35^{d}	0.64^{gh}	56.66^{i} (7.52)
	Lalbazar	67.57^{b}(8.22)	285.90^{d}	1705.74^{f}	1.74^{f}	0.66^{j}	57.90^{a}(7.60)
Anantnag	Bijbehara	81.32^{a}(9.01)	745.01^{a}	2409.17^{a}	4.95^{j}	0.94^{bc}	85.47^{b}(9.24)
	Mattan	80.91^{h}(8.99)	678.00^{b}	2192.58^{b}	4.80^{i}	0.91^{def}	85.32^{f}(9.23)
	Anchidora	80.32^{e}(8.96)	594.31^{b}	1943.25^{c}	4.55^{h}	0.90^{cd}	74.91^{e}(8.65)
Pulwama	Barsoo	79.64^{bc}(8.92)	580.84^{b}	1903.28^{e}	4.44^{k}	0.87^{ab}	74.68^{c}(8.64)
	Batpora	79.22^{l} (8.90)	574.75^{e}	1383.08^{k}	4.29^{i}	0.85^{a}	70.11^{l}(8.37)
	Kakapora	78.07^{d}(8.83)	480.79^{c}	1577.14^{h}	3.77^{e}	0.77^{ef}	62.36^{e}(7.89)
Budgam	Wahabpora	78.42^{g}(8.85)	502.00^{c}	1152.58^{i}	3.79^{e}	0.83^{de}	65.51^{g}(8.09)
	Mirgund	69.43^{j} (8.33)	443.13^{f}	980.01^{l}	3.20^{c}	0.75^{f}	60.76^{i} (7.79)
	Narbal	68.42^{k}(8.27)	363.31^{e}	945.21^{o}	3.10^{d}	0.73^{g}	59.85^{k}(8.35)
C.D.($p \leq 0.05$)		**0.01**	**159.20**	**1.96**	**0.03**	**0.02**	**0.02**

***Figures in the parenthesis are sine transformed values and values sharing same letter are statistically non-significant at 5%**

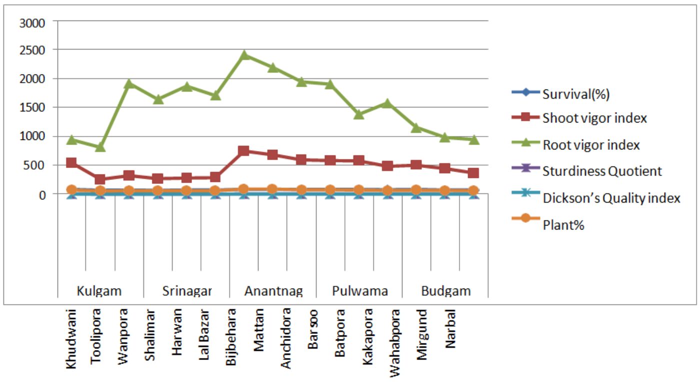
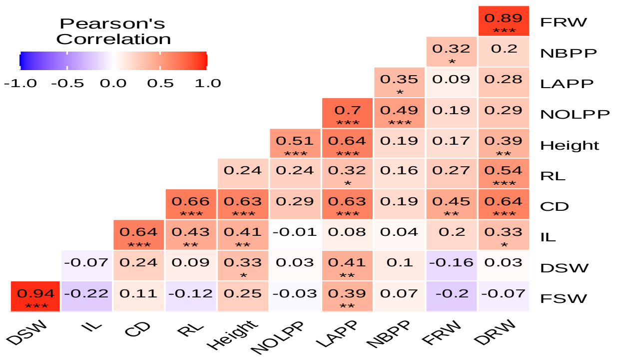


Fig. 3. Survival, RVI, SVI, Sturdiness quotient, Dickson's quality index and plant percent of *Ulmus villosa* seedlings.

Simple Correlation Studies. The analysis of various seedling growth and biomass traits (Plot 1 and 2) highlights their collective influence on the quality and performance of seedlings of *Ulmus villosa*. These associations provide valuable insights into the genetic framework governing growth and biomass traits and identify key parameters for simultaneous improvement and therefore these characters must be given proper emphasis during selection programme.

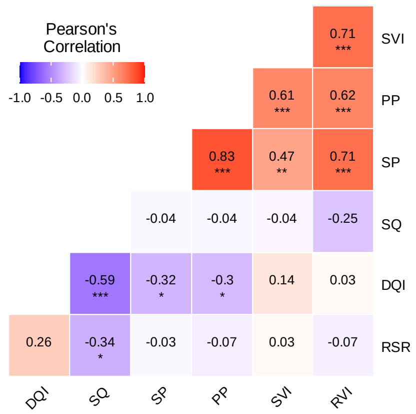
Fresh shoot weight (FSW) exhibited positive and high significant correlation with dry shoot weight (DSW, r = 0.94) and fresh root weight with dry root weight (FRW, r = 0.89). Moderate significant and positive correlation was observed in collar diameter (CD) with root length (RL, r = 0.66) followed by internodal length (IL) with collar diameter (CD, r = 0.64). Similarly, moderate significant and positive correlation was observed in collar diameter (CD) with dry root weight (CD, r = 0.64), height (H) with leaf area per plant (LAPP, r = 0.64), collar diameter (CD) with height (H, r = 0.63), collar diameter (CD) with leaf area per plant (LAPP, r = 0.63).

In Plot 2, there was a significant and positive correlation between survival percentage (SP) and plant percent (PP, r = 0.83), survival percentage (SP) and root vigor index (RVI, r = 0.71), shoot vigor index (SVI) and root vigor index (RVI, r = 0.71). Moderate positive correlation was observed in plant percent (PP) and root vigor index (RVI, r = 0.62), shoot vigor index (SVI) and plant percent (PP, r = 0.61). This demonstrated that these various characters under study may have an association with each other and ultimately affect the character of the yield. Relationship and dependency of components characters provide a complex genetic system and as a result of selection of one component character brings about the simultaneous change in other traits. The strong correlations underscore their interdependence and importance in predicting seedling vigor and performance and thus highlighted that correlation reflects an insight to the amount of inter relationship existing between different characters and provide a baseline of indirect selection of juvenile mature correlated traits. Some trait combinations exhibited weak or non significant correlations, suggesting that these are influenced more by environmental factors. Similar findings were observed between growth and biomass characters and reported by Kumar *et al*. (2022) in *Melia dubia* and Kumar *et al*. (2015) in *Pongamia pinnata*. Similarly, Thakur *et al.* (2013) suggested strong correlations of seedling growth traits with biomass in *Ulmus villosa* and must be given emphasis throughout the selection programme.



Where: FRW- Fresh Root weight, NBPP- Number of branches per plant, LAPP- Leaf area per plant, NOLPP- Number of leaves per plant, H- Height, RL- root length, CD- Collar Diameter, IL- internodal length, DSW- Dry shoot weight, FSW- Fresh shoot weight.

Plot 1.



Where: SVI–Shoot vigor index, PP-plant percent, SP-survival percentage, SQ-Sturdiness quotient, DQI- Dickson's quality index, RSR- Root shoot ratio, RVI- Root vigor index

Plot 2.

Genetic Parameters. The analysis of phenotypic and genotypic coefficient of variation (PCV, GCV), heritability, genetic advance and genetic gain (Table 4) depicted the genetic variability of seedling and biomass traits. Maximum PCV was recorded in root shoot ratio (64.24), followed by the dry root weight (47.08). Lowest PCV 6.29 was recorded for the survival percent. Highest GCV was recorded for root shoot ratio (60.11). Survival percent had lowest GCV value of 4.62. Maximum genetic advance was recorded in root vigor index (26.71), followed by the shoot vigor index (15.89). Dickson's quality index recorded minimum value for genetic advance (1.5). The magnitude of phenotypic coefficient of variation was greater than the corresponding genotypic coefficient of variation for all the traits which indicates that the traits were highly influenced by environment than gene action as evidenced in the work done on *Pongamia pinnata* by Rahangdale *et al.* (2015) and *Melia dubia* (Kumar *et al*., 2013). Another study on genetic variability of

Avena sativa L. by Kumari *et al*. (2022) concluded that the phenotypic coefficient of variation was greater than corresponding genotypic coefficient of variation, that are in consonance with the present study. High genotypic coefficient of variation (GCV), combined with significant genetic advance suggests that selecting superior individuals at a 5% selection intensity could lead to substantial genetic gains. Similar findings have been reported by Murali (1997); Saleem *et al.* (1994) in other species, further supporting these conclusions. Our results are in line with the study conducted by Panwar *et al*. (2021) in *Cicer arietinum* and concluded that PCV was larger than GCV showing that environment had an impact on expression of these characters and high heritability coupled with high genetic gain indicated that these characters can be improved by and *Acacia catechu* (Gupta *et al*., 2012) where high genetic gain facilitated seedling growth and biomass traits. Study conducted on *Ulmus villosa* by Thakur *et al*. (2013) reported higher coefficient of variability for root dry weight and high heritability with moderate genetic gain for collar diameter, plant height and petiole length indicating the effectiveness of these characters in selection for enhancing biomass productivity in the species. Anjali *et al.* (2022) conducted a study on morphological evaluation of variability, heritability and genetic advance in relation to seed yield in Indian selection. Similar results were obtained for genetic variability by Barik *et al.* (2021) in *Vigna mungo* L., Basu *et al.* (2022) in *Oryza sativa* L. and Patro *et al.* (2016) in *Eluesine coracana* L. Gaertn.

Heritability in narrow sense was high for all characters. Maximum heritability was observed for seedling height, fresh shoot weight and leaf area per plant (0.81) followed by internodal length (0.80). Sturdiness quotient recorded the least value for heritability (0.62). Maximum genetic gain was observed in dry root weight (75.67) and minimum in survival percentage (12.92). The traits with high values of heritability and genetic gain would be most effective for selection since these traits indicate additive type of gene action. Similar findings have been reported in *Melia dubia* (Kumar *et al*., 2022), *Pongamia pinnata* (Kumar *et al*., 2015).

mustard and concluded that to improve grain yield per plant these traits could be used directly. Thus the characters with higher heritability and genetic gain can be exploited well for advanced breeding programs..

Significant variability present in the tree species or germplasm provides opportunity for effective selection to the breeder as selection acts on the variability already present in the species and thus responsible for the success of any tree improvement programme (Sodhi *et al*., 2023).

Table 4: Genetic parameters of various seedling growth and biomass parameters in *Ulmus villosa* Brandis.

Seedling parameters	PCV	GCV	Heritability	Genetic advance	Genetic gain (%)
Seedling height(cm)	26.61	23.10	0.81	12.61	54.79
Collar diameter(mm)	34.10	31.21	0.78	4.40	64.78
No. of branches per plant	25.97	22.10	0.73	5.50	48.80
No. of leaves per plant	21.37	18.34	0.77	8.68	42.97
Leaf area per plant (cm²)	28.07	25.82	0.81	5.73	57.83
Internodal length(cm)	35.35	31.51	0.80	3.85	72.48
Root length (cm)	29.77	26.31	0.79	15.56	61.31
Shoot weight(Fresh) (g)	32.87	30.21	0.81	11.29	67.69
Shoot weight(Dry)(g)	32.10	27.52	0.77	6.75	66.05
Root weight(Fresh)(g)	44.76	40.04	0.72	10.08	52.11
Root weight(Dry)(g)	47.08	40.11	0.78	5.26	75.67
Survival percentage	6.29	4.62	0.77	11.65	12.92
Root-Shoot ratio	64.24	60.11	0.77	0.77	25.31
Shoot vigor index	34.68	31.22	0.66	15.89	69.84
Root vigor index	36.36	32.01	0.77	26.71	74.87
Sturdiness quotient	27.80	25.13	0.62	2.19	57.26
Dickson's quality index	9.63	7.56	0.75	0.15	19.17
Plant percent	8.79	6.11	0.79	14.78	18.09

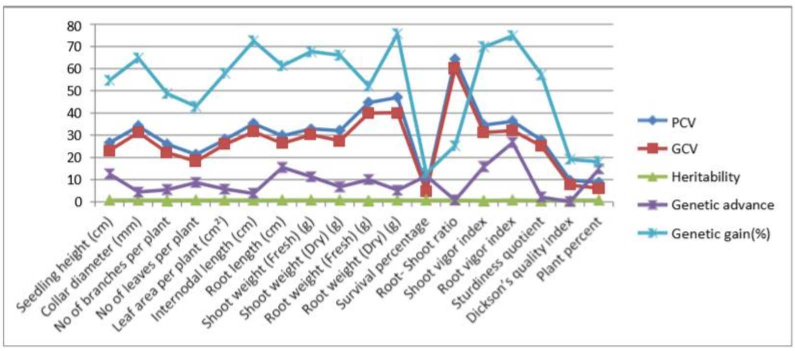


Fig. 4. Genetic parameters of seedling growth and biomass traits of *Ulmus villosa* seedlings.

CONCLUSIONS

The current study is first of its kind about the source variation in seedling and biomass traits of *Ulmus villosa* Brandis in Kashmir. The findings of our study indicate substantial variation in seedling, biomass, and genetic traits among half-sib progenies of *Ulmus villosa*. Progenies derived from seeds collected at the Bijbehara-Anantnag site demonstrated exceptional performance across multiple key traits, such as seedling height, collar diameter, leaf area, root length, number of branches and leaves, plant percentage, and survival rate. Sturdiness quotient and Dickson's quality index were highest in Bijbehara- Anantnag, indicating robust seedling vigor and quality. Biomass analysis further confirmed the superiority of Bijbehara-Anantnag in terms of fresh shoot weight, dry shoot weight, fresh root weight, and dry root weight. Phenotypic and genotypic variances, along with heritability estimates, varied significantly among traits, with root shoot ratio exhibiting the highest coefficient of variation. High genotypic coefficient of variation (GCV), combined with significant genetic advance suggests that selecting superior individuals at a 5% selection intensity could lead to substantial genetic gains. Seedling height, fresh shoot weight, and leaf area per plant showed the highest heritability, indicating substantial genetic control over these traits. Notable genetic advances were observed in root vigor index, while Dickson's quality index demonstrated minimal genetic gain. Strong positive correlations between seedling growth traits and biomass underscored their importance in selection programs. Hence, it is concluded that the Bijbehara-Anantnag site represents the most promising source of germplasm for future afforestation initiatives.

FUTURE SCOPE

The results indicate a strong genetic influence on the traits studied in *Ulmus villosa* Brandis, highlighting potential for focused improvement programs. These findings enhance our understanding of seedling variability and offer valuable guidance for future breeding and conservation initiatives for the species.

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Conflict of Interest. None.

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