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LK Behera
Department of Silviculture and Agroforestry, College of Forestry, Navsari Agricultural University, Navsari, Gujarat, India

SK Jha
Department of Silviculture and Agroforestry, College of Forestry, Navsari Agricultural University, Navsari, Gujarat, India

RP Gunaga
Department of Silviculture and Agroforestry, College of Forestry, Navsari Agricultural University, Navsari, Gujarat, India

D Nayak
Department of Silviculture and Agroforestry, College of Forestry, Navsari Agricultural University, Navsari, Gujarat, India

MB Tandel
Department of Silviculture and Agroforestry, College of Forestry, Navsari Agricultural University, Navsari, Gujarat, India

DB Jadeja
Department of Silviculture and Agroforestry, College of Forestry, Navsari Agricultural University, Navsari, Gujarat, India

Correspondence
LK Behera
Department of Silviculture and Agroforestry, College of Forestry, Navsari Agricultural University, Navsari, Gujarat, India

Genetic variability and correlation study for growth characters among clones of *Eucalyptus*

LK Behera, SK Jha, RP Gunaga, D Nayak, MB Tandel and DB Jadeja

Abstract
The present investigation was carried out in College of Forestry, Navsari Agricultural University, Navsari, Gujarat to study the genetic variability, heritability, genetic gain, genetic advance and correction for growth traits among 20 clones of *Eucalyptus*. Low to medium values for PCV, GCV, ECV, heritability, genetic advance and genetic gain were recorded among different growth parameters. Among different genetic variability volume was found maximum in GCV with 22.67 per cent, heritability with 0.52 and genetic gain with 33.78 per cent. Similarly significant and positive correlation of volume with DBH, mid-diameter, tree height and form quotient was observed. From the study, it is evident that volume was with maximum genetic variability and showed positive correlate with all the remaining growth characters. Hence, clone(s) with maximum volume could be used for clonal improvement programme in South Gujarat condition.

Keywords: *Eucalyptus*, genetic variability, growth characters, heritability

Introduction
Myrtaceae family member Eucalyptus is one of the fast growing tree species and introduced to Indian subcontinent as an exotic species from Australia. There are more than seven hundred species of *Eucalyptus* which are mostly native to Australia (Moffett, 2012) [19]. The Eucalypts are normally found with a natural latitudinal range extending from 7˚N to 43˚39'S and flourishes from coastal areas to areas situated at an altitude of 2000 m, tropical to warm temperate climate and rainfall ranges of 400-4000 mm (Tewari, 1992) [29]**.** In the context of scarcity, *Eucalyptus* with astonishing growth characteristics, are capable of reducing wide gap between demand and production of wood in shortest possible time and meets requirements of people, industries and helped to reduce pressure on natural forests (Chandra and Yadava, 1986) [6].

India is one of the largest *Eucalyptus* growing countries with a total area of 1.36 million ha plantations up to 1999 (FSI, 1999) [8] which increased to around 8.00 mha up to 2010 (Aregowda *et al.*, 2010) [1]. *Eucalyptus* one of the species among top 10 tree species found in the growing stock of Tree Outside Forest (TOF) area which contributing stem and volume of 3.98 and 2.11 per cent of total stems and total volume respectively (FSI, 2015) [9]. Eucalypts are multipurpose tree species and their wood is in much demand for paper and pulp, plywood, furniture, packing cases and light constructional timber all over the world (Behera, 2016) [2]. Among the *Eucalyptus*, different clones are being developed to get the quality pulpwood plantations which can give higher pulp yield and better growth rate. Wood properties of trees are changing throughout the world (Zobel *et al.*, 1983) [34] and causes of the changes must be known. In order to use wood efficiently, the variation patterns within trees, among tree within species and among species must be understood (Zobel and van Buijtenen, 1989) [33].

Genetic variation is the basis for adaptation and survival of living organisms under changing environmental conditions. The presence and maintenance of genetic variation in tree population plays a significant role in the long term stability of forest ecosystems (Libby *et al.*, 1997) [16]. *Eucalyptus* a cross- pollinated tree with large genetic variation which exists in natural as well as planted forests. Clonal propagation of this tree offers vast possibilities of taking advantages of the natural variation for immediate gains in productivity. To exploit this variation to its maximum, there is a need to screen large number of trees to identify clones with superior traits. Field testing and selection of highly productive site- specific clones is a high priority research focus (Lal, 1999: Campinhos, 1999) [14, 5].

The assessment of genetic variability is a pre-requisite for the success of any tree improvement programme (Zobel, 1971) [32]. Therefore, this study was conducted with an objective to estimate the genetic parameters and correlation for growth characters among clones of *Eucalyptus* in South Gujarat conditions.

Material and Methods

The present trial was carried at the instructional farm of College of Forestry, Navsari Agricultural University, Navsari. The plantation was established during September 2009 consists of 20 clones planted at 2 x 2m spacing in three replications following Randomized Block Design (RBD). Total 3 ramets per clone were selected randomly and growth parameters such as Diameter at Breast Height (DBH), mid-diameter, tree height were recorded at the age of 6 years as per standard procedure. Coefficient of variation such as Phenotypic Coefficient of Variation (PCV), Genotypic Coefficient of Variation (GCV) and Environmental Coefficient of Variation (ECV) was worked out as suggested by Burton and De-vane (1953) [4] and Pillai and Sinha (1968) [24]. Broad sense heritability was calculated as suggested by Burton and De-Vane (1953) [4] and Johnson *et al*. (1955) [11]. Similarly the expected genetic advance at 5 per cent selection intensity was calculated by the formula suggested by Lush (1940) [18] and further used by Burton and De-Vane (1953) [4] and Johnson *et al.* (1955) [11] whereas genetic gain was worked out following the method suggested by Johnson *et al.* (1955) [11]. The simple correlation coefficients (Karl pearons) were worked out for growth characters by using the formula recommended by Panse and Sukhatme (1967) [23].

Results and Discussion

In this trial, low to medium values for PCV, GCV, ECV, heritability, genetic advance and genetic gain were recorded among different growth parameters (Table 1). GCV ranged from 3.94 (tree height) to 22.67 per cent (volume), whereas heritability ranged between 0.26 and 0.52 respectively in tree height and volume. The same trend was recorded for genetic grain. Most of the genetic parameters showed comparatively higher values for volume and this trait may be considered while selection of genotypes. Luna and Singh (2009) [17] also reported medium values of GCV (12.98 % and 13.03 %), PCV (15.37 % and 17.52 %), heritability (0.71 and 0.55) and genetic gain (22.54 % and 19.95 %) for height and DBH, respectively among different progenies of *Eucalyptus* hybrid. Based on traits with higher values were considered for further selection. Similarly, Singh *et al.* (2011) [27] found GCV, PCV, genetic gain and heritability values of 4.46%, 8.26%, 4.95% and 0.29, respectively for height after 12 months of *E. camaldulensis* plantation in the field. Higher estimates of heritability were recorded for height and sectional area (Borralho *et al.*, 1992) [3] in *E. globulus* and yield, uniformity, survival, limb diameter and crown vigour in various clones of *Eucalyptus grandis* (Lambeth and Endo, 1990) [15]. Kedharnath (1982) [12] reported low heritability for height in *Eucalyptus grandis.* Similar findings were reported by Wilcox and Farmer (1967) [31] and Singh *et al.* (2001) [28] in *Populus deltoides* whereas Pande *et al.* (2013) [21] found high heritability for GBH in *Leucaena leucocephala.*

There was a strong and positive association between tree volume with DBH (r= 0.952), mid-diameter (r= 0.964), tree height (r= 0.553) and form quotient (r= 0.392) indicating these growth parameters increases with increase in volume (Table 2). Again DBH is positively correlated with mid-diameter (r= 0.921) and tree height (r= 0.422). Similarly mid-diameter was positively correlated with tree height (r= 0.366) and form quotient (r= 0.964). The high positive correlation of volume with DBH and other traits indicates that improvement in one character may be accompanied on improvement of another trait. Similarly Luna and Singh (2009) [17] found positive correlation between height and DBH with other characters like clear bole, straightness and axis persistence in *Eucalyptus hybrid* progeny. It is also true in the case of Verma and Sharma (2011) [30], where they recorded a positive relation between height and DBH of *Eucalyptus* hybrid. Such trend was also reported in different species by different scientists. For instance, Kumar and Bangarwa (2010) [13] in *E. tereticornis* for growth traits; Gapare *et al.* (2003) [10] in *E. grandis*; Rawat *et al.* (2001) [26] in *Populus deltoides*; Pandey *et al.* (1993) [22] in *Populus spp.*; Wilcox and Farmer (1967) [31] and Randall and Cooper (1973) [25] and Nelson and Tauer (1987) [20] on *Populus* spp.; Costa e Silva *et al.* (1998) [7] in *Picea sitchensis*.

Table 1: Estimation of genetic variation in growth attributes among clones of *Eucalyptus*

Growth Traits	Genetic parameters					
	PCV(%)	ECV (%)	GCV (%)	Heritability	Genetic Advance	Genetic Gain (%)
DBH	13.52	10.24	8.26	0.39	1.49	10.68
Mid-diameter	15.60	11.83	10.17	0.43	1.24	13.65
Tree height	7.68	6.59	3.94	0.26	0.89	4.17
Form quotient	6.00	4.37	4.11	0.47	0.04	5.80
Volume	31.33	21.63	22.67	0.52	0.07	33.78

PCV = Phenotypic Coefficient of Variation, ECV = Environment Coefficient of Variation, GCV = Genotypic Coefficient of Variation

Table 2: Correlation among growth attributes in *Eucalyptus* clones

Sr. No.	Growth attributes	1. DBH	2. Mid-diameter	3. Tree height	4. Form Quotient	5. Volume
1	DBH	1.000				
2	Mid-diameter	0.921**	1.000			
3	Tree height	0.422**	0.366*	1.000		
4	Form Quotient	0.169	0.534**	0.008	1.000	
5	Volume	0.952**	0.964**	0.553**	0.372*	1.000

** significant at 1% p level, * significant at 5% p level

Conclusion

Overall result shows that among different genetic variability volume was found maximum in GCV, heritability and genetic gain. Similarly significant and positive correlation of volume with DBH, mid-diameter, tree height and form quotient was observed. From the study, it is evident that volume was with

maximum genetic variability and showed positive correlate with all the remaining growth characters. Hence, clone(s) with maximum volume could be used for clonal improvement programme in South Gujarat condition.

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