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Research article

Genotype-environment (GE) interaction study for different growth characters and estimation of genetic parameters to identify phenotypically superior clones of *Gmelina arborea* Roxb.

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Abstract: The genotype interaction study of established clonal trials of *Gmelina arborea* was estimated for different the growth characters in the three different environmental conditions. Total 25 numbers of selected clones were established. Among the clones, across the three environments for collar diameter (CD) best clone observed GA096, GA034, GA104. Considering the height (Ht) clone number GA116**,** GA103**,** GA96 shows best and for the number of branches (Br) the clones GA045, GA016, GA099 resutled best. Estimation of genetic parameter of genotypic coefficient of variation (GCV) for all the traits collar diameter, height and branches per plant resulted 13.96%, 11.54% and 11.74%, respectively. The phenotypic coefficient of variation (PCV) recorded 18.14%, 19.62 % and 22.32%, respectively. Heritability (h^2) recorded 9.19%, 34.64% and 27.69% respectively. The genetic advances, as percent of means are 22.12%, 14.00% and 12.73% for collar diameter, height and branches per plant respectively.

Keywords: GCV, PCV, Heritability, Genetic advance, Environment interaction.

INTRODUCTION

Information on genetic structure and diversity of candidate plus trees provide basis for planning of efficient utilization of genetic resources to realize potentiality for maximizing growth and yield. Hence, to achieve significant improvementsof different traits like productivity, quality and genetic superiorty of selected genotypes which needs to be tested under different geographical and soil conditions through progeny or clonal trials for various genetic parameters. The present steps of investigation has been carried out to study the clonal variations for the selection of superior clones and to study the genotype environment, to assess true genetic worth and to identify phenotypically superior clones for improved planning stock to strengthen the programme. As the number of *Gmelina* plantations increases, the study of its mating system and the genetic improvement of the species becomes more important. Dvorak (2003) emphasized that though potential landraces could effectively be utilized for short term gains and genetic testing and improvement through well-defined breeding program need to be carried out to realize long term benefits of plantation forestry. Hodge & Dvorak (2003) conducted genetic tests on multilocation basis in six countries for 31 progenies and assessed using important traits like height, diameter at breast height, volume, straightness at three ages (one, two and three years). Performance of different species and clones shows diverse response in different environment. Growth characteristics are also complex in inheritance and are greatly influenced by various environmental conditions (Fang *et al*., 1999). Hence, genotypic environment (GxE) interaction is the differential response of genotypes to environmental changes (Isik & Kleinschmit, 2003).

MATERIALS AND METHODS

To retaining the genetic constitution, propagules produced by vegetative means of parent plants can be produced without segregation for clonal multiplication. Selected twenty five numbers of clones clones were regenerated through bud grafting for establishment of clonal trials (Fig. 1). Hence, after completion of screening experiment ne VMG was established at RFRI, Jorhat (Fig. 2A) and another one at Luwangsangbam, Imphal East, Manipur under the research division of state forest departments (Fig. 2B, C). To study genotype environment (GE) interaction and to estimate the genetic parameters different growth characters, the above clones were planted in three different locations of North Eastern region namely Luwangsangbam (Manipur) (E1) (Fig. 3A), Noney (Tamenglong) (E2) (Fig. 3B, C) and Barapani (Meghalaya) (E3) (Fig. 3D) for their performance evaluation in randomized block design (RBD) with four replications. The quantitative morphological traits were recorded for collar diameter (CD mm), plant height (PH cm) and number of branches. The observation taken were analysed for analysis of variance (ANOVA) as per Sukhmate &

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Amble (1989) and estimate different genetic parameters.

Variance

The genotypic and phenotypic component of variance were calculated from ANOVA as described by Burton (1952)

Genotypic coefficient of variance: $GCV = (\sqrt{\sigma^2 g}/mean) \times 100$

Phenotypic coefficient of variance: $PCV = (\sqrt{\sigma^2 p}/mean) \times 100$

Heritability: Board sense heritability was calculated as per Lush (1949):

$$h^2 = \sigma^2 g/\sigma^2 p \times 100$$

Genetic advance or genetic gain: The genetic advance was calculated as described by Johnson *et al.* (1955).

$$(Gs) = K.\ h^2.\ \sqrt{\sigma^2_p}$$

where, K=2.66.

Genetic gain as percent of mean: The expected genetic gain, as percent of mean, was calculated following Burton and Devane (1953).

$$\text{Genetic gain} = (Gs/mean) \times 100$$

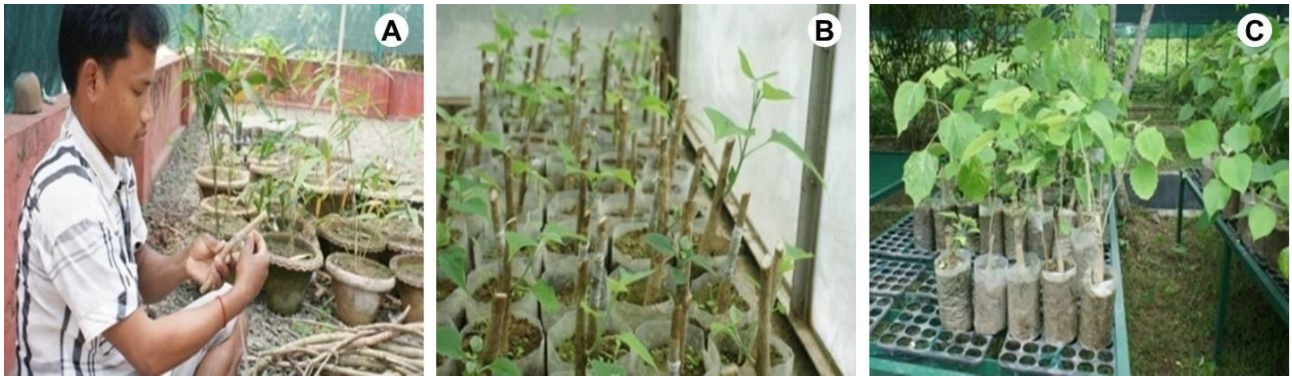

Figure 1. Grafting of selected clones of *Gmelina arborea* Roxb.: **A**, Preparation of grafts; **B**, Healthy growths of grafts; **C**, Grafts under field condition.

Figure 2. Established Vegetative Multiplication garden (VMG) of *Gmelina arborea* Roxb.:**A**, RFRI Jorhat; **B-C**,. Luwangsangbam, Imphal.

Figure 3. Established clonal trial of *Gmelina arborea* Roxb.:**A**, Luwangsangbam, Imphal; **B-C**, Noney, Tamenglong; **D**, Barapani, Shillong.

RESULTS

The use of vegetatively propagated material brings additional benefit through increased correlation between the selection criterion and actual breeding value and leads to larger genetic gain when incorporated into breeding strategies

(Danusevicius & Lindgren, 2002; Isik *et al*., 2005). Three year growth data were analysed using standard statistical procedures in each of the individual environments. It was observed that the error variances for the characters were not found homogeneous at 5% level of significance. Therefore the data were transformed before performing pooled analysis. The transformation involved dividing observations of each individual environment by the square root of error mean square (EMS) so as to make the error mean squares homogeneous. These data were again analysed using standard statistical procedures in each of the individual environments for one - way ANOVA. The mean sums square to the clones were found to be highly significant across three locations for collar diameter, plant height and branches. The clone x location MS was also significant for collar diameter, plant height and branches. MS due to location was highly significant for the traits collar diameter and number of branches but not significant for the trait plant height. This is by indicating that the clone means differ significantly from location to location from the traits collar diameter and number of branches. Since interaction effect is significant, hence examine its size relative to the average effect of the treatment. On the other hand, if the interaction effect is relatively large and the ranking of the treatment changes over year hence the examination of the interaction would be useful. Nature of interaction can be examined by partitioning the pooled error SS based on the set of desired contrast. From the pooled ANOVA (Table 1) it was evident that the genotype mean square was highly significant (at 1% level of significance) for all the traits across the environments depicting that the genotypes differed significantly across the three environments.

Table 1. Pooled analysis of variance (ANOVA) for collar diameter (CD), height and number of branches across the three environments of transform data of *Gmelina arborea* Roxb.

Source of Variation	DF	Mean Squares		
		Collar diameter (CD)	Plant Height (PH)	No. of Branches
Environment	2	720.485**	0.838	38.939**
Rep within environment	9	1.124	1.609	4.274
Genotype	24	5.351**	2.59**	2.149**
Genotype X environment	48	3.768**	2.918**	2.303**
Pooled Error	216	1	1	1

The mean square due to genotype environment interaction was also found highly significant for all the traits. This indicated that the genotypes performed differently in the environments in respect of each of the traits. The clones listed in (Table 2) were compared based on critical and list differences calculated based on transformed data.

Table 2. Mean performance of genotypes across three environments for three different traits of transform data of *Gmelina arborea* Roxb.

Clone	Collar diameter (CD)	Plant Height (PH)	No. of Branches
GA002	4.796	3.00	2.142
GA006	4.479	3.01	2.368
GA008	3.666	2.96	2.133
GA011	4.231	2.96	2.640
GA015	2.734	2.17	2.263
GA016	4.784	3.64	3.186
GA017	4.412	3.10	2.674
GA021	4.391	2.88	2.398
GA025	3.843	2.77	2.731
GA027	4.854	3.37	3.099
GA033	4.534	3.04	2.922
GA034	5.074	2.88	2.619
GA039	3.829	3.26	2.887
GA040	4.601	3.26	2.277
GA045	3.769	2.89	3.290
GA096	5.259	3.73	2.861
GA099	4.219	3.60	3.134
GA102	4.866	3.68	3.009
GA103	4.978	3.82	2.943
GA104	5.067	3.71	2.930
GA106	3.801	2.90	1.973
GA107	4.958	3.02	2.912
GA109	2.781	2.30	1.688
GA112	3.812	2.78	2.683
GA116	4.132	4.10	2.117
CD (environment)	0.390	0.466	0.760
CD (genotype)	1.061	1.061	1.061
CD (genotype X environment)	1.838	1.838	1.838

It was evident that the clones namelyGA096, GA034 and GA104 were the three best clones for the character collar diameter based on transformed data. These three germplasm GA096**,** GA034 and GA104 gave the observed mean for critical difference across the environments of collar diameter is 5.259, 5.074 and 5.067 respectively. The three clonesGA116**,** GA103andGA96 gave the observed mean for height across the environments as follows 4.10, 3.82 and 3.73 respectively. The three clones GA045, GA016 and GA099 gave the observed mean for branches per plant across the environments as follows 3.29, 3.186 and 3.134 respectively.

The estimated different genetic parameter were recorded, GCV for collar diameter, height and number of branches per plant were 13.96%, 11.54% and 11.74% and PCV18.14%, 19.62 % and 22.32% respectively. The heritability (h^2) for collar diameter, height and branches per plant were 59.19%, 34.64% and 27.69% respectively. The genetic advances as percent of means are 22.12%, 14.00% and 12.73% for collar diameter, height and branches per plant, respectively (Table 3).

Table 3. Genetic parameters collar diameter, height and branches per plant across environments of *Gmelina arborea* Roxb.

Genetic parameter	Characters		
	CD	**Height**	**Branches**
GCV	13.96	11.54	11.74
PCV	18.14	19.62	22.32
h^2	59.19	34.64	27.69
GS as percent of mean	22.12	14.00	12.73

DISCUSSION

The variations in growth characteristics of clones may be attributed to inherent genetic factors as well as the effect of environmental conditions, which may vary in different environmental conditions. Noh *et al*. (1997) selected studied on *Populus davidiana* Dobe clones at the age of six and seven the results reported that they were not only superior in growth performance but also stable over a range of environments. They selected 7 clones out of 58 from seven sites. The genetic variability was analysed by working out different genetic parameters *viz.* GCV, PCV, heritability (h^2) and genetic advance as per cent of mean. Burton (1952) suggested that genetic coefficient of variation together with heritability estimates could give appropriate estimate of genetic gain to be expected from selection. However, it depends upon genetic makeup of the individuals and the environment in which they are grown. Thus, information on genetic parameters such as heritability and genetic advance becomes pre-requisite for making efficient selection strategies by geneticists and breeders (Lewis *et al*., 2010).The testing of genotypes for their superiority of different traits is necessary to produce best genotypes for the next generation (Kumar, 1995). In our study the clonal trials were tested over for their genetic worth through multilocation trial in three different geographical locations. The present data revealed significant genetic variation among the twenty five clones for growth attributes in different environments. The evaluation of performance of growth of various clones of the average result of different parameters of clonal trials shows to its maximum potential in Noney, Tamenlung district Manipur (E2). This may be attributed to edaphic and climatic conditions prevailing over evaluation of sites of the outcome of the average analysis of different clones under different environment may be the effect of genotype. Kumar *et al.* (2010) estimated 18 clones of *Eucalyptus tereticornis* Smith. and recorded growth parameters at the age of 3 years to record significant variations for different growth traits. Similarly, Pandey *et al.* (2010) studied the growth parameters in *Pongamia pinnata* (L.) Pierre. indicating the presence of considerable variability. Evaluation in population variability of *P. pinnata* has also been reported by Mukta & Sreevalli (2010) and Sahoo *et al*. (2009). These facts indicated the effect of varying environmental conditions on the expression of genotypic worth of different clones. Kirkpatrick (1975) recorded presence of distinct pattern of geographical variation on growth of adult plants of *Eucalyptus globulus* Labill. Performance of clones for height, CD, DBH and pest incidence was affected by locations, where environments would be larger than that of due to genotypes. Clonal effect for *Populus* species was also reported by Yu & Pulkkinen (2003). On *Eucalyptus tereticornis* and clearly described the significant clonal differences for various growth traits and environments. Pathak *et al.* (1984) reported that genetic and environmental factors influenced the growth performance of plants. Rawat & Nautiyal (2007) suggested that variation in growth characteristics of the plants is essentially genetic in nature if it differs in identical environmental conditions. However, some clones were found to be performing better at one location and not adaptable to all the locations. Similar findings were reported by Kumar & Bangarwa (2011) in *Eucalyptus tereticornis*. In the present study, experimental sites were located distantly from each other so that real impact of environment could be results and make use to understand potential of a genotype. Different clones were tested for different traits where, best clones were sensitive to environment and performed well at favourable ones only. Rana *et al.* (2006) supported similar results in *Pisum sativum* L. for pod yield and reported that genotypes adapted to more favourable growing conditions manifested high mean performance as compared to grand mean. Pichot & Cros (1989) working on estimation of genetic

parameters in *Populus deltoids* Bartr. found that heritability estimates for diameter were higher in comparison to plant height at the age of two years.

Similar to our study low GCV for height was reported by Sundararaju *et al*. (1995) in *Eucalyptus tereticornis*. Thus exhibition of low to moderate GCV and PCV for plant height and CD was in harmony with above findings. The genotypic and phenotypic coefficient of variation for height, CD and number of branches for current study provides evidence for existence of adequate genotypic variations. Similarly, some authors reported that the PCV estimated for all the traits was higher than respective GCV indicating environmental influence of phenotype expression. The highest PCV estimates were recorded for number of branches followed by height, collar diameter suggesting large amount of genetic variability. Heritability (broad sense) was found to be moderate for all traits. The similar pattern was recorded for genetic advance. The GCV was found to be of low magnitude than PCV for all the traits, studied to indicate that these traits are influenced by the environment factors as evidenced in *Melia azedarach* L. (Meena *et al*., 2014) *Leucaena leucocephala* (Lam.) de Wit. (Chavan & Keerthika, 2013).

In case of heritability, it is defined as the ratio of total genetic variation to the phenotypic variation, and is of practical application in tree improvement particularly with stock multiplied using clonal propagation technology (Zobel & Talbert, 1984). The selected genotypes will increase genetic gains by allowing breeders to optimally deploy them to various sites. Our findings also possess of moderate heritability for all the traits. Similarly low to moderate heritability was also recorded in *Eucalyptus globulus* and *Eucalyptus nitens* (H.Deane & Maiden) Maiden (Raymond, 2002). The authors reported that the heritability varied with changing environment and age.

Many researchers have shown GxE interaction in growth of clones and varieties (Clair & Kleinschmit, 1986; Yu & Pulkkinen, 2003). As for example, Clair & Kleinschmit (1986) reported that significant clone x site interaction of 40 clones of Norway spruce tested on seven constructing sites in northern Germany. Subramanian *et al.* (1995) studied and reported height, CBH, girth, diameter and basal area showed moderate heritability and genetic advance in *Eucalyptus grandis*. Similar findings had earlier been reported for plant height and stem diameter by Sharma & Sharma (1995) in *Grewia optiva* J.R. Drumm. ex Burret**.**

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