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Genetic analysis of fruit and seed parameters in teak (*Tectona grandis* L. F.): Implications in seed production programme

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Abstract

Genetic analysis of fruit and seed parameters in teak (*Tectona grandis* L. F.) was carried out using open pollinated fruits from 40 plus trees of Madhya Pradesh, Central India. The results indicated highly significant variation for all the characters studied. Fruit size, fruit weight and seed weight exhibited moderately high to very high heritabilities coupled with relatively high genetic gain for fruit and seed weight. Fruit size showed significant phenotypic and high genotypic correlations with fruit weight filled and unfilled locule. Implications of the present findings in seed production programme of teak have been discussed.

Key words : Teak, seed production, additive gene effect

Introduction

Teak (*Tectona grandis* L. F.) is one of most valuable hardwood timber species. It occurs naturally in many countries of South-East Asia namely India, Myamnar, the Laos People's Democratic Republic and Thailand. Because of its desirable wood properties, fine grain, durability, and amenability for plantation, the species has been introduced and planted in a number of tropical countries out side its natural range. About 94 percent of global teak plantation is in the tropical Asia, with major chunk of about 44 per cent in India [1]. Teak improvement work in India was started during early sixties and since then a good number of plus trees have been selected from different teak growing areas of the country and utilized to establish 1100 ha of clonal seed orchards and more than 70 ha of seedling seed orchard [2]. Though, all out efforts have been made to make available superior quality seeds for plantation by establishing seed production populations of various kinds, yet availability of sufficient quantity of superior seeds is still a bottleneck. The main reason for acute shortage of quality seeds and set back to the expectation of teak breeders lies in inherently low seed production potential of teak. Teak shows extremely low flower to fruit ratio. Under natural pollination fiuit setting is as low as 0.2 to 2 %. Similarly, ovule to seed ratio is also extremely low. About 10-35% fiuits are reported to be seedless [3]. Considerable variation in fruit production was reported among different clones in teak seed orchards. Singh *et al.* [4] attributed this variation to the genetic potential of the individual clones and suggested that due emphasis on fruiting ability of trees, while selecting plus trees may help in minimizing problems of low seed yield in orchards. Though many workers have proved the existence of significant variation in growth characters (which is prerequisite for improvement through selection) and investigated inheritance of these characters [5], yet studies on variation in seed characters are lacking. Present paper reports for the first time, the result of a study undertaken to know the magnitude and type of genetic variation and direction of association among different seed and fruit parameters in teak and to suggest measures for improving seed yield in seed production populations.

Material and methods

Materials for this study came from 40 phenotypically superior trees selected from different locations of Mdhya Pradesh, central India. Open pollinated fruits from these trees were collected. Observations were recorded on fruit weight (g), seed weight (g), fruit size (cm) and number of filled and unfilled locules. Fruits so obtained from each tree were divided equally into three lots. Observations on different characters were taken on 100 randomly drawn fruits from each lot representing three replications. Fruit size was measured as mean of diameter taken at cross section to each other. Fruits were carefully cut open horizontally to observe for filled and unfilled locules and counted in numbers. Filled seeds were then carefully extracted and weighed to estimate 100 seed weight. Data so obtained were subjected to analysis of variance and co-variance followed by estimation of variance components as well as phenotypic and genotypic correlations [6]. Broad sense heritability (h^2) was estimated from replicated

plot means and estimates of expected genetic gain (Δ G) was calculated and expressed as per cent of mean [7].

Results and discussion

The primary objective of tree improvement programme is to change both gene and genotypic frequency in the desired direction. Applying selection for the desired trait(s) can bring about such change. Availability of variability is a prerequisite to make any selection effective. Populations of many tree species exhibit considerable variations in different seed and seedling parameters [8]. Present investigation also revealed highly significant variation for all the fruit and seed parameters in teak, studied using a group of selected trees of central Indian origin (Table 1). Interestingly, replication mean squares were found to be non-significant for all the characters, which indicates that the development of these characters is not significantly influenced by environmental fluctuations.

Table 1. Analysis of variance for different seed and fruit parameters in teak (only mean sum of squares)

Source	DF	Character				
		Fruit size	Fruit weight	Filled locule	Unfilled locule	Seed weight
Replication	2	0.000763	2.313	0.0335	0.0347	0.0051
Plus tree	39	0.00577**	102.49**	0.0686**	0.0691**	0.0639**
Error	79	0.000917	4.533	0.0170	0.0173	0.0112

**Significant at 0.01 level

Mean values with standard error, range and coefficient of variation are presented in Table 2. Fruit weight, filled locule, and seed weight showed wide range. As expected the traits with wide range are also more variable as indicated by their coefficient of variation. Maximum value of coefficient of variation was observed for filled locule (10.92 per cent).

Table 2. Mean, range and coefficient of variation of fruit and seed parameters in teak

Trait	Mean±SE	Range	CV	PCV	GCV
Fruit size (cm)	1.075±0.017	0.94-1.20	2.82	4.70	3.75
Fruit wt. (g)	44.65±1.23	35.40-60.17	4.77	13.66	12.78
Filled locule	1.195±0.075	0.87-1.70	10.92	15.48	10.97
Unfilled locule	2.82±0.076	2.30-3.13	4.69	6.63	4.68
Seed wt. (g)	1.34±0.061	0.94-1.54	7.91	12.66	9.88

The relative amount of variation expressed by different characters can be properly judged through estimates of phenotypic and genotypic coefficient of variation. Genotypic coefficient of variation was maximum for fruit weight (12.8 per cent) and its difference with phenotypic coefficient of variation was also least amongst all the traits. This suggests that this character is least affected by environmental fluctuations. Differences between GCV and PCV for other traits were also found to be less. Genotypic coefficient of variation for these traits was accounted for more than 70 per cent of their respective phenotypic coefficients of variations. These traits also appear to have less influence of the environment on their expression.

As indicated by analysis of variance maximum proportion of total variation was due to plus trees. However, it is very important to know how much of this variation is due to environmental, genotypic and phenotypic causes. Estimates of environmental genotypic and phenotypic components of variation, heritability in broad sense and genetic gain in per cent of mean are presented in Table 3. Environmental components of variance were comparatively high for filled locule, unfilled locule and seed weight. However, respective genotypic variance for these characters accounted for 50 %, 50% and 61 % of total phenotypic variance. Partitioning of total phenotypic variance into heritable and non-heritable components is highly useful as heritable portion of variation is only exploitable through selection. Heritability expresses the reliability of the phenotypic value as guide to the breeding value. It is a property not only of a character but also of the population and of the environment to which individuals are subjected [9].

Table 3. Estimates of different genetic parameters for fruit and seed characters in teak

Trait	Variance component			h^2	ΔG%
	σ^2p	σ^2g	σ^2e		
Fruit size (cm)	0.002	0.001	0.0009	63.97	6.18
Fruit weight (g)	37.19	32.65	4.53	87.81	24.71
Filled locule	0.034	0.017	0.017	50.21	17.48
Unfilled locule	0.035	0.017	0.017	49.92	6.82
Seed weight (g)	0.029	0.018	0.011	60.98	15.89

σ^2p = Phenotypic variance, σ^2g = Genotypic variance, σ^2e = Environmental variance, h^2 = Heritability (broad sense), ΔG % = Genetic gain in % of mean

Although narrow sense heritability is more meaning full, heritability in broad sense may give useful indication about the relative value of selection. However, since broad sense hritability represents the upper limit that can be achieved through selection, such estimates should be used judiciously. Therefore, heritability in conjunction with genetic gain is more useful than the heritability alone in predicting the resultant effect for selecting the best genotype for a given trait [7]. In the present investigation, fruit weight was found to be the most heritable (Table 3). The present analysis also indicates that fruit weight, fruit size and seed weight are strongly inherited while other two traits are moderately inherited. Such high to moderate heritabilities of seed parameters have also been reported in Aleppopine [10]. Fruit weight filled locule and seed weight showed high heritabilities coupled with relatively high genetic advance. These traits are, probably under the influence of additive gene effect. Direct individual selection for these characters may be effective. In case of fruit size non-additive gene effect appears to be of considerable importance. Individual and family selection, and incorporation of selected individuals in recurrent breeding programme would probably be more effective in realizing genetic gain.

Phenotypic and genotypic correlation coefficients among different traits are given in Table 4. In general the sign and magnitude of correlation at both phenotypic and genotypic level is similar. Fruit size exhibited significant and positive phenotypic correlation with fruit weight and filled locule but negative with unfilled locule. Fruit weight showed non-significant but positive correlation with filled locule. Relationship at both phenotypic and genotypic levels between filled and unfilled locule is highly negative. Seed weight displayed negative association with all other traits except filled locule. However, these negative associations were found to be very weak. Interestingly and in general the relationships as emerged from the present study are in the desired direction and also in agreement with normal situations of fruit and seed development processes. Although fruit weight displayed high heritability and high genetic gain estimates, its low correlation with filled locules limit its usefulness as single character for selection to effect indirect improvement in seed-fullness and reduction in emptiness in fruits. Therefore, fruit size which is highly heritable and showed significant relation in the desired direction with most of the characters should be considered for selection in seed improvement and production programme.

Teak has extremely low ovule to seed ratio. About 10-35 % of fruits are reported to be seedless [11]. Recent studies (3) on emptiness in teak fruit indicated about 33% of the total fruits were seedless, 46 % with one seed, 16 % with two seeds, 5 % with three seeds and 0.33 % with four seeds. The reason for this low fruit to seed ratio may be attributed to the tendency for fixed abortion either through competition among embryos or by direct control from the maternal plant [12].

Table 4. Phenotypic and genotypic correlation coefficients among different fruit and seed traits

Traits	Fruit weight	Filled locule	Unfilled locule	Seed wirhgt
Fruit size	0.7431**	0.3335*	–0-3317*	–0.0475
	(0.8138)	(0.3555)	(–0.3518)	(–0.0086)
Fruit weight		0.2063	–0.2055	–0.0965
		(0.2261)	(–0.2243)	(–0.1010)
Filled locule			–0.9999**	0.0848
			(–0.9999)	(0.2883)
Unfilled locule				–0.0854
				(–0.2901)

Significant at * 0.05; * Significant at 0.01 level; Figures in parenthesis indicate genotypic correlation.

Teak is planted widely in India since 1842 [13]. Most teak plantations have been raised with unimproved seed sources. Though some efforts have been made to select phenotypically superior trees with greater expression of characters for production of superior timber, no conscious attempts have been made to select trees with high seed production potential. Present study indicated the existence of significant genetic variation in characters related to fruit and seed yield. The Indian region is considered to be the center of origin and genetic diversity of teak [14]. Therefore, careful search has to be made while selecting phenotypically superior trees for higher fruit size and higher number of filled locules per fruit. Finally, such trees should be included in seed orchard programme for obtaining high seed yield and used in controlled crossing programme for transfer of the traits in other genetic background.

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