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Variation in Phenology and Reproductive Biology in a Clonal Seed Orchard of Teak

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ABSTRACT

Variation in phenology and reproductive biology among different clones of a species help in the selection of better genotypes. We studied a 33 year old clonal seed orchard of Teak (*Tectona grandis*) to estimate the variation in phenology and reproductive biology of 13 distinct clones derived from two different provenances. The peak phonological events like leaf shedding, leaf renewal, flowering, fruiting and fruit fall were observed in January, May, August, September and December respectively. The clones such as ORANP4 and ORANR2 showed their activeness in having phonological events earlier. The number of flowers produced per inflorescence was highest in ORANP3 (5230) while ORANR5 produced the lowest (3030). However, ORANP7 produced highest number of fruits per tree (570) closely followed by ORANP4 (563) and ORANP3 (528). All the reproductive traits expressed very high percentage of heritability (>90%) which indicates that these traits are useful for further selection to produce high yielding genotypes.

Key Words: *Tectona grandis* L.; Clone; Phenology; Heritability; Genotypes; Provenance

INTRODUCTION

Teak *(Tectona grandis* L. F.) is one of the most valuable and popular hardwood timber species. Its natural distribution range in South-East Asia includes India, Myanmar, Laos People's Democratic Republic and Thailand. Due to the multipurpose use of teak wood, the species has been introduced and planted in a number of tropical countries outside its natural range. Tropical Asia is characterised by 94 percent of global teak plantations a which about 44 percent is found in India. The natural habitat of teak lies between 10° N and 25° N in the Indian subcontinent and South East Asia, especially in India, Burma, Thailand, Laos, Cambodia, Vietnam and Indonesia. In India, it has a discontinuous distribution from its western limit in the western Aravallis at 24°42'N Latitude, northern most limit to Jhansi (25° 33') from where it extends to Mahanadi river in the east (Brandis 1906). Teak prefers moist, warm tropical climate. It can withstand extremes of temperature, but maximum and minimum shade temperatures of 39- 44°C and 13 - 17°C, respectively are the most favourable for its growth. It grows well in the zone of 1200-2500 mm rainfall.

Teak is a light-demanding species; it does not tolerate shade or suppression at any stage of its life and requires unimpeded overhead light for its proper development. Teak coppices and pollards vigorously and sometimes retain its coppicing potential even after attaining large size. Teak begins flowering and seeding at a young age, about 5-6 years and produces abundant seeds almost every year (Seth and Kaul 1978). The hard thick pericarp of the seed prevents easy germination and a considerable portion of fresh seeds remains dormant in the first year. Teak seeds remain viable for many years. The rotation period of teak is 50–60 years and 70–80 years in southern and central India, respectively.

Flowering phenological patterns are most diverse and least understood in the tropics (Corlett and Lafrankie 1998). Despite having increased priority on planting programmes and the importance of increasing fruit production in seed orchards, little research has been carried out on the clonal variation for reproductive biology of teak. The use of floral traits as a criterion while selecting the clones has made it essential to understand their genetic control. Hence, in order to achieve better genetic gain, it is imperative to assess variation and genetic control of the floral and fecundity traits in an orchard. The present study was carried out in a 33-year old clonal seed orchard to examine the variation in phenology and reproductive biology among different teak clones.

MATERIALS AND METHODS

The study was based on observations in 13 different clones of teak, derived from two distinct provenances and planted in Latin Square Design with a spacing of 4m× 4m. The location of the CSO is at Silvicultural Research Station, Kosala, Angul of the State Forest Department, Odisha (21° 01' 17.8" N latitude and 84° 55'19.6" E longitude). There were thirteen clones of Teak as treatments with 13 replications. The clones were collected from thirteen plus trees of Purunakote and Raigoda provenances of Odisha.

The observations were recorded on phonological events, seed characteristics, phenotypic coefficient of variation, genotypic coefficient of variation, heritability and genetic advance of different parameters studied. The phenology of different clones was recorded in terms of time of peak leaf shedding, time of peak leaf renewal, time of peak flowering, time of peak fruiting and time of fruit fall. The weeks of these events was taken into account when more than 80% of particular phonological character occurred. The production of flowers was recorded as number of flowers per inflorescence. Photographs of three inflorescences per tree were taken with camera of high resolution and number of flowers was counted from the photographs. The production of fruits was recorded as number of fruits per inflorescence and number of fruits per tree. High resolution photographs of three inflorescences per tree were used to count the number of fruits. The data were analyzed as per the procedure described for LSD and DMRT (Duncan Multiple Range Test).

The phenotypic coefficient of variation (PCV) was calculated by using the formula given by Singh and Chaudhary (1985),

$$PCV = (\sigma_p / \bar{\chi}) \times 100$$

where, σ_p = phenotypic standard deviation and $\bar{\chi}$ = grand mean of the trait.

The genotypic coefficient of variation (GCV) was calculated by using the formula given by Singh and Chaudhary (1985),

$$GCV = (\sigma_g / \bar{\chi}) \times 100$$

where, σ_g = genotypic standard deviation.

The heritability in the broad sense (H^2) was estimated by using the formula prescribed by Allard (1999)

$$\text{Heritability (\%)} = (\sigma^2 g / \sigma^2 p) \times 100$$

where, $\sigma^2 g$ = genotypic variance, $\sigma^2 p$ = phenotypic variance, $\sigma^2 g$= (MSG - MSE /r), $\sigma^2 p$= (MSG /r) and MSG, MSE and *r* are the mean squares of genotypes, mean squares of error and the number of replication, respectively.

Genetic advance percentage was calculated by using the formula proposed by Shukla et al. (2006)

$$GA (\%) = (GA / \bar{\chi}) \times 100$$

where, GA = genetic advance ($i\sigma_p H^2$) and

$\bar{\chi}$ = grand mean of the trait.

where, i is the standardized selection differential, a constant (2.06), σ_p is the phenotypic standard deviation and H^2 is the heritability

RESULTS AND DISCUSSION

The peak period of leaf shedding occurred during January although it varied from the first week to last week in different clones (Table 1). The clones such as ORANP3, ORANP4, ORANP7 and ORANR2 shed their leaves comparatively earlier i.e. during 1st week to 3rd week of January. The other clones shed their leaves in the second half of January. Similar findings have been reported by Gunanga and Vasudeva (2002a) and Kumar et al. (1993). Tewari (1999) and Luna (2005) have also mentioned that teak trees in India generally shed their leaves during November to January depending upon the locality. Early shedding of leaves in some clones may be due to their genetic characters which govern for early cessation of physiological activities with the approach of cold season.

Table 1. Phenology of different Teak clones indicating time of peak activity

Clones	Leaf Shedding	Leaf Renewal	Flowering	Fruiting	Fruit Fall
ORANP1	January 3rd –last wk	May 2nd–3rd wk	August 2nd–3rd wk	September last wk –October 1st wk	January 3rd–last wk
ORANP2	January 3rd –last wk	May 3rd –last wk	August 2nd–3rd wk	September 3rd–last wk	December last wk– January 1st wk
ORANP3	January 2nd –3rd wk	May 1st–2nd wk	July 1st–2nd wk	September 1st–2nd wk	3rd–last wk of December
ORANP4	January 1st –2nd wk	May 1st–2nd wk	July 1st–2nd wk	September 1st–2nd wk	3rd–last wk of December
ORANP5	January 3rd–last wk	May 3rd–last wk	August 2nd–3rd wk	September 3rd–last wk	December last wk – January 1st wk
ORANP6	January 3rd–last wk	May 3rd–last wk	August 2nd–3rd wk	September last wk –October 1st wk	January 2nd–3rd wk
ORANP7	January 1st–2nd wk	May 1st –2nd wk	July 1st–2nd wk	September 3rd–last wk	January 1st–2nd wk
ORANR1	January 3rd–last wk	May 3rd–last wk	August 2nd–3rd wk	September last wk –October 1st wk	January 1st–2nd wk
ORANR2	January 1st–2nd wk	May 1st–2nd wk	July 1st–2nd wk	August last wk–September 1st wk	December 1st–2nd wk
ORANR3	January 3rd–last wk	May 2nd–3rd wk	July last wk–August 1st wk	September 1st–2nd wk	January 3rd–last wk
ORANR4	January 3rd–last wk	May 2nd–3rd wk	July last wk–August 1st wk	September 3rd–last wk	January 3rd–last wk
ORANR5	January 2nd–3rd wk	May 2nd–3rd wk	August 2nd–3rd wk	September last wk–October 1st wk	January 1st–2nd wk
ORANR6	January 3rd–last wk	May 3rd–last wk	July last wk–August 1st wk	August last wk–September 1st wk	January 1st2nd wk

The time of renewal of major quantity of leaves was noticed in month of May for all the clones (Table 1). However, it varied from 1st week of May to last week of May. ORANP3, ORANP4, ORANP7 and ORANR2 put forth their new leaves in 2nd week of May, whereas, ORANP1, ORANR3, ORANR4 and ORANR5 renewed major leaves in the 3rd week of May.

The rest of the clones renewed their most of the leaves in last week of May. The variation in time of leaf renewal may be attributed to their genetic characteristics which govern the initiation of vegetative buds after rise of temperature with the advent of summer monsoon.

The time of peak flowering varied between 1st week of July to 3rd week of August among different clones of Teak. The observations are in line with those of Gunaga and Vasudeva (2002a and 2002b). This may be primarily due to the variation in genetic characters of different clones governing flowering. The clones such as ORANP3, ORANP4, ORANP7 and ORANR2 exhibited early flowering in comparison to other clones. ORANP1, ORANP2, ORANP5, ORANP6, ORANR1 and ORABR5 were found to produce their flowers comparatively late (2nd and 3rd week of August). Gunanga and Vasudeva (2002b) has mentioned that initiation of flowering, peak flowering and fruiting is controlled by genetic factors where as duration of these events is influenced by environmental factors. Palupi and Owens (1996) have also reported variation in flowering time in different Teak clones in East Java, Indonesia.

The information depicted in Table 1 evinced that formation of major fruits take place during first week of September and first week of October. ORANR2 and ORANR6 formed the fruits in first week of September which was earlier to other clones. ORANP3, ORANP4 and ORANR3 completed their major fruiting during second week of September whereas; ORANP2, ORANP5, ORANP7 and ORANR4 completed maximum fruiting in the last week of September. The rest of the clones formed their major fruits in the first week of October. Variation in fruiting time of different clones of Teak have also been reported by Palupi and Owens (1996), Gunanga and Vasudeva (2002a and 2002b).

Many authors have reported genetic variation for flowering, fruiting and their influence on fruit production in other tree species such as Nagarajan et al. (1998) on *Tamarindus indica*, Zhang et al. (1984) on *Pinus koraiensis* and Yazdani et al. (1998) on *Pinus sylvestris*.

The time of peak fruit fall varied from 2nd week of December to 2nd week of January. ORANR2 was noticed to drop its fruit earlier (1st and 2nd week of December) while ORANP1 dropped its fruits in 3rd and last week of January. The other clones found to drop their maximum fruits in between the above two clones. The fruits which were matured earlier, thus dropped earlier. This may be primarily due to the genetic characters of the clones which govern early flowering, fruiting and maturity of fruits.

The scrutiny of data in Table 2 on the number of flowers per inflorescence indicates significant variation in number of flowers produced by different clones. It ranged from 3030-5230 which is somewhat close to the figure reported by Mohandas et al. (2002) in Kerala, India. The highest number of flowers was produced by ORANP3 and lowest number by ORANR5 which may be ascribed to their different level of genetic potential with regard to flower production. The performance of flower production per inflorescence was in the order of ORANP3 > ORANP4 > ORANR3 > ORANP7 > ORANP2 > ORANP1 > ORANR2 > ORANP6 > ORANR6 > ORANP5 > ORANR1 > ORANR4 > ORANR5. This may be due to their variation in genetic potential to produce flowers.

Table 2 Production of flowers and fruits in different Teak clones

Clones	Number of flowers per inflorescence	Number of fruits per inflorescence	Number of fruits peer tree
ORANP1	3940[e]	70[g]	278[g]
ORANP2	4134[d]	40[j]	402[de]
ORANP3	5230[a]	62[h]	528[ab]
ORANP4	4960[b]	175[a]	563[a]
ORANP5	3150[gfh]	51[i]	444[cd]
ORANP6	3224[gf]	73[fg]	320[fg]
ORANP7	4814[c]	130[b]	570[a]
ORANR1	3110[gh]	43[j]	350[ef]
ORANR2	3274[f]	90[c]	482[bc]
ORANR3	4920[bc]	81[de]	434[cd]
ORANR4	3074[h]	75[efg]	486[bc]
ORANR5	3030[h]	80[def]	364[ef]
ORANR6	3160[gfh]	83[d]	487[bc]
$SE_{(m)}$	44.80	2.43	18.91

*Means with the same letter are not significantly different.

Significant variation was observed in the number of fruits per inflorescence among different clones which ranged from 40-175. ORANP4 occupied the top position whereas ORANP2 occupied the bottom position. The range of fruit production per inflorescence is in line with the findings of Palupi and Owens (1998). The significant variation in fruiting may be attributed to variation in genetic characters that influence fruit set. It is evident from the genetic attributes such as high phenotypic coefficient of variation (26.80), genotypic coefficient of variation (25.91), heritability (98.67) and genetic advance (53.01) shown in Table 3.

The number of fruits per tree exhibited significant differences among various clones of Teak. It ranged from 278-570. The quantity of fruits produced is in line with Verghese et al. (2006). The variation in number of fruits per tree may be due to the variation in genetic characteristics of different clones investigated to produce fruits. The number of fruits per tree were in the order ORANP7 > ORANP4 > ORANP3 > ORANR6 > ORANR4 > ORANR2 > ORANP5 > ORANR3 > ORANP2 > ORANR5 > ORANR1 > ORANP6 > ORANP1. The performance of ORANP4 and ORANP7 was statistically at par with each other. The better performance of ORANP4 and ORANP7 may be ascribed due to superior genetic makeup with regard to fruit set and relatively early flowering of these clones (Table 3) which might have helped higher fruit set because of less intensity of rainfall which causes flower drop.

CONCLUSION

The variation in phonological events, flower and fruit production were significant among 13 different clones of teak. This is mainly because of their genetic characters which govern the period of occurrence of phonological events and flower and fruit production. Further, the high heritability and moderate genetic advance values for number of flowers and fruits indicate the inherent potential of these traits for producing superior genotypes. These characters should be given priority in any tree breeding and improvement work for maximizing the productivity of teak.

Table 3. Genetic attributes of different aspects

Traits	PCV (%)	GCV (%)	Heritability (%)	Genetic Advance (%)
No. of flowers per inflorescence	12.88	12.82	99.18	26.31
No. of fruits per inflorescence	26.08	25.91	98.67	53.01
No. of fruits per tree	12.72	11.97	88.53	23.2

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