Tree to tree variation in reproductive phenology in Indian sandalwood (*Santalum album* Linn)

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ABSTRACT

In the present study, reproductive phenology of 15 individuals of Indian sandalwood (*Santalum album*) was carried out at the campus of Forest Training Institute, Gungaragatti, Dharwad, Karnataka. Results showed that there was tree to tree variation for time of flowering and fruiting in Indian sandalwood. Marked individuals showed two peak flowerings in a year viz first peak during Jun-Aug and second during Dec-Jan. Among 15 individuals, one tree showed peak flowering in Sept and Nov. Fruiting phenology showed that all individuals fruited during Aug to May except during Jun to Jul. Peak fruiting period for seed collection was between Apr to May and Oct to Nov.

Keywords: Flowering synchrony; reproductive phenology; sandalwood; tree variation

INTRODUCTION

Indian sandalwood (*Santalum album* L, Santalaceae) is one of the high traded medicinal tree species of India having ecological and conservation value. It is a hemi-root parasite and requires suitable host plants for its successful regeneration and establishment (Rai 1990). The global distribution of the sandal family is between 30° North and 40° South from Indonesia in west to Juan Fernandez Island in the north to New Zealand in the south. These species are mainly found in India, Indonesia, Australia, Timor, Hawaii etc (Subasinghe 2013). Sandalwood trees are found in southern tropical dry deciduous forests of India (sub types $5A/C_2$ and $5A/C_3$) ie from south (Karnataka, Tamil Nadu and Kerala) to other parts of the country viz Andhra Pradesh, Maharashtra, Madhya Pradesh, Orissa, Rajasthan, Uttar Pradesh, Bihar, Gujarat and Manipur (Luna 1996).

Sandal is prized for its aroma in the heartwood and the wood is used for carving which fetches good price in the national and international markets. Sandalwood oil is used in perfumes, cosmetics, aromatherapy and pharmaceuticals (Ambasta 1986), therefore, great demand for heartwood of sandalwood. Farmers from different parts of the country are already cultivating this species on their farmlands in blocks or agroforest plantations.

Sandalwood improvement programme has already been initiated in the country to improve the quality and quantity of wood biomass and oil content (Radomiljac et al 1998). For breeding tree species, knowledge of reproductive biology including phenology is very essential that eventually helps in production of quality germplasm for large scale seedling production and plantation programme (Zobel and Talbert 1984). Therefore, this study was undertaken to understand the pattern of flowering and fruiting phenology in sandalwood.

MATERIAL and METHODS

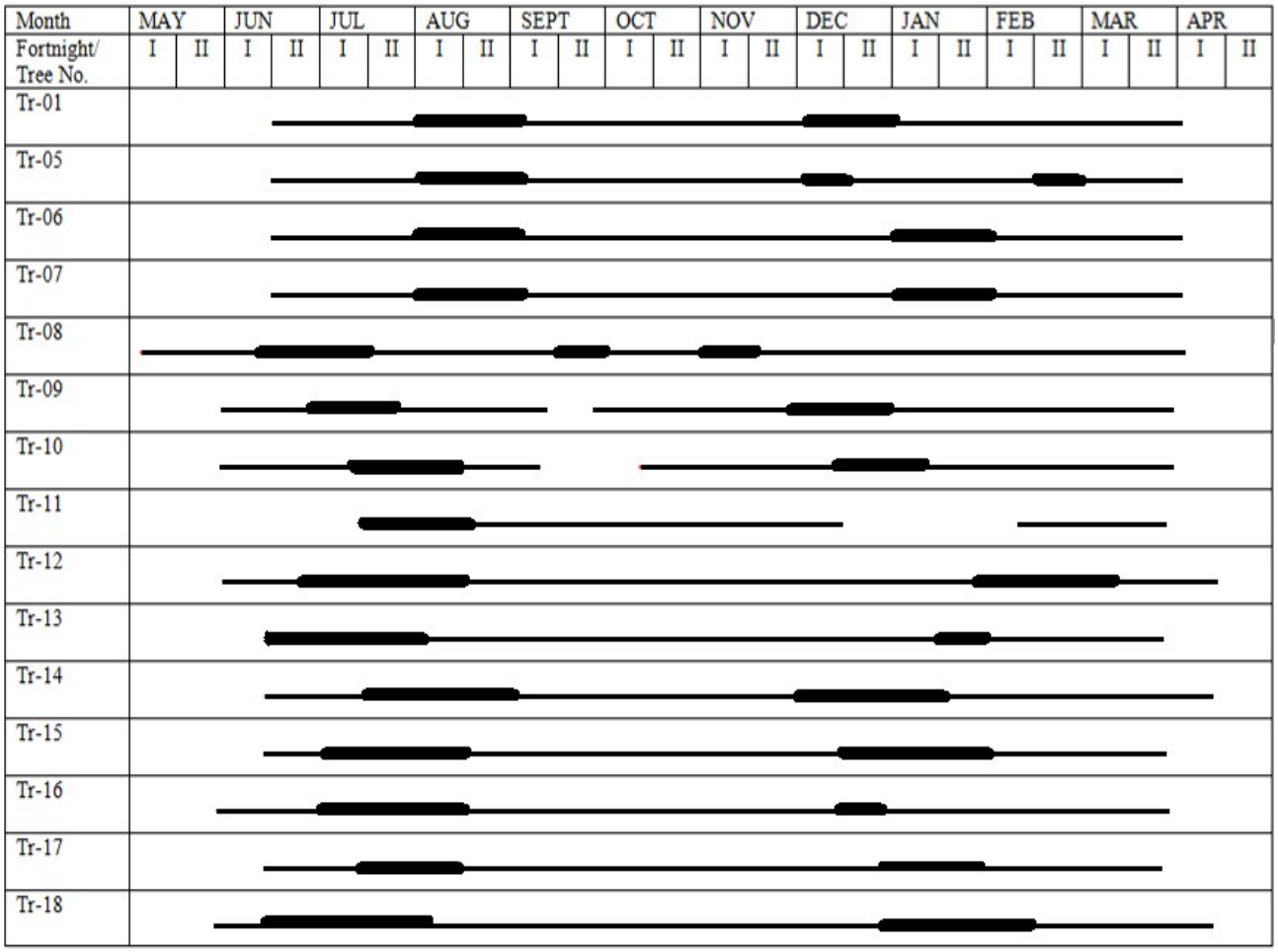
This study was carried out at the campus of Forest Training Institute, Gungaragatti, Dharwad, Karnataka. Sandalwood is naturalized in the campus and adjoining areas. Several bird species visit the sandalwood trees hence, the natural regeneration of

sandalwood is found to be medium to abundant under tree plantation, bamboo plantation, medicinal plants garden and natural forests within the campus (Hanumantha et al 2012). Phenological variation was initially observed among trees in sandalwood at the campus. Therefore, detailed study was undertaken by selecting 15 trees distributed in the research plot of sandalwood to record the reproductive phenological pattern during 2010-11. Trees were visited at fortnightly intervals and methodology was followed as per Gunaga and Ramesh (2002a, 2002b).

RESULTS and DISCUSSION

Tree to tree variation for time of flowering and fruiting was recorded in the study (Figs 1, 2). All the marked trees flowered during Jan to Mar. Many marked individuals showed peak flowering (>70% of crown bloomed) twice in a year, the first during Jul-Aug and the second during Dec-Jan as shown in Fig 1. One of the individuals showed peak flowering during Sept and Nov (Tr-08). Tree bearing number Tr-05 showed peak flowering thrice in a year (Aug, Dec and end of Feb) followed by Tr-08. However, in Tr-12, second peak flowering occurred during Feb-Mar. The similar pattern of variation was also recorded for fruiting phenology. Continuous fruiting except during Jun-Jul, was observed in the sandalwood as presented in Fig 2. Peak fruit collection period would be Apr-May and Sept-Oct for large scale propagation of seedlings in the nursery.

Knowledge of breeding system and patterns of gene flow among forest trees are more informative for planning of seed collection as well as designing and managing seed orchards to maintain genetic diversity of breeding population (Zobel and Talbert 1984). The reproductive phenology also plays a vital role for incorporating diverse clones while establishing seed orchard to avoid asynchronous flowering and to

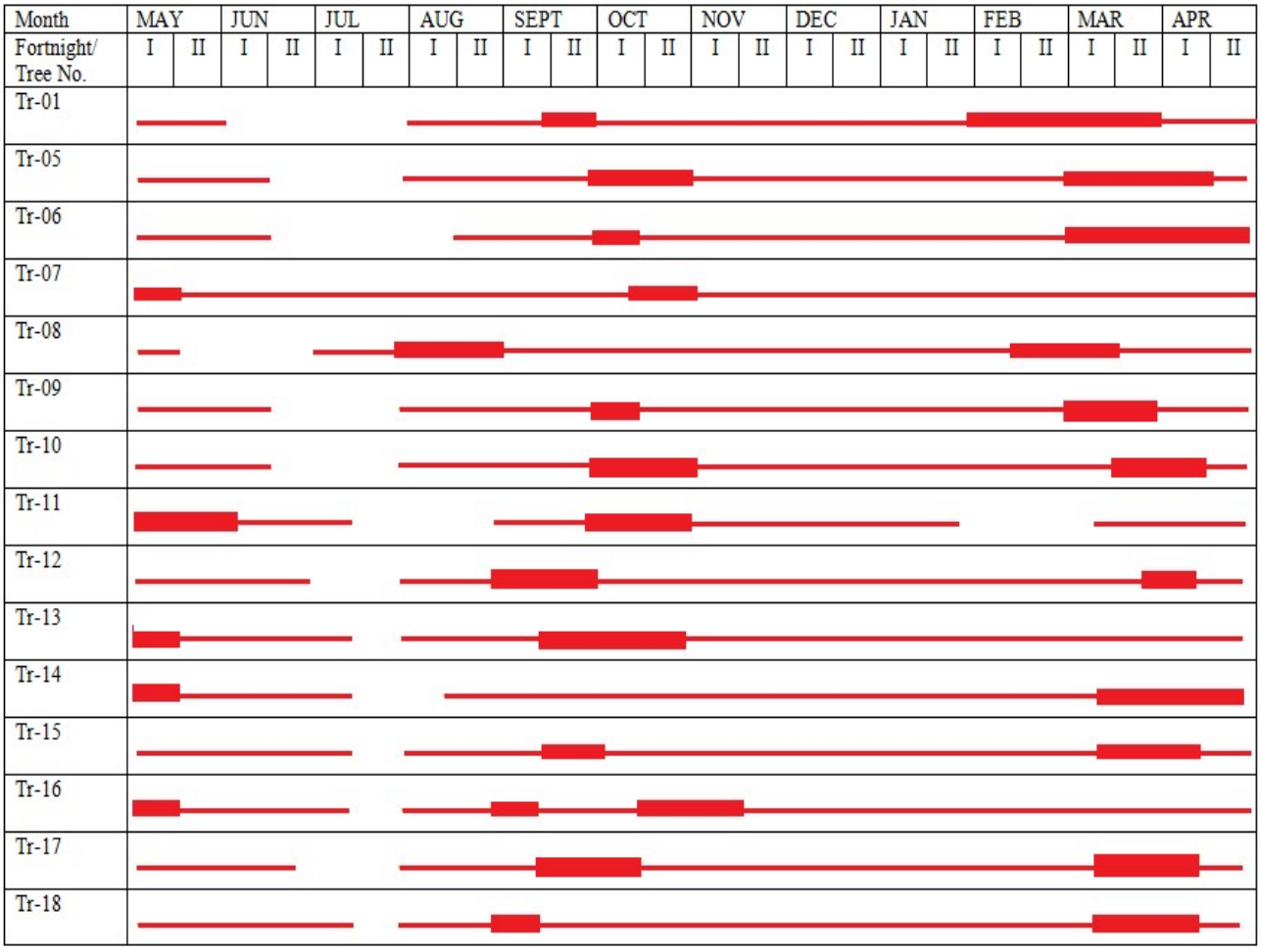


Thin line indicating period of flowering; Thick line indicating peak flowering period

Fig 1. Variation in flowering phenology among 15 trees of sandal

improve the quality and quantity of seed output in the clonal orchard (Nagarajan et al 1998, Gunaga and Ramesh 2002a).

The present study showed the different patterns of phenology in terms of flowering and fruiting in sandalwood. In general, two peak flowerings were recorded and such observation was also reported in sandalwood (Kulkarni and Muniyamma 1998, Annapurna et al 2005, Ratnaningrum and Indrioko 2015, Krishnakumar and Parthiban 2017). Patterns of flowering within a site or provenance would be attributed by genotypes, however, time of flowering is mainly influenced by genotype, temperature and photoperiod (Iannucci et al 2008, Ramesh and Gunaga 2012). In sandalwood, annual climatic conditions like temperature and rainfall alter the flowering behaviour, maturity of sexual organs, fruit set, seed quality and yield (Annapurna et al 2005, Ratnaningrum and Indrioko 2015). Kulkarni and Muniyamma (1998) documented the reproductive cycle in sandalwood where period required from bud initiation to fruit ripening was recorded to be 110-140 days. Fig 1 determines the asynchronous flowering pattern among 15 individuals and such pattern was also reported by Kulkarni and Muniyamma (1998) in sandalwood where asynchronous flowering and duration required for completion of blooming for each inflorescence varied among genotypes. They also noticed that one of the studied trees flowered throughout the year and yielded maximum seed output than other morphotypes. In this study, accession Tr 07 fruited almost throughout the year and peaks were achieved twice – first during early May and another during late October. From ecological point of view, it can be said that presence of such individuals in the ecosystem may be useful for birds (Hanumantha et al 2012) and/or bees (Tamla et al 2012) that visit sandalwood for their food.



Thin line indicating period of fruiting; Thick line indicating peak fruiting period

Fig 2. Variation in fruiting phenology among 15 trees of sandal

CONCLUSION

The tree to tree variation for flowering and fruiting phenology was observed. Trees produce fruits throughout the season that helps birds for their food. Moreover, two peak fruitings were recorded which would be useful in large scale seedling production in the nursery. Study implies that before establishment of CSO, the reproductive phenology of selected genotypes (plus trees or clones) must be known while incorporating clones from local or distance geographic regions into CSO in order to match the flowering synchrony among clones for production of quality seeds in large quantity.

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REFERENCES

Ambasta SP 1986. The useful plants of India. Publications and Information Directorate, CSIR, New Delhi, India, 918p.

Annapurna D, Rathore TS and Somashekhar PV 2005. Impact of clones in a clonal seed orchard on the variation of seed traits, germination and seedling growth in *Santalum album* L. Silvae Genetica **54(4-5):** 153-160.

Gunaga RP and Ramesh V 2002a. Variation in flowering phenology in a clonal seed orchard of teak. Journal of Tree Sciences **21(1-2):** 1-10.

Gunaga RP and Ramesh V 2002b. Genetic variation for fruiting phenology among teak clones of different provenances of Karnataka. Indian Journal of Forestry **25(2):** 215-220.

Hanumantha M, Gunaga RP, Patil RS, Nagaraja and Biradar SS 2012. Natural regeneration in *Santalum album* Linn: a case study from campus of Forest Training Institute, Gungargatti, Dharwad, Karnataka. Indian Forester **138(4):** 386-389.

Iannucci A, Terribile MR and Martiniello P 2008. Effects of temperature and photoperiod on flowering time of forage legumes in a Mediterranean environment. Field Crops Research **106(2):** 156-162.

Krishnakumar N and Parthiban KT 2017. Flowering phenology and seed production of *Santalum album* L. International Journal of Current Microbiology and Applied Sciences **6(5):** 963-974.

Kulkarni HD and Muniyamma M 1998. Floral biology and breeding systems in sandal, *Santalum album* L. In: Sandal and its products (AM Radomiljac, HS Ananthapadmanabho, RM Welbourn and K Satyanarayana Rao, eds), Proceedings of International Seminar, 18-19 December 1997, Organized by Institute of Wood Science and Technology (ICFRE) and Karnataka State Forest Department, Bangalore, Karnataka, lndia, Australian Centre for International Agricultural Research, Canberra, Australia.

Luna RK 1996. Plantation trees. International Book Distributors, Dehradun, Uttarakhand, India.

Nagarajan B, Nicodemus AK, Mandal AK, Verma RK, Gireesan K and Mahadevan NP 1998. Phenology and controlled pollination studies in tamarind. Silvae Genetica **47(5-6):** 237-241.

Radomiljac AM, Ananthapadmanabho HS, Welbourn RM and Rao KS 1998. Sandal and its products. Proceedings of International Seminar, 18-19 December 1997, Organized by Institute of Wood Science and Technology (ICFRE) and Karnataka State Forest Department, Bangalore, Karnataka, lndia, Australian Centre for International Agricultural Research, Canberra, Australia.

Rai SN 1990. Status and cultivation of Sandalwood in India. In: Proceedings of the Symposium on Sandalwood in the Pacific, 9-11 April 1990, Honolulu, Hawaii, General Technical Report, PSW-GTR-122, Berkeley, CA, Pacific Southwest Research Station, Forest Service, US Department of Agriculture, pp 66-71.

Ramesh V and Gunaga R 2012. Flowering phenology in teak seed orchards: genetic variation, measurement and implications to seed orchard fertility. In: Phenology and climate change (X Zhang, ed), IntechOpen, pp 179-192.

Ratnaningrum YWN and Indrioko S 2015. Response of flowering and seed production of sandalwood (*Santalum album* Linn, Santalaceae) to climate changes. Procedia Environmental Sciences **28:** 665-675.

Subasinghe SMCUP 2013. Sandalwood research: a global perspective. Journal of Tropical Forestry and Environment **3(1):** 1-8.

Tamla HT, Cornelius JP and Page T 2012. Reproductive biology of three commercially valuable *Santalum* species: development of flowers and inflorescences, breeding systems and interspecific crossability. Euphytica **184(3):** 323-333.

Zobel BJ and Talbert J 1984. Applied forest tree improvement. John Wiley, New York.