Indian Sandalwood Crisis

While exploitation threatens Indian sandalwood, a plea for conservation and regeneration resounds

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For thousands of years now, the sandalwood tree has been a source of pride for India. Sandal (*Santalum album* L.), one of the most economically important forest trees harvested for its heartwood oil, forms an important component of the total foreign exchange earned in the country. The tree is generally known as the "dollar earning parasite" and its wood is commercially known as "East Indian sandalwood," whereas its fragrant oil is called the "queen of essential oil" (**F-1**).[1] Owing to its wide use in both Hindu and Buddhist religious ceremonies, in ayurvedic medicine and perfumery, and in the wake of increasing world demand for its oil, it has more prospects of trade than what is being realized currently in the country.[2]

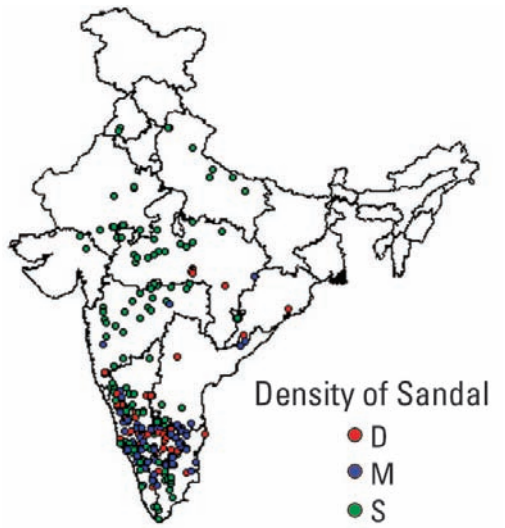
Sandal (*Santalum album* L.) tree in its natural habitat **F-1**

Distribution: The distribution of the tree spans 30ϒN to 40ϒS from Indonesia in the West to Jaun Fernandez Islands in the East and from Hawaiian Archipelago in the North to New Zealand in the South.[3] In India, although the tree is distributed rather widely, the populations are geographically more concentrated in South India covering parts of Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu and Kerala. The state of Karnataka itself accounts for more than 70% of the area. The occurrence of sandalwood is also recorded in Northern (Uttar Pradesh) and Central (Madhya Pradesh, Orissa) parts of India; however, their distribution is very sparse (**F-2**).[4]

Chemistry and uses: Seeds of all members of Santalaceae possess santalbic acid, which is a characteristic feature of the family.[5] Sandalwood seeds are used in treatment of diuretic hypotensive, antitremorogenic and antiviral activities, in addition to a number of skin diseases.[6,7] Sandalwood bark extract is a chemosterilant and an insect growth inhibitor.[8] Both wood and oil of the sandalwood tree are used in incenses, perfumes and medicines and have great commercial importance. Heartwood of sandalwood is astringent, bitter, antipyretic and a cooling agent. Being closely grained and amenable to carving, sandalwood is one of the finest woods for this purpose. It is used for making idols, boxes and other curios of exquisite beauty. About 5% of wood produced annually is used in carving idols and other utility articles. Some important centers in South India for carving are Ankola, Bangalore, Honnavar, Kumta, Mysore, Sagar, Sirsi, Talagoppa (in Karnataka), Tirupati in (Andhra Pradesh), Thiruvananthapuram (in Kerala) and some places in Tamil Nadu.[3] However, most of these centers have ceased to function because of nonavailability of sandalwood.[9] The fixative properties and tenacious aroma of sandalwood oil is due to its major odoriferous sesquiterpenic constituents, α- and β-santalols.[10] The highly purified sandalwood oil is used with other perfumery materials and has also earned a prominent place in the incense, cosmetic, fragrance and soap industries.

Heartwood and oil: It is believed that the finest odor and higher oil is yielded from the wood grown in the driest region, particularly on red or stony ground.[11–14] The tree attains commercial maturity at 27–30 years and at this period the heartwood is well developed at a depth of 5 cm below the surface.[15] It has been observed that trees extracted from open fields or edges of a plantation yield more heartwood than those of comparative size extracted from adjoining forests.[16,17] Studies inferred that the formation of heartwood, growth and development are influenced by the host.[18] The heartwood formation may be dependent on general factors of the individual tree and the phenotypic factors may play only a secondary role.[3] The age of a sandalwood tree and color of its heartwood may also influence the quality and content of sandalwood oil.[19,20] Heartwood from young trees (around 10 years of age) contains 0.2–2% of oil and that from mature trees (around 30–50 years of age) contains 2.8–5.6% of oil. Sandalwood oil content markedly decreases along the length of the tree (root: 3.5–6.3%; stem: 3–5%; branches: 1–3%). Generally, there is a decrease of about 45% in oil content from root to tip and about 20% from core to periphery.[21]

Distribution of sandal (*Santalum album* L.) in India[1,4] **F-2**



D = dense; M = medium; S = sparse

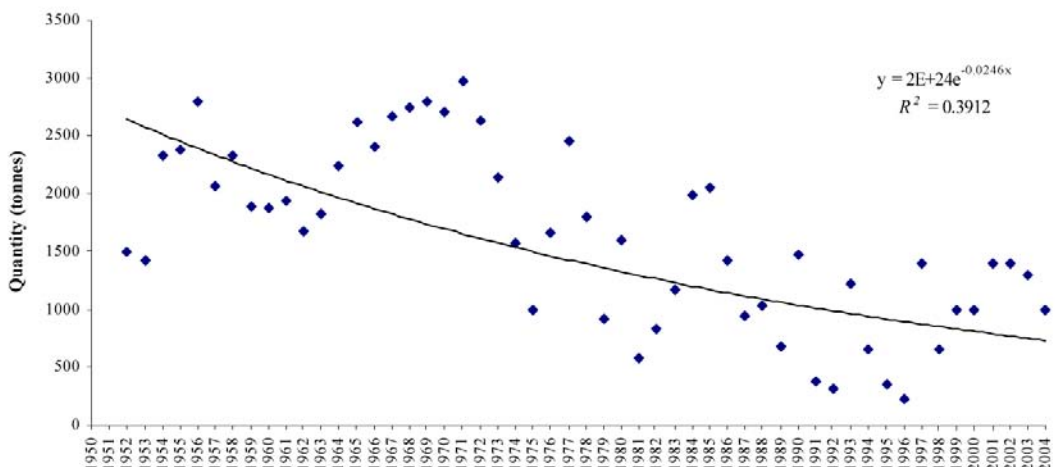
Market demand: Sandalwood and oil have had a good market in the United Kingdom, Europe, the United States, Japan and Arab countries since 1882.[22] The worldwide demand for sandalwood is estimated to be about 4,000 tonnes/annum.[9] It is roughly estimated that wood extracted from both Mysore (in the Karnataka state) and Madras forests (in the Tamil Nadu state) amounts to around 3,000 tonnes a year.[3] About one tonne of good wood, on distillation, yields 50 kg of sandalwood oil.[23] Around 150 tonnes a year of oil is extracted and values exceeding Rs 2,000,000,000. Mysore alone supplies nearly 70–80% of the sandalwood oil.[24] Extensive studies have indicated that *S. album* is the only species yielding high quality sandalwood oil. A few other species of *Santalum* and four genera also yield fairly scented wood oil but these are not comparable to either the wood or oil of *S. album*.[3]

Substitutes for sandalwood oil: The international market demand caused by shortage due to sporadic supply has led researchers to develop and use cheaper substitutes that are low cost, easily available and commercially feasible. Australian sandalwood oil, African sandalwood oil, West Indian sandalwood oil, *S. yasi* oil and a host of synthetic sandalwood aroma chemicals have been used as substitutes for sandalwood oil. Some commercially available synthetic sandalwood aroma chemicals are Sandela, Santalydol, Osyrol and decahydrobetanapthyl formate. However, none of them is a perfect analogue to the natural oil of *S. album* in its sweet, fragrant, persistent, spicy, warm and woody note. These synthetics only serve as partial replacements for sandalwood.[3]

The Exploitation of Sandalwood

In India, sandalwood has been a nationally protected resource since the time of Tippu Sultan (1792), the former King of Mysore state (present day Karnataka state). The monopoly on the cultivation and extraction of sandalwood by the monarchy has been followed by successive rulers and has been carried on even after the country's independence. Sandalwood is a "Forest Produce" under Sec. 2(7)-a of the Karnataka Forest Department, therefore the control of sandalwood in transit is vested in the state government.[25] The nature of prevalent laws related to sandalwood in Karnataka has affected the natural regeneration of sandalwood trees. According to present laws, the person on whose premises the sandalwood tree is growing is held responsible for its maintenance as well as for the protection of that tree (Sec-85 of *The Karnataka Forest Act*, 1963). The penalties associated with the violation are imprisonment for up to seven years with a fine of Rs. 25,000.[25] Many people prefer to quietly uproot and destroy a sapling of sandalwood, if by chance it comes up on their premises, rather than becoming liable to the responsibilities and penalties associated with its protection and maintenance. Even if few trees are available in a private land, these are always under threat of either illicit

The decrease in the quantity of sandalwood extracted over the years (1950–2004)[1,4] **F-3**



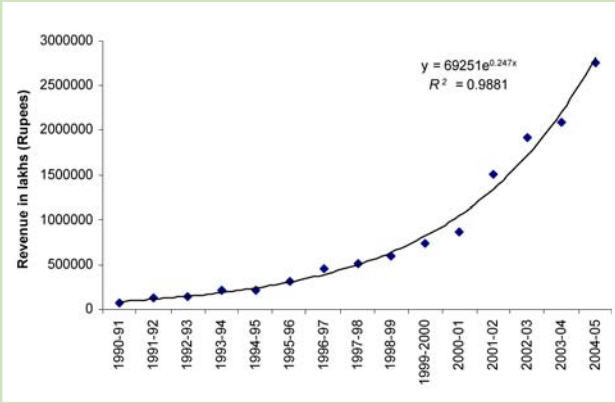
felling or smuggling leading to harassment of the owners by the state government. However, no such stringent laws have been levied in the neighboring states for sandalwood. The absence of uniform laws for sandalwood trade on one hand and ever-increasing demand for sandalwood and its products on the other has led to the exploitation of the available natural resources.[26]

Threats: Despite the protection status, the natural resources of sandalwood have been indiscriminately exploited due to its extremely high export value.[2,9,23,27–29] The harvesting has been more extensive since the latter half of the 19th century, after the beginning of large scale export of sandalwood and its oil. Systematic logging, poaching and major changes in land-use patterns have severely decimated the natural stocks and rendered many populations fragmented.[1] Immature trees have been recklessly cut down in their pristine natural habitats. Natural regeneration in most of the population is poor due to both biotic and abiotic interferences.[3] All of this has led to a significant decline in the sandalwood resources in the state of Karnataka (**F-3**).

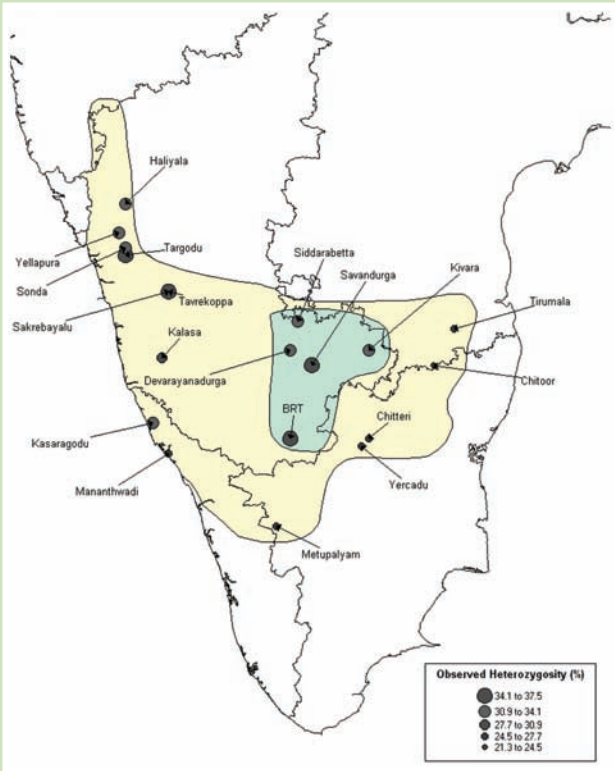
Data collated over the last 53 years suggest that there has been ~80% decline in the quantity of sandalwood extracted from the state of Karnataka.[1] Between 1952 and 1973, the average annual extraction of sandalwood was approximately 2,276 tonnes, while during the period 1974–2004, the quantity extracted decreased to 1,144 tonnes. These figures probably reflect the dwindling resource base of sandalwood. It is possible that this decline in extraction has led to an increase in the value of sandalwood from Rs. 100,000/tonne in 1990 to Rs. 2,700,000/tonne in 2005 (**F-4**). Apart from extraction in natural areas, illicit felling and smuggling has been another major threat to the trees. Between 1980 and 1997, about 100–500 tonnes of sandalwood were recovered annually, amounting to about 30% of the state's revenue from sandalwood.[4,9] But this is just the tip of the iceberg, as estimates show that the recovery might be just about 10–20% of the sandalwood illicitly felled. The decline in extraction is also mirrored in the reduction of the quantity of sandalwood supplied to the sandalwood-based industries. For instance, the sandalwood oil factories at Shimoga and Mysore (in the state of Karnataka), which require at least 2,000 tonnes of heartwood per annum, have been facing acute shortage of billets. In fact, the factory at Shimoga closed down for lack of raw materials.[2] The traditional craftsmen are those most negatively affected by the shortage; not only are they losing their inherited sources of income, but also the skills associated with the craft, which is forcing them to seek nontraditional occupations.[7,27,28]

Genetic diversity loss: While the above concerns are quite disturbing, a far more important, but less realized, problem is the loss of the precious genetic resources of sandalwood. Valuable germplasm of sandalwood that have evolved over millions of years are being obliterated recklessly, thus destroying any possibility of using them in the future. Besides this, the loss could also stop the efforts in genetically improving the sandalwood trees for their heartwood and oil content. It is unfortunate that there are only a few national level plans to attend to the conservation and management of sandalwood genetic resources of the country. The lack of basic information on the extent of natural genetic variability of sandalwood populations has been a major handicap in formulating conservation plans. Generating genetic diversity maps of economically important species, such as sandalwood, could lead to the identification of 'hotspots' of genetic variability, which can then be targeted for efficient conservation and sustainable utilization of these genetic resources.[1,4]

The increase in the value of the sandalwood over the years (1990–2005)[1,4] **F-4**

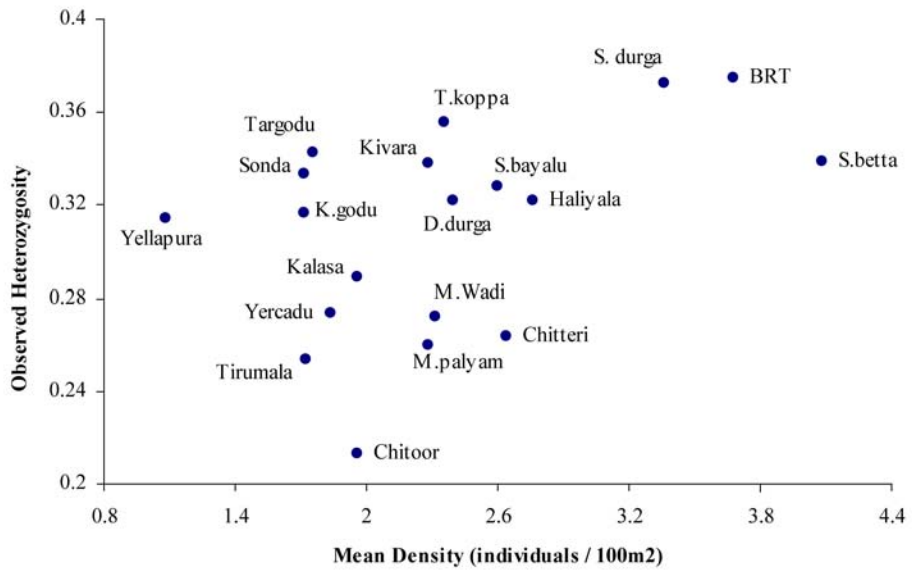


Genetic diversity map of sandal populations in South India[1,4] **F-5**



Populations circumscribed in the light aqua color zone in the map have high genetic conservation value

Relation between genetic diversity and the mean density of sandal populations ($p < 0.05$) in South India[1] **F-6**



Conservation Efforts

To develop genetic diversity maps, population genetic variability of 19 sandalwood populations over four southern states of India (Karnataka, Kerala, Tamil Nadu and Andhra Pradesh) were assessed using various basic metabolic enzymes.[1] The genetic diversity was found to be higher for populations in Karnataka as compared to other states in Southern India (**F-5**). Statistical analysis indicated a clear separation of the individual populations based on their geographic origin and suggested that the gene flow and mating opportunities might have been severely constrained. This study highlighted a strong positive correlation between lack of genetic diversity with poor population density (**F-6**). The loss in genetic diversity may lead to severe consequences, such as reduction in fitness of the population in terms of reduced reproductive performance, increased susceptibility to various pandemic diseases and to various environmental (biotic and abiotic) stresses that could eventually lead to local extinction of a species.[30–34] Such loss in genetic diversity could also halt the efforts in genetically improving the sandalwood trees for their heartwood and oil content.[4]

Tree regeneration, improvement and conservation efforts: Seeds are mainly used for natural regeneration and artificial propagation, even though the seedlings of sandalwood are extremely heterozygous due to outcrossing.[35] Many artificial methods of sandalwood propagation are in use, such as dibbling of seeds in bushes, sowing of seeds on the moulds, planting of container-raised seedlings and vegetative propagation through grafting, air layering and root suckers.[36,37] However, the production of clones is time consuming.[38] It is also recalcitrant to in vivo and in vitro propagation.[39] Tissue culture has also been used to achieve high frequency regeneration of sandalwood in vitro. Various explants such as hypocotyl, endosperm, nodal and internodal segments, protoplasts, zygotic embryo, leaves and nodal stem segments with dormant axillary buds have been used.[35,40–46] Sandalwood plants have been successfully micropropagated by in vivo methods using mature plants.[47] Synthetic seeds have also been developed in sandalwood that could be germinated in vivo.[48,49] However, the bottleneck is in vitro rooting, which limits the widespread application of micropropagation techniques in sandalwood.[35]

Several attempts have been made to address the conservation concerns related to sandalwood in South India. Studies suggested that sandalwood should be artificially regenerated in areas with no sandalwood growth or where the stock of sandalwood was very poor.[3] However, in such planting programs it might be necessary to obtain seeds from genetically superior populations for successful plantation and better plant productivity. Efforts have been made to establish ex situ conservation gardens of sandalwood at different sites in the country. Three clonal banks in South India have been established. Besides the clonal orchards, there have been efforts to establish a germplasm bank at Gottipura, in Karnataka. For the in situ conservation of sandalwood genetic resources and for the development of a "gene-base," eight sandalwood-bearing areas have been identified as potential provenances in the country.[50] These sites are being maintained and protected in collaboration with the respective forest divisions. While these studies have helped to initiate conservation planning for sandalwood in the country, they lack a genetic perspective primarily for want of information on the spatial distribution of genetic variability in the species.

The Way Forward

The genetic studies highlighted above represent one of the few efforts in India to map the genetic diversity of

sandalwood trees (see ***Genetic diversity loss***) and will be useful in drawing inferences to successfully conserve and improve the existing genetic resources of sandalwood in the country.[1,4] These maps will serve as a platform for researchers and may also be helpful in future studies to correlate the genetic diversity with desirable traits of good oil quality and high heartwood content. The valuable information generated from such studies will enable the natural resource policy makers and managers to make sound decisions on the best ways to effectively preserve the genetic resources. It will also help promote the intelligent use of genetic resources for the benefit of the environment, industry and to maintain cultural and religious sanctity in the areas where sandalwood thrives.

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References

1. M Nageswara Rao, KN Ganeshaiah and R Uma Shaanker, Assessing threats and mapping sandal (*Santalum album* L.) resources in peninsular India: Identification of genetic hot-spot for in-situ conservation, *Conservation Genet*, **8**, 925–935 (2007)

2. M Nageswara Rao, *Mapping genetic diversity of Sandal (*Santalum album *L.) genetic resources in peninsular India using biochemical and molecular markers: Lessons for in-situ conservation*, PhD thesis, Forest Research Institute (FRI), ICFRE, Dehra Dun, India (2004)

3. VV Sreenivasan, VR Shivaramakrishnana, CR Rangaswamy, HS Anathapadmanabha and KH Shankaranarayan, *Sandal*, ICFRE, Dehra Dun, India (1992)

4. M Nageswara Rao, KN Ganeshaiah and R Uma Shaanker, Mapping genetic diversity of sandal (*Santalum album* L.) in south India: Lessons for in-situ conservation of sandal genetic resources, In: *Forest Genetic Resources: Status, Threats and Conservation Strategies*, Eds, R Uma Shaanker, KN Ganeshaiah, KS Bawa, Oxford and IBH Publications, New Delhi 49–67 (2001)

5. HH Hatt and F Schoemfeld, Some seed fats of Santalaceae and Oleaceae, *Aust J Chem*, **12**,190 (1956)

6. VB Desai and KH Shankaranarayana, On the utilization aspects of sandal seed oil, *Res Industry*, **35**, 232–233 (1990)

7. KR Kirthikar and BD Basu, *Indian Medicinal Plants*, International Book Distributors, Dehra Dun (1987)

8. KH Shankaranarayana, VR Shivaramakrishnan, KS Ayyar and PK Sen, Isolation of a compound from the bark of sandal and it's activity against some lipidopterous and coleopterous insects, *J Entomol Res*, **3**, 116–118 (1979)

9. C Meera, M Nageswara Rao, KN Ganeshaiah, R Uma Shaanker and MH Swaminath, Conservation of sandal genetic resources in India: I. Extraction patterns and threats to sandal resources in Karnataka, *My Forest*, **36**(2), 125–132 (2000)

10. KH Shankaranarayana, G Ravikumar, AN Rajeevalochan, KS Theagarajan and CR Ramaswamy, Content and composition of oil from the central and transition zones, In: *Sandal and It's Products*, ACIAR Proceedings (84), Eds, AM Radomiljac, HS Aanathapadmanabha, RM Welbourn and K Satyanarayana Rao, Publication Australian Centre for International Agricultural Research, Canberra 86–88 (1998)

11. E Gunther, *The Essential Oils*, D. van Nostrand Comp. Inc., **5**, 173–194, London (1952)

12. SP Bhatnagar, *Studies in Angiospermic Parasites (No. 2)* Santalum album—*The sandalwood tree*. National Botanical Gardens, Lucknow, India (1965)

13. Gildemeister and Hoffman, *Die Atherischen Ole*, 3rd Vol.II. 50 B in Guenther (1952)

14. P Singh, Memorandum on the oil value of sandalwoods from Madras, *Forest Bull*, **6** (1911)

15. J Cameron, *Forest tress of Mysore and Coorg*. Mysore Govt Central Press, Bangalore (1894)

16. CC Wilson, Sandalwood (a) a parasite, (b) susceptibility to fire, (c) damage by borers, (d) spike disease, *Science*, **188**,1081–1021 (1915)

17. JFM Mitchell, *Sandalwood problems, factors affecting heartwood and oil content in sandalwood*, Proc 5th Silvi Conf, Dehra Dun (1941)

18. MR Rao, Host plants of the sandal tree, *Indian Forest Records*, **2**(4), 159–207 (1911)

19. KH Shankaranarayana and K Parthasarathi, Compositional differences in sandal oils from young and mature trees and in oils undergoing color change on standing, *Indian-Perfum Kanpur: Essential Oil Association of India*, **28**, 138–141 (1984)

20. KH Shankaranarayana and KR Venkatesan, Chemical aspects of sandalwood oil, In: *Cultivation and Utilization of Aromatic Plants*, CK Atakal and RPL Kapoor, (CSIR), Jammu 406–411 (1982)

21. KH Shankaranarayana and K Parthasarathi, On the content and composition of oil from heartwood at different levels in sandal, *Indian-Perfum Kanpur: Essential Oil Association of India*, **31**, 211–214 (1987).

22. AM Chandrashekharaiah, Sandal tree, *My Forest*, **8**, 21–25 (1971)

23. HS Ananthapadmanabha, Sandalwood and its marketing trend, *My Forest*, **36**, 147–151 (2000)

24. NS Kaikini, The Indian sandal wood, *My Forest*, 25–40 (1969)

25. KA Kushalappa, Trade liberalization in sandalwood, *Indian Forester*, **125**(9), 891–894 (1999)

26. M Nageswara Rao, KN Ganeshaiah and R Uma Shaanker, Fading fragrance?, *Deccan Herald*, May 6, 2008

27. M Nageswara Rao, S Padmini, KN Ganeshaiah and R Uma Shaanker, Sandal genetic resources of South India: Threats and conservation approaches, In: *National Symposium on Role of Plant Tissue Culture in Biodiversity Conservation and Economic Development*, 63, Kosi-Katarmal, Almora, U.P. (1999)

28. AM Chandrashekharaiah and VM Dabgar, The effect of sandalwood availability on the craftsman community, In: *Sandal and Its Products*. ACIAR proceedings (84), Eds, AM Radomiljac, HS Aanathapadmanabha, RM Welbourn and K Satyanarayana Rao, Publication—Australian Centre for International Agricultural Research, Canberra 19–21 (1998)

19. R Uma Shaanker, KN Ganeshaiah and M Nageswara Rao, Conservation of sandal genetic resources in India: problems and prospects. In: *International Conference on Science and Technology for Managing Plant Genetic Diversity in 21st Century*, Kuala Lumpur, Malaysia (2000)

30. R Uma Shaanker, KN Ganeshaiah, M Nageswara Rao and G Ravikanth, Forest gene banks—a new integrated approach for the conservation of forest tree genetic resources, In: *Managing Plant Genetic Resources*, Eds, JMM Engels, AHD Brown and MT Jackson, CABI Publishing, Nosworthy, Wallingford, Oxon, UK 229–235 (2002)

31. R Uma Shaanker, KN Ganeshaiah, M Nageswara Rao and NA Aravind, Ecological consequences of forest use-from genes to ecosystem: a case study in the Biligiri Ranganswamy Temple Wildlife Sanctuary, South India, *Conservation Soc*, **2**, 347–363 (2004)

32. AG Young and TJ Boyle, Forest fragmentation, In: *Forest Conservation and Genetics—Principles and Practice*, Eds, A Young, D Boshier and T Boyle, CSIRO Publishing, Australia 123–134 (2000)

33. S Padmini, M Nageswara Rao, KN Ganeshaiah and R Uma Shaanker, Genetic diversity of *Phyllanthus emblica* in tropical forests of South India: Impact of anthropogenic pressures, *J Trop For Sci*, **13**(2), 297–310 (2001)

34. R Uma Shaanker, KN Ganeshaiah and M Nageswara Rao, Genetic diversity of medicinal plant species in deciduous plants of India: Impacts of harvesting and other anthropogenic pressures, *J Plant Biol*, **28**(1), 91–97 (2001)

35. Sanjaya, B Muthan, TS Rathore and VR Rai, Micropropagation of an endangered Indian sandalwood (*Santalum album* L.), *J For Res*, **11**, 203–209 (2006)

36. SN Rai and CR Sharma, Relationship between height and diameter increment of sandal (*Santalum album* L.), *Van Vigyan*, **24**, 105–138 (1986)

37. PS Rao and RA Srimati, Vegitative propagation of Sandal (*Santalum album* L.), *Curr Sci*, **46**, 276 (1977)

38. RA Srimati, KR Venkateshan and HD Kulkarni, Guidelines for selection and establishment of seed stands, seed production areas, plus trees and clonal seed orchards for sandal (*Santalum album* L.), In: *Recent Advances in Research and Management of Sandal (*Santalum album *L.) in India*, Eds, RA Srimati, KR Venkateshan and HD Kulkarni, Associated Press, New Delhi 281–299 (1995)

39. Sanjaya, HS Anathapadmanabha and VR Rai, *In vitro* and *in vivo* micrografting of *Santalum album* shoot tips, *J Trop For Sci*, **15**, 234–236 (2003)

40. VA Bapat and PS Rao, Vegetative propagation of sandalwood plants through tissue culture, *Can J Bot*, **56**, 1153–1156 (1978)

41. PS Rao and VA Bapat, Micropropagation of Sandalwood (*Santalum album* L.), In: *Biotechnology in Agriculture and Forestry, High-tech and Micropropagation II*, Vol 18, Ed, YPS Bajaj, Springer, Berlin, Heidelberg, New York 193–210 (1992)

42. LG Sita, NV Raghava Ram and CS Vaidyanathan, Triploid plants from endosperm culture of sandalwood by experimental embryogenesis, *Plant Sci Lett*, **20**, 63–69 (1980)

43. VA Bapat, and PS Rao, Regulatory factors for *in vitro* multiplication of sandalwood tree (*Santalum album*): 1. Shoot bud regeneration and somatic embryogenesis in hypocotyl cultures, *Proceedings of The Indian Academy of Sciences Plant Sciences*, **93**(1), 19–28 (1984)

44. VA Bapat and PS Rao, Regeneration of somatic embryos and plantlets from stem callus protoplasts of the sandalwood tree (*Santalum album* L.), *Curr Sci*, **54**, 978–982 (1985)

45. VR Rai and J McComb, Direct somatic embryogenesis from mature embryos of sandalwood, *Plant Cell Tiss Org Cult*, **69**, 65–70 (2002)

46. A Mujib, *In vitro* regeneration of sandal (*Santalum album* L.) from leaves, *Turk J Bot*, **29**, 63–67 (2005)

47. LG Sita, CS Vaidyanathan and T Ramakrishnan, Applied aspects of plant tissue culture with special reference to the improvement, *Curr Sci*, **51**, 88–92 (1982)

48. VA Bapat and PS Rao, Sandalwood plantlets from synthetic seeds, *Plant Cell Rep*, **7**(6), 434–436 (1988)

49. PC Fernandes, VA Bapat and PS Rao, *In vivo* germination of encapsulated somatic embryos of *Santalum album* L. (Sandalwood), *Indian J Exptl Biol*, **30**(9), 839–841 (1992)

50. SH Jain, VG Angadi, AN Rajeevalochan, KH Shankaranarayana, KS Theagarajan and CR Rangaswamy, Identification of provenances of sandal in India for genetic conservation, In: *Sandal and Its Products*, ACIAR proceedings (84), Eds, AM Radomiljac, HS Aanathapadmanabha, RM Welbourn and K Satyanarayana Rao, Publication - Australian Centre for International Agricultural Research, Canberra 117–120 (1998)