Gene diversity considerations while creating south Indian forests

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This summery describes results from a collaboration between an Indian Scientist (Mohan Varghese) and a Swedish (Dag Lindgren) and their collaborators. It is also described at http://www.sasnet.lu.se/forestgenetics.html

For tropical rural development, planted forests are an essential component. We have learned how to use the land efficiently for food production and with improving standards the request for wood products is increasing in the same time as it is better understood that forests are important for sustainability. Domestication of tropical forest tree species is in its infancy and little knowledge or expertise is available. Most of the forest plantations are with exotic species. It is essential to improve adaptation by using genotypes which perform well locally as parents to future generations and also that a sufficient number of genotypes are represented in the progeny. An algorithm developed by Swedish collaborators was used for converting an *Eucalyptus* clone trial to a seed orchard meeting both of these goals in an optimal way.

There has been a recent trend of increasing use of native forest species in afforestation. Unlike most exotics, the native species are comparatively slow growing. Studies have been made in Teak, Sandal, Neem and Tamarind. Flowers and fruits have been inventoried for different trees and clones in a number of stands and seed orchards. Large variations in ability to produce offspring were generally found in many cases (see the table), often larger than in similar Swedish inventories. If seed collections are done from objects with few trees or clones and these are very variable, it will lead to reduced gene diversity, inbreeding and variations and unpredictability. Higher number of clones and families may have to be used in Indian seed orchards than used for conifers in the west.

Several grafted seed orchards of teak were established in the seventies, with the hope of supplying quality seeds of this important timber species. But seed production from these orchards has been dismally low, hardly any seed is used from them. There has been a renewed interest in teak, stands are used as seed sources, and attempts have been made to understand the genetic variation between populations in the south Indian peninsula.

Many of our efforts have aimed at monitoring variation in fertility among trees and clones for different types of forests situated in southern India. Some results have been compiled in the Table.

Species	Type of object	Ψ	Ψ with action
Teak	Clonal orchard	1.71	1.23
Teak	"	8.33	3.50
Teak	Seed production area	3.7	
Teak	"	2.9	
Teak	"	1.9-3.7	
Teak	"	3.2	
Teak	Natural stand	2.1	
Teak	Seed production area	3.2	2.2
Neem	Plantation	2.7	
Sandal	Plantation	1.8-5.6	
Tamarind	Plantation	3.3-4.3	
Tamarind	Clonal orchard	2.0-2.4	

Ψ stands for sibling coefficient and is a measure on how variable trees are. Ψ=1 means that all trees get the same number of offspring (or have the same number of reproductive structure). If Ψ=2 the chance that two offspring has the same parent is double as high as if the parents were equally fertile. Ψ=1.3-3 are common values in non tropical conditions. If there are a number of trees, the effective number (from a fertility stand point) can be seen as the number divided by Ψ.

When observations were done several years, the observed fertility variations were often (although not always) remarkable similar (the table shows averages of similar values, and notes differences only when they are considerable). Fertility variation was generally higher in a natural stand compared to the SPAs (as indicated by the sibling coefficient value) even though 99% of the trees were fertile in two adjacent years. In the SPAs there was a positive year to year correlation in fertility parameters like proportion of fertile trees (0.935), flowers (0.572) and fruits produced (0.857) per tree. The female fertility variation (-0.35) and the fruit set percentage (-0.742) in two successive years were negatively correlated implying that there is a tendency for alternate bearing in trees in a population.

Actions to reduce fertility variation were tested in teak by either putting limits on the harvest of seeds per tree or by thinning. It is possible to reduce variations in the contribution to the progeny, but this severely reduces seed production. Another way to reduce fertility variation is thinning considering fertility. Selection for tree DBH was observed to reduce the fertility variation as DBH was positively correlated to reproductive output in teak.

Sandal flowers twice a year, much higher fertility variation was observed for flowering in August than in February. Fertility variation was found to be low in ten year old sandal plantations compared to those of neem and tamarind**.**

List of scientific papers the cooperation has resulted in

Kamalakannan R, Varghese M, Bilir N and Lindgren D 2006..Conversion Of a Progeny Trial Of *Eucalyptus tereticornis* To A Seedling Seed Orchard Considering Gain And Fertility. Isik F (ed) Low input breeding. Proceedings of conference in Turkey 2006

Kamalakannan R, Varghese M and Lindgren D 2007.Fertility variation and its implications on relatedness in seed crops in seedling seed orchards of *Eucalyptus camaldulensis* and *E. tereticornis.* Silvae Genetica in press (0611).

Prescher F, Lindgren D & Varghese M. 2004. Genetic Thinning of Clonal Seed Orchards using Linear Deployment. In Li B & McKeand S Eds Forest Genetics and Tree Breeding in the Age of Genomics: Progress and Future. See the Conference Proceedings, pp 232-240.

Varghese, M., Ravi, N., Son, S.G. and Lindgren, D. 2002. Optimising selection in an open pollinated progeny trial of Eucalyptus tereticornis. Proc. International Conference on Eucalypt Productivity, Hobart, Australia, 10-15, November, 2002, pp 26-29.

Varghese, M., Ravi, N., Son, S.-G. & Lindgren, D. 2003 Variation in fertility and its impact on gene diversity in a seedling seed orchard of Eucalyptus tereticornis. In: Eucalyptus Plantations – Research, Management and Development, R.-P. Wei and D. Xu (eds), World Scientific, Singapore, 111-127.

Varghese M, Lindgren D and Nicodemus A. 2004. Fertility and effective population size in seedling seed orchards of Casuarina equisetifolia and C. junghuhniana Silvae genetica 53:164-168.

Varghese M, Nicodemus A, Nagarajan B & Lindgren D. 2006. Impact of fertility variation on gene diversity and drift in two clonal seed orchards of teak (*Tectona grandis* Linn f). New Forests 31: 497-512

Varghese M, Lindgren D & Ravi N 2006. Linear thinning in a clonal test of Eucalyptus camaldulensis for conversion to a clonal seed orchard. Journal of Tropical Forest Science 18(2): 102-108.

Submitted:

Varghese, M., Lindgren, D. & Son, S.-G. 2006 Seedling seed orchard thinning considering breeding value, fertility variation and gene diversity

Varghese M., Ravi N., Son S-G & Lindgren D. 2005 Strategies for optimising gain and diversity in a seedling seed orchard of *Eucalyptus tereticornis*

Varghese M, Kamalakannan R, Nicodemus A, and Lindgren D 2006. Fertility variation and its impact on seed crop in seed production areas and a natural stand of teak in southern India. Can. J. For. Res. Submitted.

Varghese M, Lindgren D & Kamalakannan R 2006. Gene diversity consideration while creating south Indian forests. Poster presented at workshop on Policies in Tropical Rural Development – Swedish contributions, influences and research needs at Umeå 061120-21, will be posted at http://uctree.slu.se