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Species and Provenance Testing in India: Field Application

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Abstract: Provenance in forestry refers to the original place of origin of seed/propagule or trees. Provenance research aims at defining the genetic and environmental components of phenotypic variability between trees from different geographical origins. However, it has great significance in introduction of the species for their testing at the new location. A wrong choice of species or provenance can lead to a big loss than benefit. This paper reflects some examples for successful choice for provenances.

Keywords: Forest area, Species, Provenances, Short rotation trees

The Forest Survey of India undertakes assessment of country's forest resources including trees outside forests after every two years. The salient features of ISFR, 2021 include a total forest cover of 7,13,789 sq km (21.71 % of the geographical area), and tree cover of 95728 sq. km (2.91 % of the geographical area).The Forest cover has increased by 1540 sq.km (0.22 %) and tree cover by 721(0.76 %) sq. km as compared to the previous assessment of 2019. The top five States in terms of forest area are Karnataka, Andhra Pradesh, Kerala, Jammu and Kashmir and Himachal Pradesh. However, the forest and tree cover are still well below the national target of 33%. The importance of this target was reinforced in a study commissioned by ICFRE, Dehra Dun. The study conducted a detailed review dating back to 1850 and concluded that based on ecosystem approach, the target of 33% forest area was justified. The study points out a forest area loss of 18.5 million ha during 1950-80 and presents alternative approaches on the subject. It recommends the ecosystem approach, which considers the dynamic interaction of forests with other system components, viz. abiotic, biotic, atmospheric and cultural factors. It then provides an assessment of land use and forest cover of the country from an ecosystem perspective in order to improve forest ecosystem services. Since 1980, the forests are managed under sustainability and conservation approach. India's forests have very low productivity. The increment of India's forests is less than 1 $m^3 ha^{-1} yr^{-1}$ as compared to the world average of 2.1 $m^3 ha^{-1} yr^{-1}$ (Lal and Bhandari 2020). The total carbon stock in the forest is estimated as 7,124.6 million tonnes and soil organic carbon contribution is 56% of total carbon stock.

On the other hand, the growing stock of TOF is 1642 million m^3. This is due to very high increments (25-30 $m^3 ha^{-1} yr^{-1}$) of trees on farmers' field especially clonal plantations of eucalyptus, poplars, leucaena, dek, casuarinas and other species. The low productivity of India's forests underscores the importance of conserving forests and preventing degradation. To this end, trees outside forests particularly agroforestry points to the way forward. Agroforestry constitutes the major source (nearly 90 %) of timber required for industrial purposes- saw mills, ply and veneer mills, and paper mills (Pandey and Roy 2020). Under the Paris Agreement on Climate Change, India has committed to grow additional trees to capture 2.5-3.0 billion tonnes of carbon dioxide by 2030. In the short time available, TOF and particularly agroforestry has the potential to contribute significantly to achieve this nationally determined target. High productivity agroforestry plantations have the potential to sequester up to 60 t C/ha (IPCC, 2000) while emission avoidance via conservation through forest protection and management have a much higher carbon mitigation potential (4-252 and 41-102 t C/ha respectively).

Thus, greater emphasis on agroforestry may be the path to conserve forests and environment as also to meet India's wood requirements. Presently, as reported by Pandey and Roy (2020) imports of wood and wood products for the years 2016-19 amounted to Rs 48,099.9 crores (around Rs 10,000 crores per year). Bamboo import alone is around 400crores annually. This demand is growing rapidly with the rise in India's GDP and the general standard of living.

The tremendous increase in demand for wood in the form of pulp and panel products due to economic and industrial development has brought about a revolution in forestry. With limited availability of wood from natural forests, foresters have adapted to new means of wood production since the 1980s. Frequently, natural species did not meet the growing industrial requirement and it became necessary to introduce exotics with high productivity per unit area. Eucalypts and Poplars are prime examples.

Introduction of Species/provenances and achievements: It may be emphasized that climatic and ecological matching of new sites and the original habitat of a species that is being considered for introduction is usually not enough since it cannot reveal adaptability of a species to grow satisfactorily on a range of sites in a new environment. It is expected that the best way forward may be through trials of the candidate species on representative locations. It is common to find that foresters and forest scientists are not fully aware of the need for species/provenance testing. Systematic research work is followed in developed nations since 1930s, unfortunately, because of the hurry to introduce new species this step is generally not followed in India. The authors have observed several examples of this involving species such as *Leucaena leucocephala, Prosopis flroa, Paulonia fortunei*, *Jatropha curcus*, etc. The notable exceptions are eucalypts and poplars where adequate testing has been done. Even here it is observed that for some inexplicable reasons species like *E. grandis* were not given a fair trial under the Australian assisted project that commenced in the late 1970s. The authors have observed some outstanding specimens of the species. The lead author also had the opportunity to see excellent clonal plantations of *E. grandis* in South Africa, where it is used in the paper industry. Some foresters continue to advocate species like Paulownia and Melia. In the latter case it is still not clear whether *Melia composita* and *M. dubia* are different or same species, or perhaps one is a subspecies of the other.

The advisability of species trials is accepted but the need for their careful planning and high standards of maintenance and assessment has often been less appreciated. For species with naturally wide geographical/ecological ranges, provenance testing is considered essential (Burley and Wood 1976). There is a danger that foresters who have a readily accessible seed or clone of a satisfactory species or provenance may feel it unnecessary to test others that could be potentially better. This has sometimes been experienced by the authors during his trips to a few places in India.

Two examples relevant to the Indian situation are those of *Eucalyptus tereticornis* Smith and *Eucalyptus camaldulensis* Dehnh. The former has been the most successful in summer rainfall areas with moderate to severe drought season while the latter is perhaps the world's most widely planted tree species in arid and semiarid areas (Eldridge et al1993). *E camaldulensis* is also found to be fairly salt tolerant and some populations were found to have greater salt tolerance than others (Karschon and Zoher 1975). Trials in India have shown superiority of some provenances over others (Chaturvedi et al 1989, Kapur and Dogra 1987a, b, c, Dogra and Sharma 2005, Dogra and Chauhan 2021).

Species/provenance testing: The size of the trial plots depends on the purpose, duration and expected growth rate of trees. Leaving aside the arboretum phase where 1-2 trees would suffice and when a large number of species and provenances are being screened in the elimination phase line plots of 5-7 tree plots may be suitable with a few replications. The next stage is the species elimination phase during which a large number of possible species may be tested in small plots for about 10% to 20% of the rotation length. Here 20-30 species may be involved (Callaham 1964, Burleyet al 1976).The next is the species testing phase which involves critical testing of a reduced number of species in larger plots (16-25 trees) with a 1-2 row surround for longer periods: about half the rotation length. Here 5-10 species may be involved. The third stage is the species proving phase which is designed to confirm under normal plantation conditions the superiority of a few species/provenances in 100 tree plots with a surround of 2 rows. Here growth and yield estimates are important. Some authors suggest that the width of the surround may be approximately equal to the expected height of trees. The trials may be done sequentially or, if there is a hurry to obtain usable results, in parallel. A similar approach was followed in species and provenance trials of eucalypts in Punjab (Kapur and Dogra 1987a,b,c, Dogra and Sharma 2005). Here the local Eucalyptus hybrid was used as a control.

Three similar stages apply to provenance testing for a species with a wide natural distribution: a range-wide provenance sampling phase, a restricted provenance sampling phase, and a provenance proving phase. In range-wide provenance phase 25 trees with no surrounds are recommended. Here we may test 10-30 provenances. In restricted provenance phase 25-49 tree plots are suggested. In provenance proving phase we may go in for 100 tree plots and one or two row surrounds. Plots are generally square or rectangular. In case of sloping land, replicates may be aligned along the contours. The spacing of trees generally varies from 2-3 m. Since these are generally applied to species that are promising or probable their plot size needs to be larger for longer duration. Plots should be large enough to provide data on growth and yield for full rotation and plot surrounds should be large enough to minimize the edge effects. At this stage, it is also appropriate to investigate wood quality and other management techniques including techniques of nursery growing, site preparation, planting methods, and spacing, pruning and thinning trials.

The objective of an experimental design for species or provenance trial is to ensure precise and accurate estimates of differences between populations and between environments. Enough replications are required to reduce the residual variance associated with any comparison of population means. As a rule of thumb, we may never have degrees of freedom of less than 10 and preferably 15. This may entail increase in the number of replicates, or the number of species or provenances being tested. Usually, a well-known local species is included in trials to have a reference point against which to judge the performance of the unknown species/populations.

Other species and provenance trials include those of *Paulownia* and tropical pines. Unfortunately, the trials of *Paulownia* and tropical pines were not diligently followed even though pine species like *Pinus caribaea, P. elliotii, P. patula* and several other species showed promise in tropical/sub-tropical areas.It is well known that tropical pines are fast growing compared to indigenous pines and yield general purpose timber and long fibre pulping material (Chaturvedi1982 and Guha 1982). In his report on *Paulownia*, Dhiman (2008) recommended that a wide-range provenance trial of selected species, and their germplasm was urgently needed. The fate of tropical pines introduced in 1960s was similar, although countries like Australia and New Zealand have adopted these pines in a big way. In both countries, *Pinus radiata* is the most widely planted softwood species with plantations over 773000 ha in Australia alone and around 89% of New Zealand plantations forests include *Pinus radiata*. The species is used as a general-purpose timber and for pulping. In Australia, plantations of *P. caribaea* and *P. elliottii* called southern pines also have around150,000 ha (Singh et al 2013). As a matter of fact, Australia is now also considered a leader in teak, chandan, neem, etc. plantations while the species did not exist there till the 1980s. The above facts should make us sit up and take a serious note of developments elsewhere. Tropical pines have the potential to meet our requirements for long fibre pulp as well as general purpose timber just like chir pine and kail. By planting these species in degraded forests and under agroforestry plantation, India can potentially emerge as a country surplus in wood production. The said pines are normally grown over a rotation of 30 years and under agroforestry contract farming is one possible route.

CONCLUSION

Decline in timber harvests from natural forests because of ecological and environmental considerations has shifted focus to planted forests or trees outside forests.The increase in tree planting activities is also due to the increase in demand for wood as a result of economic development and population growth. In India, agroforestry is the single biggest component of planted forests and meets more than 90% the demand for wood. Currently stress is on a limited number of fast-growing species. However, foresters and scientists are expected to look at a much wider spectrum of species. In other words, it is appropriate to grow comparatively fast-growing timber species and develop appropriate agroforestry models for them as well. It is therefore imperative that we choose appropriate species/clones to meet the demand for timber; of furniture grade, general purpose timber and for veneer and ply mills; and long-fibre tropical pines for paper mills.

REFERENCES

Anonymous 2019. *India State of the Forests Report*, 2019. Forest Survey of India, Dehra Dun, India, Vol. 1, 185p.

Anonymous 2021. *Indian State of Forest Report 2021*. Forest Survey of India, Dehradun, India, 586p.

Burley J and Wood PJ 1976.*A manual on species and provenance research with particular reference to the Tropics*. Tropical Forestry Papers No.10. Department of Forestry, Commonwealth Forestry Institute, University of Oxford, 226 pp.

Callaham RZ 1964. Provenance research: Investigation of genetic diversity associated with geography. *Unasylva* **18**: 73-74.

Chaturvedi AN, Sivaji P and Prasad DVJ 1989. *Eucalyptus* provenance trials in Andhra Pradesh. *Indian Forester* **115**(7): 445-454.

Chaturvedi JK 1982. Tropical pines in Madhya Pradesh. *Indian Forester* **108**(2): 163-170.

Dhiman RC 2008. *Paulownia*. UNDP-ICFRE Project. IND/92/038. Forest Research Institute (Indian Council of Forest Research and Education), P.O. New Forest, DehraDun, 248006.

Dogra AS and Sharma SC 2005. Performance of *Eucalyptus* species and provenances in South-West Punjab. *Indian Forester* **131**(12): 1521-1528.

Dogra AS and Chauhan SK 2021. Species and provenance research in Eucalyptus: A review of Punjab experiences. *Indian Forester* **147**(1): 1039-1043.

Eldridge KG, Davidson J, Harwood CE and Van Wyk G 1993. *Eucalypt Domestication and Breeding*. Oxford University Press.

Guha SRD 1982. Suitability of tropical pines for pulp and paper. Seminar-cum-Workshop on *Tropical Pines Koraput*, Orissa, 7p.

IPCC 2000. *Land Use, Land-use Change and Forestry. Inter-governmental Panel on Climate Change. A Special Report to IPCC*. Cambridge University Press.377p.

Kapur SK and Dogra AS 1987a. Provenance trial of *Eucalyptus tereticornis* in Punjab. *Indian Forester* **113**(1): 2-5.

Kapur SK and Dogra AS 1987b. Species-cum-provenance trial of *Eucalyptus* in Punjab. *Indian Forester* **113**(4): 238-242.

Kapur SK and Dogra AS 1987c. Provenance trial of *Eucalyptus camaldulensis* in Punjab. *Indian Forester* **113**(7): 471-475.

Karchon R and Zohar Y 1975. Effects of flooding and irrigation water salinity on *Eucalyptus camaldulensis* Dehn. from three sources. Leaflet 54. Division of Forestry. Agricultural Research Organization, Israel. In. Eucalypt Domestication and Breeding. Oxford University Press. Eldridge KG, Davidson J, Harwood CE and Van WykG (1993).

Lal P and Bhandari S 2020. *Agroforestry with commercial clonal plantations in India*. TERI New Delhi, 249p.

Pandey CN and Roy S 2020. Plywood and panel industry in India-current scenario and key issues. *IWST*. Wood is Good.

Singh S, Cunningham D, Davidson J, Bush D and Read S 2013. *Status of Australia's forest genetic resources*. Research by the Australian Bureau of Agricultural Sciences. Research report 133, February 2013.

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