

GUEST EDITORIAL

STRENGTHENING THE TROPICAL ACACIA PLANTATION VALUE CHAIN: THE ROLE OF RESEARCH

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Three *Acacia* species native to northern Australia and adjacent regions of Papua New Guinea and eastern Indonesia have attained prominence for short-rotation plantation forestry in the humid tropics. Plantation areas of *Acacia auriculiformis* and *A. mangium* expanded from 1970s, while *A. crassicarpa* planting commenced in the 1990s, after species trials showed it could outperform the first two species on certain site types such as peat soils and seasonally flooded sandy soils. Research into reproductive biology and propagation methods laid the foundation for expansion of clonal *Acacia* hybrid (*A. mangium* × *auriculiformis*) plantations, most notably in Vietnam, where over 250 000 ha of hybrid plantations are now established. Well-managed and appropriately-sited *Acacia* plantations in Indonesia and Vietnam display rapid growth rates, with mean wood annual increments exceeding 30 m³ ha⁻¹ over six-year rotations in some cases. Altogether, in the humid lowland tropics of south and South-East Asia there are now over 2 Mha of plantations of these *Acacia* species. Over half of this area has been established on grasslands, degraded scrublands or land previously planted with other tree or crop species, but substantial clearing of natural forests for plantation establishment has also taken place. In hindsight, the latter will be seen by many as a poor landuse decision.

To what extent has forest research contributed to the development and value of this new plantation estate? What are the known problems and the knowledge gaps where research might still contribute?

Genetic resources and breeding

Range-wide seed collections were carried out for over 50 promising tropical and subtropical *Acacia* species in the 1970s and 1980s. These collections were used to establish species/provenance trials in many countries. The aim was to identify

fast-growing species suitable for plantations on degraded land, which would produce timber to substitute for declining wood availability from native forests. CSIRO's Australian Tree Seed Centre and collaborating forest genetic resource centres in Papua New Guinea and Indonesia led this work, with financial support from ACIAR and FAO. During this testing phase, taxonomic identities were refined and several new *Acacia* species were described. There are nearly 1000 species of *Acacia* in Australia, but only the three referred to above were subsequently taken up for tropical plantations. This parallels the history of *Eucalyptus*, a genus with over 800 species, with only nine species from the subgenus *Symphyomyrtus*, and hybrids among them, accounting for over 90% of the 20 Mha worldwide area of eucalypt plantations. Clearly, conservation through use is not going to protect the genetic resources of the great majority of species in these two genera. It seems unlikely that there are other as-yet-unrecognised *Acacia* species from Australia and nearby countries that will attain prominence for plantation forestry. However, interspecific hybridisation between the three commercial species discussed here and other closely related *Acacia* species might perhaps confer improvements in adaptability, pest resistance or wood properties.

In addition to the screening of candidate *Acacia* species, results of many provenance trials were reported, enabling superior provenances to be identified. Most breeding programmes now focus on *A. auriculiformis* provenances from north Queensland and Papua New Guinea, and *A. crassicarpa* and *A. mangium* provenances from Western Province, Papua New Guinea and adjacent West Papua. Use of inferior provenances or land races resulted in slower-growing plantations, with wood yields less than half those obtainable by breeding from the best provenances. Self fertilisation, which occurs

in isolated trees or in seed production stands with poor and asynchronous flowering, was shown to greatly reduce vigour of progeny in *A. mangium*, so guidelines for improved seed orchard management were developed. Breeding has also markedly improved tree form and stem straightness. In northern and central Vietnam, selected *A. mangium* × *auriculiformis* hybrid clones clearly outperform the two parent species, but *A. mangium* grows at a similar rate to the hybrid in the south of that country. To date, the best *A. mangium* seed sources appear to outgrow *Acacia* hybrid clones in equatorial environments such as Borneo and Sumatra, although this may change as hybrid breeding intensifies there. Research on propagation has determined that selected clones of *A. auriculiformis* and *Acacia* hybrid can readily be deployed via clonal forestry, thus enabling effective exploitation of non-additive genetic variance. However, maturation effects reduce clonal vigour in *A. mangium* and *A. crassicarpa*, making clonal forestry with these species non-viable. Clonal family forestry (propagation of cuttings from seedling hedges derived from family seedlots of the best, tested orchard trees) has been successfully developed to enhance the deployment of genetic gains in these two species.

Silviculture

Most tropical *Acacia* plantations are grown for pulpwood on five- to eight-year rotations, with all three species producing short-fibre pulp acceptable to international markets. However, there is increasing demand for growing of *Acacia* logs for timber to produce sawn boards for furniture and decorative applications. In Vietnam, for example, straight logs with small-end diameter exceeding 150 mm are commonly sawn and fetch a stumpage price up to twice that obtainable for smaller-dimensioned pulpwood. *Acacia auriculiformis* logs command a premium price over *A. mangium* and *Acacia* hybrid in that country because this species has higher wood basic density and more attractive heartwood.

There is a tendency to view *Acacia* plantations as intrinsically of low value and hence warranting only low silvicultural inputs. However, appropriate initial spacing, modest rates of fertiliser application (phosphorus is often the most common limiting element), form pruning of young trees in their first year of growth and adequate weed control in the first two years of

the rotation, can add greatly to wood value by increasing stand volume and the proportion of higher value sawlogs. Tropical *Acacia* plantations are sensitive to intra-specific competition, so initial stocking of no more than 1100 stems per hectare or thinning within the first three years is required to yield a significant proportion of sawlogs on short rotations. Lift pruning of first-order branches is seldom practised but can add further value to the logs destined for sawing and veneering through reduction of knot-related defects. Realisation of these opportunities for value adding through improved site and stand management by many thousands of smallholder growers in diverse countries is a real challenge. Participatory research efforts are now under way to adapt research results to smallholder circumstances.

Acacias are prone to wind damage because their wood is relatively low in strength and their heavy crowns increase bending stress; in regions where storms and cyclones are common, such as central Vietnam and the northern Philippines, investment in silviculture to improve stand value, and indeed the decision on whether to plant *Acacia*, must be weighed against the risk of catastrophic stand damage. Another concern has been a tendency by growers to plant these relatively drought sensitive species in drier environments. It is not sufficient to define suitable climates for *Acacia* plantations by mean annual rainfall alone; the length and severity of the dry season, indicated by mean monthly rainfall and pan evaporation, are critical to their success or failure. Environments in southern India and Australia's Northern Territory with mean annual rainfalls exceeding 1500 mm but with long, severe dry seasons have proven unsuitable for good plantation performance. Improved understanding of *Acacia* ecophysiology, currently being developed through process-based growth modelling, should assist in better delineation of suitable planting environments for these three *Acacia* species and the *Acacia* hybrid.

Tropical *Acacia* plantation forestry must pay serious attention to the risks posed by diseases and insect pests. Since the 1980s, concern has been expressed about the potential for stem heart-rot to compromise *A. mangium* sawlog plantations. More recently, root rot (with *Ganoderma* as the main pathogen) has emerged as a potent threat because inoculum can build up over successive rotations through spore germination on harvested stumps and as a saprophyte on

diseased harvesting debris, stumps and coarse roots from previous rotations. The root-rot threat appears more severe in equatorial environments in Malaysia and Indonesia where plantation productivity has been reduced by more than 20% in some second-rotation plantations. In Vietnam, three or more *Acacia* plantation rotations have been harvested successfully without detectable losses to root rot. Pathogens of the *Acacia* canopy have been described and studied but have not significantly impacted on plantation productivity to date. They could do so in the future, given the experience with other tropical plantation genera such as *Eucalyptus*.

A concern in *Acacia* silviculture is weediness, arising from the heavy production of long-lived seeds. This creates problems during stand re-establishment; seedling recruitment must be removed through herbicide application or hand weeding. There is also concern that conservation values may be compromised by their invasion of natural vegetation. Development of infertile triploid *Acacia* clones for plantations is a possible solution.

An emerging issue in management is maintenance of long-term site productivity. While these *Acacia* species are nitrogen-fixing, site resources of other nutrient elements and soil carbon must be protected and, if possible, enhanced. CIFOR-supported international trials have examined productivity trends over multiple short rotations in several countries. Soil conservation during harvest, and retention of harvest residues (bark, twigs and phyllodes) on-site, rather than their burning or removal for fuel or other uses, should be practised. Improvement in soil condition following such sound inter-rotation practices has been demonstrated for *A. auriculiformis* plantations in southern Vietnam.

Wood harvesting and processing

Acacia wood of the three species reviewed here has proven generally acceptable for pulpwood and solid-wood processing. Studies of wood quality show that there is substantial genetic variation in wood traits such as basic density and wood stiffness in *A. auriculiformis*, offering the prospect of improving the wood quality of this species and *Acacia* hybrid through breeding and clonal selection. To date, there has been little public reporting of genetic variation in basic density and kraft pulp yield of *A. crassicarpa* and *A. mangium*, although gains in wood properties

of these species through breeding can also be anticipated. Recently, research on the molecular biology and genetics of wood traits in tropical *Acacia* species has accelerated. This will need to link closely with the best breeding programmes to achieve impact. Research has been conducted in Indonesia and Malaysia to develop the utilisation of *Acacia* wood for engineered wood products such as medium density fibreboard and veneer-based products.

As processing industries develop further and labour costs increase with rising living standards, greater automation in wood processing can be anticipated, which will in turn demand more uniform and better quality logs. Silvicultural operations and harvesting in many grower countries are labour intensive and a trend towards greater labour productivity in these areas is also likely. Enterprises that can successfully integrate improvements in breeding, silviculture and processing to reduce growing costs and improve product quality stand to reap the benefit.

Research collaboration and knowledge sharing

A series of international research projects supported by ACIAR involving (notably) Australia, China, India, Indonesia, Thailand and Vietnam gave impetus to research collaboration both within and between countries. Public-private partnerships have been important in research because large areas of *Acacia* plantations are owned by private companies. Research conferences held in the 1980s and 1990s under the auspices of IUFRO, ACIAR and COGREDA, and the associated proceedings, were important sources of information.

Although many challenges lie ahead, a valuable resource of productive plantations has been established. This now produces substantial industrial wood flows, contributing to poverty alleviation of smallholder tree farmers and helping to reduce harvesting demands on natural forests. Countries developing new *Acacia* plantation estates stand to benefit from the achievements and knowledge acquired thus far.

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