**International Conference**
**Working Party 2.08.07: Genetics And Sivilculture Of Acacia**


# SUSTAINING THE FUTURE OF ACACIA PLANTATION FORESTRY

IUFRO

VIETNAMESE ACADEMY OF FOREST SCIENCES
VAFS

# Acacia 2014
# "Sustaining the Future of Acacia Plantation Forestry"

| March 18 - 21, 2014 | Hue - Viet Nam

IUFRO Working Party (WP) 2.08.07

**Genetics and Silviculture of Acacia**

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## Welcome from the IUFRO Working Party Co-ordinator

I would like to welcome you to **"Acacia 2014"**, the first meeting of the new IUFRO Working Party 2.08.07 Genetics and Silviculture of Acacias. Tropical acacias have been domesticated for less than 50 years but over 2 million hectares of plantations in SE Asia now make a significant contribution to world wood supply. It is very appropriate that we convene in Vietnam, one of several countries which have developed major industries based on acacia wood.

Until 2012 the only IUFRO forum for discussion of our problems and opportunities was within the tropical hardwood or nitrogen-fixing tree Working Parties. The new Working Party will provide a more focused and ongoing opportunity for sharing of knowledge of the science underlying productivity and sustainability of acacia plantations. It is my strong expectation that many of you participating in this Conference will develop effective international networks which persist long beyond 2014.

The Conference program is deliberately designed with a cross-disciplinary focus. Concurrent sessions in the three theme areas *Plantation management for sustainable wood production; Genetics and breeding;* and *Risk Evaluation and Management,* will allow in-depth technical discussions but all participants will also have the opportunity to listen to the diverse group of speakers who will deliver the Plenary talks. We are particularly anxious that the Conference produces an outcome which is of some value to managers and policy makers as well as scientists and have therefore scheduled a forum addressing "Science for Better Policy Decisions". All participants are encouraged to attend and to help with subsequent dissemination of our conclusions.

I would like to express gratitude to the Vietnamese Academy of Forest Sciences for hosting the meeting, which has been made possible with support from our Foundation Sponsors MARD, ACIAR and MBFP and other generous sponsors. A great many people have assisted with fund raising, organisation and the science program, and my deputy co-ordinators and I are very grateful for these contributions. Rather than single out any people here I would refer you to the details published elsewhere in the Booklet.

I am also grateful to the invited speakers, many here at their own expense, and to all of the delegates from 19 countries who have made the effort to attend. I hope that everyone enjoys the Conference and makes many new friends.

Rod Griffin Co-Ordinator WP 2.08.07
Hue 18.3.14

## Welcome from Host Organisation

The Vietnamese Academy of Forest Sciences (VAFS) extends a warm welcome to delegates to the IUFRO Conference "Sustaining the Future of Acacia Plantation Forestry" in Hue, Vietnam's former capital city, a UNESCO World Heritage Site and one of the busiest places for acacia business in Vietnam.

Acacia has become an important global resource with 3.5 M ha of plantations in over 70 countries in Asia, Africa and South America. Acacias are grown to provide wood, fibre and other raw materials for industry, building materials and fuel, and acacia plantations also contribute to land rehabilitation and environment protection. Their fast growth, good adaptability to infertile and degraded soils, ease of management, capacity to improve soil fertility and production of wood suitable for a range of end products have led both forestry companies and smallholder farmer growers to establish acacia plantations, especially in SE Asia.

It is our pleasure to host this first meeting of the new IUFRO Working Party 2.08.07 Genetics and Silviculture of Acacias. However, this is not the first scientific meeting on acacias. The Australian Centre for International Agriculture Research organized meetings in Gympie, Queensland (1986), Bangkok, Thailand (1991) and Hanoi, Vietnam (1997) to consolidate knowledge in genetics and breeding, silviculture and utilization of Australian acacias of interest to developing countries. Other international meetings in the 1990s were organized by the Consultative Group for Research and Development of Acacias (COGREDA).

In the 17 years since the last ACIAR meeting in Hanoi there have been major advances in genetics and breeding, study and management of pests and diseases, silviculture and utilization of wood along with a dramatic increase in the area of acacia plantations worldwide. The aim of our conference is to bring together scientists involved in developing new technologies for acacia plantations and forest managers facing practical problems in growing acacias.

Vietnam provides a good example of successful acacia development, having established a plantation estate of over 1 M. Acacia growing in Vietnam has significantly reduced poverty in rural areas, creating employment opportunities and supporting the development of wood processing industries.

The Vietnam Academy of Forest Sciences (VAFS) is a government research institute and has led forest research in Vietnam for over 50 years. Commencing in the late 1980s, VAFS has been engaged with research on

acacias, especially genetic improvement, pest and disease management and silviculture, and has achieved significant successes, notably in breeding and the wide distribution of genetically improved planting stock. VAFS has sought and developed contacts with other research organizations in the tropics, especially in SE Asia and in particularly has been an

active contributor to IUFRO Working Party 2.08.07 Genetics and Silviculture of Acacias.

The rapid expansion of plantations has seen the emergence of major challenges to sustainability. Acacia plantations face both physical stresses under changing climates and biological threats from pests and diseases. Protecting site resources over successive short rotations requires careful management based on an understanding of the basis for sustainable production. Linking with and supporting smallholder growers, who manage nearly half of Vietnam's acacia plantation estate, is another challenge for researchers. The emergence of these challenges requires internationally cooperative efforts to confront complex and generic questions. In addition to facilitating the exchange of information, this Conference should facilitate the development and strengthening of international alliances and networks. VAFS seeks to develop and strengthen its collaborative partnerships during this meeting.

I wish to thank many VAFS staff members who have been involved in the organization and running of this Conference. In particular, I must mention the major contributions made by Drs. Trieu Van Hung, Ha Huy Thinh, Nghiem Quynh Chi, Phi Hong Hai, Vu Tan Phuong and Nguyen Duc Kien. On behalf of the VAFS, I cordially welcome you to Hue, and look forward to a productive Conference.

Ass/Prof Dr Vo Dai Hai

Director General, Vietnamese Academy of Forest Sciences

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## General Information

**Registration and Information Desk**
Registration and Information Desk is set up in front of the ballroom from Monday 17th March.

**Food and Beverage**
Tea-breaks and lunches are served in the Gallery room at the ground floor.

**Poster set up and session**
Posters will be set up in the lounge from 17:00 Monday 17th March and they will be displayed there for the duration of the conference.
Poster session is presented on Wednesday, March 19th from 16:30 - 18:00.

**Conference Abstracts**
All abstracts will be printed and handed in when participant registers.

**Mobile phones**
As a courtesy to speakers, delegates are requested to please switch off mobile phones during the conference sessions.

**Contact Phone Numbers**
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**Hue Railway Station**: 02 Bui Thi Xuan Str., Hue City, Vietnam. Tel: (84 54) 382 2175
**Airport Bus**: 20 Ha Noi Str., Hue City, Vietnam. Tel: (84 54) 382 6826.
**Airlines:**

***Phu Bai Airport***: Phu Bai Town, Huong Thuy Dist., Thua Thien - Hue Province. Tel: (84 54) 386 1261
***Vietnam Airlines:*** Tel: (84 511) 381 1111. Website: www.vietnamairlines.com
***VietjetAir:*** 1900 1886 (hotline). Website: www.vietjetair.com

## Social Program

**Welcome Dinner: Monday 17th March 18:30**

On the night of Monday, 17th March, we welcome our guest with a formal dinner at Hotel Saigon Morin. The venue is La Rendez-vouz where the attendances enjoy a meal together in one of the fantastic dining area is the ideal venue for casual rendez-vous.

In this evening, everyone would enjoy the Buffet Dinner and listen to Hue Traditional Music under the shimmer of hundred of lantern and candle that would make you feel unforgettable.

*Hue Traditional Music*

Hue traditional music is a special art of Hue ancient capital city. It consists of over eighty melodies of the folk music, the chamber music, and the court music ten continuous pieces of which called "mười bản ngự" are used for instrumental ensembles.

In only ninety munities, the program would like to charm your soul with the most typical songs of the Hue traditional music accompanied by the performer tactful communication, graceful laps of Vietnamese traditional dresses.

The event is a great opportunity for everybody to meet their new research colleagues from many different countries.

**Gala Dinner: Wednesday 19th March 19:00**

Organizing Committee warmly welcome about 200 participants from 20 counties, including scientists, plantation managers, industry representatives and forestry policymakers.

The evening will start with champagne in the La Rendez-vous. A splendid meal in the magnificent garden area will be served and people will be enjoyed good music that called "The Royal Refined Music" during the dinner-time. Other social activities would be encouraged by a local MC.

*The Royal Refined Music of Hue*

The Royal Refined Music was first introduced in the 13th century, but only reached its peak under the Nguyen Dynasty. The Royal Refined Music had long enjoyed a preference as an official form of royal music. It was recognized as the symbol of a powerful and long-lasting monarchy and as an indispensable part of all ceremonies.

Varied in its themes, the Royal Refined Music is considered a means of communication to express the respect to gods and kings.

## Mid- conference Agenda

There will be three tour stops, and four separate buses with separate two itineraries to reduce crowding at each stop and make for a relaxed field tour. The stops are as follows

* *Acacia crassicarpa* planted and other dry-zone acacias trials on coastal sands at Phong Dien - Hue (42km from SG Morin Hotel)
* Quang Tri MDF Geruco Wood Factory at Dong Ha - Quang Tri (75km from SG Morin Hotel)
* Research trials including Progeny trial of *Acacia crassicarpa* planted 2011; Clonal trial of *Acacia* hybrid planted 2012; and Sustainable yield trial of *Acacia* hybrid planted 2008 in Cam Lo - Quang Tri (85km from the hotel)

There will be four large bus groups. Buses A, B, C, D and divided into two groups as shown in schedule below

**GROUP 1: Bus A + B**

| Time | Itinerary | Note |
|---|---|---|
| 7:30 | Depart from Saigon Morin Hotel | |
| 7:30 - 8:30 | On the road | 42km from SG Morin Hotel |
| 8:30 - 9:30 | Visit trials in Dien Hoa | |
| 9:30 - 10:30 | On the road | 75km from SG Morin Hotel |
| 10:30 - 11:30 | Visit MDF factory | |
| 11:30 - 12:30 | Take a break and have a lunch at Research Station in Cam Lo | 1 hour |
| 12:30 - 15:30 | Visit trials in Cam Lo | 3 hours include road trip |
| 15:30 - 17:30 | Back to the hotel | |

**GROUP 2: Bus C + D**

| Time | Itinerary | Note |
|---|---|---|
| 7:30 | Depart from Saigon Morin Hotel | |
| 7:30 - 9:30 | On the road | 85km from SG Morin Hotel |
| 9:30 - 12:30 | Visit trials in Cam Lo | 3 hours include road trip |
| 12:30 - 13:30 | Take a break and have a lunch at Research Station in Cam Lo | |
| 13:30 - 14:30 | Visit MDF factory | 1 hour |
| 14:30 - 15:30 | On the road | |
| 15:30 - 16:30 | Visit trials in Dien Hoa | 1 hour |
| 16:30 - 17:30 | Back to the hotel | |

VAFS presenters will be present at each site to receive the two groups in sequence.

Travel times between the stops will vary from about 1 to 2 hours.

There will be a stop at Dong Ha station and 10 mini-buses to take each large bus group from the highway to the field trial sites at the station.

## POST-CONFERENCE ITINERARY

**March 22 (Saturday)**

Fly from Hue to Hanoi

Stay at Aranya Hotel (3 stars) in Hanoi Old Quarter

Free day: Hanoi city tours in afternoon and evening

Note: You will be picked up at the Noi Bai Aiport.

Evening you will have a chance to join a very special tradition Water Puppet Show.

| **March 23 (Sunday)** | |
|---|---|
| **Time** | **Itinerary** |
| 6:30 - 7:30 | Breakfast at the hotel |
| 8:00 | Depart hotel (80 km from Hanoi) |
| 10:00 -10:30 | Visit progeny trial of *A. mangium* with a short presentation and discussion on *A. mangium* breeding in Vietnam |
| 11:00 -11:30 | Visit satellite silviculture trial nearby |
| 11:30 - 12:30 | Visit 4x *A. mangium* clone 11 & 22 and CFF trial |
| 12:30 - 13:30 | Take a break and have a lunch at Ba Vi Research Station |
| 13:30 - 14:00 | Nursery visit |
| 15:00 - 15:30 | Visit family run sawmill |
| 16:00 - 16:30 | Tea break at Da Chong Research Station |
| 16:30 | Back to the hotel |
| 18:00 | Dinner |
| **March 24 (Monday)** | |
| 7:00 - 8:00 | Breakfast at the hotel |
| 8:00 | Depart hotel for Ba Vi national park |
| 9:00 - 10:00 | A short visit to an area near the top of the mountain |
| 10:30 - 11:30 | Visit botanic garden |
| 11:30 - 12:30 | Have a lunch at La Co restaurant |
| 12:30 | Return to Hanoi |
| **March 25 (Tuesday)** | |
| By 12:00 | Breakfast, rest and check-out hotel. Trip ends. |

***Note:*** If you would like to continue your trip in Hanoi or book any tour to explore the North of Vietnam. Please kindly contact our Conference Secretariat via info@iufroacacia2014.com.vn for help with bookings of accommodation, tours, transportation...

## Conference Program

| Day 1: Monday 17th March | | | | |
|---|---|---|---|---|
| | | Time | | |
| | p.m &evening | 17:00 | Organizing committee meeting | |
| | | 18:00 | Registration and poster set up | |
| | | 18:30 | Welcome party | |
| **Day 2: Tuesday 18th March** | | | | |
| **Chair of Session** | **Registration from 8:00** | **Time** | **Speaker** | **Topic** |
| Dr VT Phuong | | 9:00-9:10 | Prof Rod Griffin | Welcome to Acacia 2014 |
| | | 9:10-9:15 | Ass/Prof Vo Dai Hai | VIP Introduction |
| | | 9:15-9:25 | Vice Minister of MARD | Official conference opening |
| | | 9:25-9:30 | Hue Governor | Official conference opening |
| | | 9:30-9:40 | Prof Mike Wingfield | Welcome on behalf of IUFRO |
| | | 9.40-9.50 | Tony Bartlett | Welcome on behalf of ACIAR |
| | | 9:50-10:05 | Prof Mike Wingfield/ Stephen Midgley | Distinguished Contribution Award Presentation |
| | | 10:05-10:25 | Group Photo | |
| | **Morning tea** | **10:25-10:55** | | |
| Dr HH Thinh | | 10:55-11:15 | Stephen Midgley | Global uses of Acacia |
| | Plenary Talk | 11:15-11:35 | Dr Nguyen Duc Kien | Acacia as national resource of Vietnam |
| | Plenary Talk | 11:35-11:55 | Dr Neil Byron | Contribution of acacia plantations to the economy of Vietnam |
| | Plenary Talk | 11:55-12:35 | Dr Sadanandan Nambiar | Challenges for sustainable production: science and application |
| | **Lunch** | **12:35-13:40** | | |
| Prof W. Ratnam | Plenary Talk | 13:40-14:10 | Dr Aitoine Galiana | Acacia-rhizobium associations and impacts on productivity and ecosystem processes |
| | Plenary Talk | 14:10-14:40 | Dr Chris Harwood | Progress in breeding and hybridisation of tropical acacias |
| | **Afternoon tea** | **14:40** | | |
| Dr R. Arnold | **Concurrent session - Genetics and Breeding (1)** | 15:05-15:35 | Dr Eko Hardiyanto (Lead Talk) | Conventional Breeding and Hybridisation |
| | | 15:35-15:55 | Prof Chonglu Zhong | *Acacia melanoxylon:* Research and Application in China |
| | | 15:55-16:15 | Vitoon Luangviriyasaeng | Growth performance of intra- specific hybrid clones of Acacia auriculiformis in Thailand |

| Chair of Session | | Time | Speaker | Topic |
|---|---|---|---|---|
| | | 16:15-16:35 | Mudji Susanto | Genetic variation in growth and wood properties of Acacia mangium for pulp production |
| | | 16:35-16:55 | Wong Ching Yong (Lead Talk) | Deployment options for improved Acacia. Seedings, Clones or Clonal Family Forestry? |
| | | 16:55-17:15 | Dr Olivier Monteuuis | Heteroblasty and capacity for adventitious rooting in *Acacia mangium* |
| | | 17:15-17:35 | Dr Doreen Goh | Options for mass producing Acacia *mangium* and *A. mangium x A. auriculiformis* superior planting materials |
| Dr A Galiana | **Concurrent session - Plantation management for sustainable wood production (1)** | 15:05-15:35 | Dr Daniel Mendham (Lead Talk) | Understanding water, nutrient and carbon dynamics in tropical acacia plantations - Interactions with environment and management |
| | | 15:35-15:55 | Dr Inagaki Masahiro | Phosphorus use in tropical Acacias and leguminous grasses |
| | | 15:55-16:15 | Ass/ Prof Pham Van Dien | Linking hydrological aspect with silvicultural techniques for sustainable development of Acacia plantations on slope lands in Vietnam |
| | | 16:15-16:35 | Trieu Thai Hung | Predicting biomass production in Acacia hybrid (*A. auriculiformis x A.mangium*) plantations across Vietnam using the 3-PG model |
| | | 16:35-16:55 | Vu Dinh Huong | Increasing and sustaining the productivity of *Acacia auriculiformis* plantations in Vietnam |
| | | 16:55-17:15 | Jetsada Wongprom | Effect of thinning on Growth and Production of 8-year old *Acacia mangium* Willd. Under Natural Regeneration in Abandoned Mining Area at Phangnga Forestry Research Station, Phangnga province, Thailand |
| | | 17:15-17:35 | David Boden | The development of *Acacia mangium* in tropical plantations in south east Asia: an overview with focus on the impact of R & D on commercial operations |
| **Day 3: Wednesday 19th March** | | | | |
| Dr PH Hai | Plenary Talk | 8:30-9:10 | Dr Trevor Booth (presentation by Dr C Harwood) | Planting Domains of Key Species in and Changing Environment |
| | Plenary Talk | 9:10-9:40 | Prof Mike Wingfield | Biological risks of Acacia and Prospects for Managing Impacts |

| | | Time | Speaker | Topic |
|---|---|---|---|---|
| | Plenary Talk | 9:40-10:10 | Prof Wickneswari Ratnam | Advances in Genomics and Molecular Biology |
| | **Morning tea** | **10:10-10:40** | | |
| Dr Anto | **Concurrent session - Risk Evaluation and Management (1)** | 10:40-11:10 | Ass/Prof Pham Quang Thu (Lead Talk) | Ceratocystis wilt - a new and serious threat to Acacia plantations in Vietnam: taxonomy and pathogenicity |
| | | 11:10-11:30 | Dr Jeremy Brawner | Rapid screening of a diverse Acacia mangium breeding population for Ceratocystis acaciivora tolerance |
| | | 11:30-11:50 | Jolanda Roux | *Ceratocystis albifundus:* A serious threat to Acacia spp., in plantations and natural ecosystems |
| | | 11:50-12:10 | Dr Robert Hill | Enhancing health and vigour of *Acacia mangium* by nursery inoculation with selected root-endophytic *Trichoderma* isolates |
| | | 12:10-12:30 | Dr Abdul Gafur | Screening for root rot tolerance in acacias |
| Dr NH Nghia | **Concurrent Session - Plantation management for sustainable wood production (2)** | 10:40-11:10 | Dr Ang Lai Hoe (Lead Talk) | Environmental and ecological benefits of growing acacias on problematic soils |
| | | 11:10-11:30 | M. Gunawan Wibisono | Quantifying nitrogen fixation in *Acacia mangium* Willd. Plantation grown under different levels of phosphorus in Sumatra, Indonesia |
| | | 11:30-11:50 | Dr Marc Ducousso (presented by Dr Antoine Galiana) | *Acacia spirorbis* a model plant to study the contribution of symbiotic root microorganisms in plant adaptation to soil constraints: news and prospects |
| | | 11:50-12:10 | Dr Fabiano De Carvalho Balieiro | Mixed-species plantations of *Acacia mangium* and *Eucalyptus urograndis* in Southeast Brazil: aboveground biomass, nutrition and soil fertility |
| | | 12:10-12:30 | Dr Phi Hong Hai | Genetic variation in growth, stem straightness, pilodyn and dynamic modulus of elasticity in second- generation progeny tests of Acacia mangium at three sites in Vietnam |
| | **Lunch** | **12:30-14:00** | | |

| Chair of Session | | Time | Speaker | Topic |
|---|---|---|---|---|
| Prof W. Ratnam | **Concurrent session - Genetics and Breeding (2)** | 14:00-14:30 | Dr Toshiaki Umezawa (Lead Talk) | Agrobacterium tumefaciens- mediated genetic transformation of *Acacia crassicarpa* |
| | | 14:30-14:50 | Mandy Maid | "High-throughput SNP genotyping of two Australian Acacia species" |
| | | 14:50-15:10 | Dr Sheh May Tam | Effects of over-expressions of novel putative miRNAs 1(21), 2(21), 1(22) and 256(21) identified from secondary xylem tissues of *Acacia mangium* on lignin biosynthesis |
| | | 15:10-15:30 | Tyler Jones | *Acacia koa* Seed Orchard Management: Seed Protection and Insecticide Injection |
| Dr J. Brawner | **Concurrent session - Risk Evaluation and Management (2)** | 14:00-14:20 | Nick Dudley | Operational Disease Screening Program for Resistance to Vascular Wilt in Hawaiian *Acacia koa* |
| | | 14:20-14:40 | Ass/Prof Pham Quang Thu | Study on bacterial endophytes from *Acacia mangium* for induced disease resistance and growth enhancemen |
| | | 14:40-15:00 | Desy Puspitasari | Screening Basidiomycete Fungi as Potential Biological Control Agents Against Rootrot Disease |
| | | 15:00-15:20 | Prof Mohammed K. Hossain | Potential Contribution of *Acacia auriculiformis* in the Plantation Forests of Bangladesh |
| | **Afternoon Tea** | **15:30-16:00** | | |
| S. Midgley | Plenary Talk | 16:00-16:30 | Robert Flynn | Market prospects for Acacia wood chips and pulp |
| | **Poster Session** | **16:30-18:00** | | |
| | **Gala Dinner** | **19:00** | | |
| **Day 4: Thursday 20th March** | | | | |
| | Field Tour | 8:30 | Depart from Hotel | |
| | | 8:30-16:30 | Field visits. Travel by bus | Program to be advised on website http://iufroacacia2014.com.vn/content/mid-conference-tour |
| | Business Meeting IUFRO WP 02.08.07 | 18:30 | agenda to be advertised | |

## Day 5: Friday 21st March

| Chair of Session | | Time | Speaker | Topic |
|---|---|---|---|---|
| T. Bartlett | Plenary Talk | 8:30-9:10 | Dr David Richardson | Invasiveness in Acacia: Can we minimize environmental risks? |
| | Plenary Talk | 9:10-9:40 | Prof Rod Griffin | Polyploid breeding: A new pathway for genetic improvement of acacias? |
| | Plenary Talk | 9:40-10:00 | Dr Julian Moreno Chan | An overview of the *Acacia mearnsii* industry: Current status and challenges |
| | **Morning tea** | **10:00-10:20** | | |
| Dr S Nambiar | Plenary | 10:20-11:30 | | **Industry Forum: "Science for Better Policy Decisions"** |
| Dr ND Kien | **Concurrent Session - Plantation management for sustainable wood production (3)** | 11:40-12:10 | Dr Henri Bailleres (Lead Talk) | Utilisation options for Acacia wood |
| | | 12:10-12:30 | Adela Torres | Pulping and papermaking characteristics of acacia mangium |
| Evi. E. Wirawan | **Concurrent session - Genetics and Breeding (3)** | 11:40-12:10 | Dr Sascha Beck-Pay (Lead Talk) | A history of polyploid breeding in Black Wattle (*Acacia mearnsii*) at the Institute for Commercial Forestry Research, South Africa |
| | | 12:10-12:30 | Dr Anthony Koutoulis | Polyploid induction in Acacia and hop (*Humulus lupulus* L.): A comparison |
| | **Lunch** | **12:30-13:30** | | |
| Prof M. Wingfiend | **Concurrent session - Risk Evaluation and Management (3)** | 13:30-13:50 | Dr Christian Kull | Australian acacias and sustainable development around the world: Marginal livelihoods, commercial plantations and/or invasive legacies? |
| | | 13:50-14:10 | Dr John Wilson | Managing invasions from old acacia plantings |
| | | 14:10-14:30 | Dr Jaco Le Roux | Genetic insights from invasive Australian acacias. |
| Evi. E. Wirawan | **Concurrent session - Genetics and Breeding (3 cont.)** | 13:30-13:50 | Dr Steve Verryn | Chlorophyll concentration and polyploid detection as well as early indications of solid wood properties of polyploids in *Eucalyptus* spp. |
| | | 13:50-14:30 | Prof Rod Griffin (facilitator) | Methodological Issues Discussion |
| | **Afternoon tea** | **14:30-15:00** | | |
| Dr Lee Su See | Plenary Session | 15:00 | Chair Dr Lee Su See | Discussion and synthesis of key outcomes |
| | **Closing Ceremony** | **16:30** | | Dr Thinh, Prof Griffin + new IUFRO WP Chair + Prof Wingfield |

# PART I
# Abstracts

## Abstracts: Tuesday 18th March Plenary session

## Global use of Acacia - why we are here

Stephen Midgley

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Acacias are now an important global resource; more than 3.5M ha are grown in Asia, Africa and South America in commercial plantations, agroforestry plantings and smallholdings. They supply wood and fibre for industry, protect water catchments and provide fuel and building materials for rural households. Over 2M ha of plantations of the tropical acacias in SE Asia supply the pulp and paper industry with pulp worth around $US4B annually. In SE Asia the pulpwood species also provide logs for an expanding solid wood product industry. Tannin and pulps are produced from *Acacia mearnsii* grown in South Africa and Brazil. A suite of multi-purpose species is helping meet the demand for food, fodder, fuelwood, poles and site amelioration in dry zone regions of Africa and elsewhere and are incorporated into agro-forestry systems. *A.saligna* is the most widely planted non-timber species with around 600,000ha established worldwide. Many acacia species also have horticultural uses particularly in Europe.

Severe biological challenges may limit expansion of the acacia resource on some sites but is expected that the scale of production from currently planted species will expand to meet demands of population growth, using improved varieties. Plantations to meet demands of modern bio-refineries and for energy and carbon sequestration are possible new uses.

**Keywords:** Acacias, global use, plantations

# Acacia as national resource of Vietnam

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Acacias were introduced to Vietnam in 1960s and became important planting species throughout the country by the late 1990s. The total area of acacia plantations was about 1M hectares in 2010, with the largest areas in northeast and central Vietnam. *Acacia mangium*, acacia hybrid and *A. auriculiformis* are the most widely planted species. They are favoured for their fast growth, good adaptability to poor and degraded soil, ease of management and suitable wood properties for most end use products and their capacity to improve soil fertility. Acacia wood has been a major source of raw material for wood chip export and local production of pulp, composite wood products and sawn timber. Acacia planting in Vietnam has significantly reduced poverty in rural areas, creating employment opportunities and development of wood processing industries. However, acacia plantations in Vietnam face emerging challenges including pests and diseases, declining yields due to unsustainable management, effects of climatic change and market uncertainties. Research to improve acacia plantations has achieved some significant successes, notably the production and wide distribution of genetically improved planting stock, but bridging the gap from research to development remains difficult, especially for smallholder plantations. Sustainable development of Vietnamese acacia plantations requires a comprehensive, multi-disciplinary approach including tree improvement, site and stand management, pest and disease management, improvements in wood processing, appropriate policy settings and capital investment to develop local industry for better utilization of resources.

# Contribution of Acacia Plantations to the Economy of Vietnam

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This paper uses the latest data available to assess how much Vietnam's rural and overall economy has benefited from the establishment of Acacia plantations over the past 20 years. When the new technology (germplasm and silvicultural techniques) were applied to degraded and little-used former forest lands, significant new commercial opportunities were generated for domestic and international processing, and simultaneously enhanced subsistence in many areas of rural Vietnam. Previous assessments under-estimated the uptake of acacia tree-farming by small-holders and companies, the pace and extent of industrial development for processing acacia wood, and the scale of subsequent impacts.

The analysis explores:

* The ingredients for the significant successes;
* The conditions under which similar innovations could be replicated in other regions, or with other species;
* Whether there are further opportunities for further expansion (including potential new product lines and market destinations);
* Whether there are vulnerabilities attached to such success in either production (e.g. impacts of pest and disease outbreaks as occurred with other plantation crops, including acacias in Indonesia and Malaysia) or market factors (downturns in demand for specific products, technological changes, or disruptions in international trade).

## Sustainable plantation forestry: science and practices

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Wood growing, processing, value adding locally and marketing can promote rural economic development and help poverty reduction. Forests and wood products are among the best contributors for long term carbon sequestration and storage for climate change mitigation. Sustainable forestry is not all about wood production; it embraces bio-physical, economic and social variables and values, interacting at various scales. But for this presentation I focus on sustained productivity as it is the foundation on which the sustainable business of forestry, small or big, rests. Even when forests are designed to provide environmental services, productivity is a key driver of ecological processes.

Managing for sustained productivity requires foremost an understanding of the local natural resource base (land, soil, water and climate) and clarity of the purpose of forestry. We need to bring together the best that science and technology can now offer in species selection and breeding, understanding of site potential and capacity, and soil management to conserve and enhance the productive capacity (e.g. supply water and nutrients), and for protection from biological threats.

It is not essential to have a near complete knowledge of all these variables in a given region to set the forestry on a sustainable course in SE Asia. We can achieve more with what we already know if scientists were to broaden out of their disciplinary confinements, learn and adopt integrated system management, actively engage in application and facilitation in partnership with managers and policy makers.

In my view, current risks to sustainability include failures to implement what we know (e.g. avoid practices which degrade soils and landscape), propensity to search for the panacea (e.g. "super clones") and fragmented thinking and actions. These need to be tackled along with seeking solutions to problems (e.g. disease out breaks). The cooperative linkages between public and private institutions need to be established and strengthened. The opportunities and challenges for advancing sustainability are highlighted as they apply to both large and small scale growers.

## Planting domains of key species in a changing climatic environment

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This study examines how climate change may affect the locations in South East Asia suitable for growing *Acacia mangium*, *A. auriculiformis* and *A. Crassicarpa*. Simple descriptions of their climatic requirements are checked and where necessary refined. Climate data for current conditions as well as projected conditions in 2030, 2050 and 2080 are then used to map areas at a ten minute (about 18 km) resolution that are likely to have suitable climatic conditions for growing the species. The vulnerability of *Acacia* plantations in general across the region is considered in terms of the impacts of climate change and the ability of managers to adapt plantations to changing conditions. Acacias are grown on short rotations, so there will be relatively frequent opportunities to change planting stock if necessary. However, the best performing provenances for these three species come from some of the hottest locations in their natural distributions, so adaptive capacity is probably only medium. Assuming a "business as usual" climate change scenario, vulnerability is expected to be low in 2030, but likely to become medium by 2050 and high by 2080 as existing plantation sites increasingly fall outside the range of conditions known to be climatically suitable. Assessing likely impacts can help to identify plantations that are potentially most at risk, where performance should be carefully monitored to pick up early signs of any problems.

# Challenges for Acacia Breeders

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Within two decades tropical acacias have emerged as important tree plantation species in SE Asia countries, grown mainly for pulpwood and sawn timber. *Acacia mangium*, *Acacia crassicarpa*, *Acacia auriculiformis* and *A. mangium* x *A. auriculiformis* hybrid have been the focus of plantation development. The introduction of new germplasm and breeding work has increased the plantation productivity substantially. However, the potential gain in productivity has often not fully been realized in operational plantations due to improper silvicultural practices. Genotype x site interactions for growth is observed. Predicted genetic gains in stem form and wood properties are considerable. However, wood properties have not been incorporated into selection criteria in the current breeding work. Pest and disease problems have rapidly emerged in second and subsequent rotation plantations. Root rot associated with *Ganoderma* sp. has caused high mortality in the second rotation of *A. mangium* stands. Wilt disease associated with *Ceratocystis* sp. has also caused high mortality in third rotation plantation of *Acacia*. Breeding for root rot and wilt disease resistance is challenging due to limited genetic variation within these *Acacia* species. Another emerging problem is the attack by monkeys and squirrels causing serious damage of *Acacia* plantations on many sites. Selection to find genotypes not favored by monkey and squirrel is likewise a daunting task as there is no indication in resistance of the four taxa planted. Collaborative breeding works in the following areas are recommended: pest and disease resistance, polyploid breeding, genomic selection and selection of genotypes adapted to climate change.

## Concurrent session 15:05 - Genetics and Breeding

# Progress in breeding and hybridization of tropical acacias

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Out of over 1000 acacia species, just three (*A. auriculiformis*, *A. crassicarpa* and *A. mangium*) and acacia hybrid (the hybrid between *A. mangium* and *A. auriculiformis*), are planted widely for wood production in the tropics. Provenance selection and the avoidance of inbreeding have been shown to be very important to achieve good growth performance of exotic populations of these species. The growth advantage of improved seed sources based on the best natural provenances over unmanaged land races derived from inferior provenances is therefore substantial; a doubling in volume production has been demonstrated for *A. auriculiformis* and *A. mangium* in several cases. Provenance-by-environment variation in growth is of little practical importance to most breeders, because those natural provenances that form the genetic base of most current breeding programs are among the best performers in all major growing regions. Major improvements in stem form (reduction in forking and improved stem straightness) have also been achieved, and the potential for improvement in wood properties has also been demonstrated, particularly for *A. auriculiformis* and acacia hybrid which are amenable to deployment via rooted stem cuttings, enabling non-additive genetic variance to be exploited through clonal forestry. However, clonal forestry has not proved feasible for *A. crassicarpa* and *A. mangium*. Advanced-generation gains in volume growth exceeding 10% for seed orchards based on the second, over the first improved generation, have not been reported. Breeding for disease resistance is now a priority, but prospects of progress are not encouraging, given the known low levels of genetic variation, particularly in *A. Mangium*.

# *Acacia melanoxylon*: research and application in China

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Australian acacias are planted in China for wood production and environmental protection. Current plantation area is around 300,000 ha, comprising main species such as *A. auriculiformis*, *A. crassicarpa* and *A. mangium* in the tropical region, and *A. mearnsii* and *A. melanoxylon* in the subtropical region. *A. melanoxylon* was first introduced to China together with many other Australian species by ACIAR projects in the 1980s, and has shown promising growth performance on degraded sites in Guangdong, Fujian, Jiangxi and Yunnan provinces. Since 2000, there has been an increasing interest in commercial planting of *A. melanoxylon* for high-value timber production, however, good quality seed and planting materials are lacking. Research conducted on this species in China to date includes genetic resource studies at provenance, family and clone levels; molecular characterization of genetic diversity; sexual and asexual propagation techniques; plantation silviculture; physiological characterstics; rhizobium association; and wood properties. In this paper we summarise results from the research and application of *A. melanoxylon* in China, and propose a strategy for production of genetically improved seed and clones to support the planting program.

**Keywords:** *Acacia melanoxylon*, genetic resources, selection, propagation, silviculture, wood property, rhizobia

# Growth performance of intra-specific hybrid clones of *Acacia auriculiformis* in Thailand

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*Acacia auriculiformis* was first introduced to Thailand from an unknown source in Australia in 1935. The species has shown good adaptability and has been planted widely throughout the country. The wood has a quality suitable for general construction and furniture making. However, the trees have a propensity to produce multiple or crooked stems which limits the use as sawn timber.

Genetic improvement of this acacia species in Thailand commenced in 1983 with a specific objective to improve the growth and stem form. Early provenance/progeny trials in the late 1980s and early 1990s with new seed sources from Queensland and Northern Territory, Australia and Papua New Guinea revealed all new introductions outperformed the local land race. Subsequently, the genetic improvement program has focused on these new introductions with local land race being excluded. Selected superior individuals of provenances from Australia and Papua New Guinea were propagated by marcotting and used in a controlled crossing program as part of an ACIAR forestry project. Seedlings raised from seeds obtained from these crosses were planted out to provide a base for selection and propagation of rooted cuttings for clone trials. The first series of clone trials consisting of 19 clones have been established on four sites of different soil and climatic conditions. Growth (height and diameter at breast height) and stem form (axis persistence, stem straightness and branch thickness) have been assessed annually. This paper reports the growth performance at age 4 years old across the four test sites. Despite only the best ortets based on growth and stem form being selected and propagated for field test, there was clear variation among the clones in the growth traits. Significant interaction between clones and test sites (G x E) was also observed. The results underpin the importance of a vigorous clonal testing program in *A. auriculformis* before deployment of the improved materials.

**Keywords:** clonal test, *Acacia* hybrid, Growth, Stem form

# Genetic variation in growth and wood properties of *Acacia mangium* for pulp production

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Genetic growth and wood properties variation for pulp production was researched to improve growth and wood quality of *Acacia mangium*. The result was reported from 2 progeny trials of *A. mangium* in South Kalimantan and Central Java. The trials have a different seedlots and different age. The progeny trial in South Kalimantan contained 63 open pollinated families representing 4 provenances from Queensland, while the progeny trial in Central Java contained 142 open pollinated families representing 17 provenances from Queensland and Papua New Guinea.

Average growth and wood properties at age 22 months in South Kalimantan were 9.92 cm for DBH; 0.40 for specific gravity; 0.89 mm for fiber length. Average growth and wood properties at age 5 years in Central Java were 14.66 cm for DBH; 0.43 for specific gravity; and 1.04 mm for fiber length. There were significant differences between both provenance and families- within- provenance for DBH; specific gravity; and pilodyn penetration in all of the trails. The only significant differences between families-within-provenance for fibre length in South Kalimantan. The strong negative genetic correlations between specific gravity and pilodyn penetration were found in the trails ($r_g$=-0.83 in South Kalimantan and $r_g$=-0.91 in Central Java). The estimates of individual tree heritability's for DBH were high ($h^2_i$=0.49) in South Kalimantan and very low ($h^2_i$=0.02) in Central Java. The estimates of individual tree heritability's for wood properties were medium to high ($h^2_i$=0.33 to 0.56 for specific gravity; $h^2_i$=0.30 to 0.62 for pilodyn penetration; and $h^2_i$=0.10 to 0.39 for fibre length).

**Keywords**: *Acacia mangium*-wood property- heritability-genetic improvement-genetic gain

# Deployment of *Acacia mangium* and *Acacia crassicarpa* in Short Rotation Pulpwood Plantation

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Large scale *Acacia mangium* and *Acacia crassicarpa* plantations have been established since early eighties for pulp and paper in Indonesia. Early planting of *A. mangium* plantations were established mainly from seed of Central Queensland provenances or seed of the land race located in Subanjeriji, South Sumatra. These plantations are low yielding with multiple stems. In the nineties, well adapted *A. mangium* provenances from PNG and Far North Queensland (FNQ) and *A. crassicarpa* from PNG provenances were used for plantation establishment. However, as there was insufficient seed of good provenances available, vegetative propagation via cuttings was developed to multiply the superior *A. mangium* and *A. crassicarpa* provenances. These initiatives together with good silviculture have raised the MAI to over 30m$^3$/ha/year in a 6 year rotation for *A. mangium* plantations and 23m$^3$/ha/year for *A. crassicarpa* over 5 year rotation. In the early 2000s, open pollinated seed of high fibre yield *A. mangium* and *A. crassicarpa* families were directly raised for mother plants to produce rooted cuttings via Clonal Family Forestry (CFF). Further refinement is made by using control pollinated seeds of desirable parent trees and propagated via tissue culture for establishment as mother plants. The mother plants are then replaced regularly with new seedlings and or plantlets to avoid ageing. Seed were deployed based on genetic merits for both species for the remaining planting program over the three decades.

The gains from CFF over open pollinated *A. mangium* seedlings are eroded by the higher incidence of wind damage and root diseases over successive rotations of planting *A. mangium* on the mineral soil. *A. mangium* cuttings are observed to have 7% higher wind damage incidence than seedlings at 4 years old. Rooting studies aimed at recovering the losses through better nursery practices have been implemented especially on improving the number of roots and root distribution on the basal cutting. Application of IBA rooting hormone to the basal one cm of cutting improved by 68% and 10% on the number of roots and root distribution respectively for *A. crassicarpa* and 29.3% and 60% for *A. mangium* at 4 weeks old respectively. Study on the effect of roots on different quadrants of *A. mangium* & *A. crassicarpa* cuttings on tree stability in the field is ongoing.

With the successive planting of acacias over several rotations, *Ganoderma philippii* and *Ceratocystis acaciivora* are the primary causes of high mortality in *A. mangium* plantation. A comprehensive program was initiated through genetic tolerance screening and the use of bio-agents, such as, endophytic *Trichoderma* to control the diseases. Where the risk of these diseases is high, species change to eucalyptus or *A. Crassicarpa* is necessary. As stocking and site productivity are the primary drivers for high fibre yield plantation, planting at higher density has also improved stocking at rotation. This has resulted in higher yield at all rotations. Recruitment of *A. mangium* wilding is also an option to increase stocking and final yield of short rotation plantation.

**Keywords**: Deployment, vegetative propagation, rooting, species site matching, site productivity.

## Heteroblasty and capacity for adventitious rooting in *Acacia mangium*

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*Acacia mangium*, a pioneer tree legume of major importance in re-afforestation programs in the humid tropics, is an heteroblastic species. In natural conditions, seedlings produce during the first phases of their ontogenetical development compound leaves that evolve into intermediate phyllode-pinnate leaves before becoming full phyllodes from the 9 to 11$^{th}$ node position upward. Compound leaves characterize thus the more juvenile physiological stage, whereas phyllodes appear roughly 12 to 16 weeks after germination, much earlier than the maturation phase classically defined as the attainment of the flowering ability. Such morphological changes are however reversible: under certain circumstances, mature *A. mangium* bearing phyllodes exclusively can produce compound leaf shoots. Physiological ageing is also responsible for changes of capacity for adventitious rooting, which decreases more or less rapidly as plants age from germination. The question to know whether these juvenile or mature-like foliage features can be considered as reliable markers of adventitious rooting capacity in *A. mangium* was investigated. In nursery conditions, mature-like phyllode cuttings derived from mature sprouting stumps displayed comparable, when not higher, rooting capacities than cuttings ontogenetically younger with the intermediate phyllode-pinnate or compound leaf morphology from the same source, or from 1 yr old seedlings. Adventitious rooting ability varied greatly according to leaf morphology X plant material age X photoperiod interactions in more stable and controlled *in vitro* environment. These observations plead for a relatively independent control of heteroblasty and capacity for adventitious rooting, which remains highly dependent on the physiological status of the (micro) cuttings, liable to vary unpredictably.

**Keywords:** *Acacia mangium*, Adventitious rooting, Ageing, Compound leaf, Heteroblasty, morphological marker, Phyllode

# Options for mass producing *Acacia mangium* and *A. mangium x A. auriculiformis* superior planting materials

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*Acacia mangium* and *A. mangium X A. auriculiformis* hybrids have gained widespread interest in re-afforestation programs under humid tropical conditions for pulp-wood production due to their outstanding growth on acid and degraded soils, and their natural nitrogen-fixing ability which helps to increase soil fertility. A 25 year-long experience in applied and research activities on these species have led to the following observations: *A. mangium* becomes physiologically mature 2 to 3 years after germination to profusely produce seeds with a high germination capacity. Species vigor is not so prone to inbreeding depression and varies greatly according to the genetic provenances. Clonal propagation by rooted cuttings, microcuttings or even grafting is eventually hampered by the negative effect of physiological ageing. The foliar dimorphism characteristic of this heretoblastic species cannot be considered as a reliable salient marker of its capacity for adventitious rooting. Mass production of superior plants from selected seed sources is likely the most recommendable option for *A. mangium*. This is however, not applicable to the interspecific *A. mangium X A. auriculiformis* hybrid. Clones from selected hybrid mature trees can be propagated far more easily and at a cheaper cost than *A. mangium* under *in vitro* culture. Physiologically rejuvenated mature genotypes can also be utilized to produce a limited number of *in vitro* microshoots with a high rooting capacity to be managed as stock plants for the mass production of rooted cuttings at cheaper cost in nursery facilities. These two options are supported by numerous concrete and practical figures in various environments.

**Keywords:** *A. mangium, A. hybrids,* clonal propagation, *In vitro* culture, rooted cuttings

## Concurrent session 15:05 - Plantation management for sustainable wood production

# Understanding water, nutrient and carbon dynamics in tropical acacia plantations - Interactions with environment and management

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With the assistance of the Australian Centre for International Agricultural Research (ACIAR), we have had the opportunity to study the nutrient, water and carbon dynamics in tropical acacia plantations in Australia, Indonesia and Vietnam. This has helped us to understand how we can better manage site resources to optimise plantation productivity. Factors such as soil depth, soil fertility and climate, all determined by the site itself, have a large impact on nutrient and water dynamics, thereby influencing the site's productivity potential. This means that site selection is one of the most critical management choices. Acacias at most, if not all, sites appear to have a significant growth response to phosphorus (P) fertilizer at establishment, but then a low requirement for P to attain maximum productivity. Nitrogen (N) cycling under acacia plantations is critically important, with significant quantities of N being fixed. Early indications suggest that this leads to a build-up of site fertility and reduces the requirement for fertilizer N of following non-leguminous crops. The key learnings from this work have been integrated into the process-based physiological model, CABALA, which is further helping us to develop our understanding of the acacia plantation system. This presentation will outline the main advances in our knowledge of how to manage water and nutrients to best exploit and sustain the productivity of acacia plantations.

## Phosphorus use in tropical *Acacia*s and leguminous grasses

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In tropical regions, phosphorus (P) in soils tends to limit plant growth, and leguminous plants are generally considered to require a large amount of P compared to nitrogen (N) used for $N_2$-fixation with symbiotic $N_2$-fixing bacteria. However, recent studies have revealed that some trees and leguminous grasses can survive under P-limited conditions due to inherent traits. In the present study, I summarize previous studies on the abilities of tropical *Acacia* trees and various agricultural grasses to acquire and utilize P under P-limited conditions. Leguminous trees and grasses tend to produce acid phosphatase in their rhizosphere, enabling greater organic-P acquisition compared to other plants. The extracellular phosphatase around the rhizosphere of leguminous plants is produced by symbiotic microorganisms such as mycorrhizal fungi and the cluster roots produced by certain leguminous grasses. Some *Acacia*s in Australian deserts enable iron (Fe)-bound inorganic P by chelating Fe using carboxylic acids released from the root surface. Tropical *Acacia* trees more intensively retranslocate P from senescent leaf tissue than they do N. The N:P ratio of leaf litter of *Acacia*s tends to be considerably higher than that of fresh leaf tissue. At an equal biomass, the accumulated P in the total aboveground biomass of *Acacia* trees tends to be smaller than that of non-$N_2$-fixing broadleaf trees. Thus, some tropical legumes, including *Acacia mangium*, are believed to have the ability to regulate P acquisition and to intensively utilize P.

**Keywords:** phosphorus limitation, acid phosphatase activity, root exudates, resorption, nutrient accumulation

# Linking hydrological aspect with silvicultural techniques for sustainable development of Acacia plantations on slope lands in Vietnam

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Hydrological characteristics take an important role for considering silvicultural techniques aiming at sustaining forest ecosystems, but this aspect has not been given proper attention so far in Vietnam. Therefore, the study addresses this problem. Based on 30 sample plots, which established in Hoa Binh province and Hanoi city in a duration from 2010 to 2012 for *Acacia mangium* and *Acacia auriculiformis*, the study has determined some important hydrological characteristics as overland flow, soil water storage and soil loss amounts as well as quatitative relationships between them with important influenced factors (by using ordinary and fuzzy regression models). From the above results, the study recommended two silviculture recomendations for both protection and production forests. For protection forests, it helps determining structured criteria for each combination of planted site. For production forests, it helps determining suitable sites for acasia plantation. The study can be considered as a typical example of linking hydrological aspect with silvicultural techniques for sustaining plantation on slope lands in Vietnam.

**Keywords**: hydrological characteristics, silvicultural technique, acacia plantation.

# Predicting biomass production in *Acacia* hybrid (*A. auriculiformis* x *A. mangium*) plantations across Vietnam using the 3-PG model

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The planting of *Acacia* hybrid (*A. mangium* x *A. auriculiformis*) as an important commercial species due to its fast growth and adaptation to a wide range of site conditions commenced in Vietnam in the late 1990s. However, for this resource there is little research information available that adequately quantifies how soils and environment contribute to realised productivity. This study uses the 3-PG (Landsberg and Waring, 1997) process-based model to examine the productivity and carbon (C) sequestration of *Acacia* hybrid across a range of soil types and climates in Vietnam. The 3-PG model was first parameterised and calibrated for *Acacia mangium* plantations using limited experimental data from commercial plantations in Vietnam with encouraging results (Sang, 2008).The applicability of the 3-PG model for simulating *Acacia* hybrid plantation biomass and timber growth was examined here. Data was collected from 13 sites of *Acacia* hybrid of differing rotation age, and from a representative range of climatic and site conditions across Vietnam for the parameterisation, calibration and validation of the model. Measurements of tree growth, wood density, biomass allocation, stomatal conductance, leaf area index, specific leaf area, litterfall and weather variables were made at one site in stands aged 1, 3 and 6 years old. We show that 3-PG can realistically simulate stand growth, biomass partitioning and leaf area index over a wide range of rotation age and growth conditions, and discuss the further research needed to increase the applicability and reliability of 3-PG for simulating plantation forest productivity and carbon sequestration in tropical environments.

**Keywords:** 3-PG model, *Acacia* hybrid, Biomass production, Growth stand, Leaf area index, Carbon sequestration

# Increasing and sustaining the productivity of *Acacia auriculiformis* plantations in Vietnam

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Acacia species occupy around 1.1 million ha of Vietnam. Their productivity in commercial plantations ranges from 10 - 25 $m^3 ha^{-1} y^{-1}$. In general, there is little information on the site, soil and management factors determining the productivity of acacia plantations, and especially on sustaining productivity over successive rotations. In a long term project (in progress since 1999/2000) we studied the effects of various inter-rotation slash and litter management practices on productivity of an *A. auriculiformis* plantation at a site in south Vietnam. We examined the impact of these treatments on tree growth and soil properties over a full second rotation (6 years) and now 5 years into the third rotation. Contrasting slash and litter management treatments were applied at the start of the second rotation, and then re-applied at the start of the third rotation with an additional P fertilizer treatment. There were genetic improvements in the planting stock at every rotation, so also major improvements in vegetation control from first to second rotation. Productivity of the stand increased from 10.6 $m^3 ha^{-1} yr^{-1}$ in the first rotation (age 7 years) to 28.3 $m^3 ha^{-1} yr^{-1}$ in the second rotation (age 6 years) and to 33.9 $m^3 ha^{-1} yr^{-1}$ in the third rotation (age 5 years). Removal of slash and litter after harvesting the first rotation removed 19,800 kg $ha^{-1}$ biomass, N 162.0 kg $ha^{-1}$, P 12.8 kg $ha^{-1}$, K 72.7 kg $ha^{-1}$ and Ca 23.7 kg $ha^{-1}$ from the site. Even greater amounts were removed after the second rotation as the amounts of slash and litter was also higher. Removal of slash and litter reduced standing volume by around 6% compared to treatments with slash and litter retained. Slash and litter retention also led to an increase in soil organic carbon by 26% and nitrogen by 40% in the surface soil after the second rotation. There was a gradual decrease in the extractable soil P during the second rotation. This was matched with a response to added P in the third rotation while there was no response in the second rotation. Overall results demonstrate the opportunities for increasing and sustaining production of *A. auriculiformis* by integrated management practices including organic matter conservation, judicious vegetation and nutrient management, better stocking and planting of genetically improved stock. The *A. auriculiformis* stand in this project had very good stem form and were suitable for furniture timber, which commands high prices in Vietnam.

# Effect of thinning on Growth and Production of 8-year old *Acacia mangium* Willd. under Natural Regeneration in Abandoned Mining Area at Phangnga Forestry Research Station, Phangnga province, Thailand

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Effect of thinning on growth and production of 8-year old *Acacia mangium* Willd. under natural regeneration in abandoned mining after *A.mangium* plantation clear cutting was carried out at Phangnga Forestry Research Station, Phangnga province, Thailand. RCBD with three replications was used with 20 m x20 m plot each. Three different thinning schemes with 175 ($T_1$), 300 ($T_2$) and 600 ($T_3$) remaining trees per ha were compared with the control, 831 trees $ha^{-1}$. Growth performance, i.e. current annual increment (CAI) and relative growth rate (RGR) of diameter at breath height (DBH), height (H), aboveground biomass (W) and total stem volume (V) of trees were analyzed the differences between treatments by analysis of variance (ANOVA) and Duncan's Multiple Range Test accordingly. The results showed that after thinning CAI of DBH and H were increased with decreasing stand density. After thinning for 1- 3 year, both CAI and RGR of DBH and H of trees observed in $T_1$ was highest. Total aboveground biomass ($W_t$) and total stem volume (V) production of 11 year old *A.mangium* (after thinning for 3 year) found highest value in $T_3$ followed by the control, $T_2$ and $T_1$ trees $ha^{-1}$ (183.55, 143.77, 110.12 and 81.89 tons $ha^{-1}$ ; 320.92, 258.58, 189.83 and 139.83 $m^3$ $ha^{-1}$), respectively. On the other hand, production of $W_t$ and V per tree, $T_1$ had highest value followed by $T_2$, $T_3$ trees $ha^{-1}$ and control (467.93, 367.06, 305.91 and 209.78 kg $tree^{-1}$; 0.80, 0.63, 0.54 and 0.37 $m^3$ $tree^{-1}$), respectively. In conclusion, thinning scheme on of 8-year old *A. mangium* under natural regeneration should remain the density 175-300 tree $ha^{-1}$. The second thinning in $T_3$ should be undertaken to promote growth rate and earn more income.

**Keywords:** Thinning, growth, production, *acacia mangium* willd., natural regeneration, abandoned mining area

# The development of *Acacia mangium* in tropical plantations in south east Asia: an overview with focus on the impact of R & D on commercial operations

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*Acacia mangium* has been the dominant species in the tropical regions of south-east Asia for almost 25 years. It is of interest to reflect on the changes in productivity that have occurred and the role that R&D has played in these developments.

*A. mangium* proved a successful species from the start as acceptable yields were obtained using wild seed and basic silvicultural inputs. Yet after 25 years of often intense R&D there are few organisations that consistently achieve Mean Annual Increments exceeding 30 $m^3$/ha. The results from a range of tree improvement programs are discussed for gains in growth and wood qualities. The impact of changing deployment strategies is outlined and aspects such as nutrition, stocking and singling investigated in the search for improved yields.

Issues which have adversely affected yields over time are considered. Natural mortality frequently results in only half of the original trees being harvested at 7 years. The adverse impact of increasing losses due to *Ganoderma* root rot and site degradation following harvesting are discussed. The changing role of *A. mangium* is considered against the changes from its use as a pulping species to a broader range of end uses. The development of thinning and pruning regimes to improve log quality are discussed.

Finally the impact of *Ceratocystis acaciivora* canker wilt is considered and the future of *A. mangium* in the region may be determined by the ability to breed around the pathogen or for currently unaffected plantations to keep infection levels low.

**Keywords**: *A. mangium*, productivity changes, R&D impacts, mortality, ceratocystis

## Biological risks for *Acacia* and prospects for managing impact

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Globally, and in comparison to the case for species of *Pinus* and *Eucalyptus*, Acacia plantation forestry is relatively new. While species such as *Acacia mearnsii* have been planted on a relatively small scale, it is only in the last three decades that large areas have been planted to *Acacia* spp. Consistent with trends for other tree species planted as non-natives, these *Acacia* spp., mostly *Acacia mangium* and *Acacia crassicarpa*, were not severely challenged by pest and disease problems during their early years of establishment. Also typical for plantings of non-native tree species, the first health problems have been caused by native pathogens and insects. As time has passed, pests and pathogens known on *Acacia* spp. in their native areas have gradually appeared and this trend is also likely to continue into the future. All indications are that *Acacia* spp. established as non-natives in plantations will be challenged by increasing numbers of disease and pest problems, a trend typical for such plantation forestry. As has been true for Eucalypt and pine forestry, it should be possible to deal with these challenges using the many already available and increasingly sophisticated technologies. With breeding, selection, hybridization and the many gene-based technologies applied to the trees of interest, but importantly also to the insects and pathogens that challenge them, there is good cause for optimism. The caveat is that failure to invest appropriately in these technologies will most likely also underpin dramatic losses.

# Advances in Genomics and Molecular Biology of *Acacia* species

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*Acacia mangium*, *A. auriculiformis*, *A. crassicarpa* and *A. mangium* x *A. auriculiformis* hybrid are the most popular *Acacia* species planted in Southeast Asia for timber and pulpwood production. The ASEAN region has an estimated 2 million hectares of plantations of these tropical *Acacia* species and there is a growing demand for improved planting materials. The other notable industrial *Acacia* species is *A. mearnsii* grown mainly in South Africa (120,000 ha) and Brazil (250,000 ha).

Genomic information, such as ESTs, transcriptome sequences, genomic sequences, microRNA sequences and DNA markers has been intensively collected from a limited number of *Acacia* species mainly to accelerate the breeding process. The accumulating information will also provide an opportunity to perform comparative analyses to decipher the evolutionary process of genomic structures and functions in leguminous plants. Currently, there are more than 10,000 entries in the NCBI dbEST for *A. mangium* and *A. auriculiformis* x *A. mangium* hybrid. Transcriptomes of *A. mangium* and *A. auriculiformis* have been sequenced, assembled and annotated. Some genes involved in wood formation, lignin biosynthesis, shoot and floral development have been identified and characterized. In an attempt to better understand the regulation of lignin genes, the role of small RNAs (microRNAs and siRNAs) which are involved in post-transcriptional gene silencing and epigenetic regulation was investigated. Two small RNAs libraries from samples with contrasting lignin content were generated using Solexa Second Generation Sequencing Technology.

Several conserved and novel small RNAs that may serve as an important regulatory sequence during secondary wall formation were identified. Majority of these small RNAs emerged as critical regulators for normal growth and developmental processes. We have validated that a cascade of small RNAs will play an interconnected role in regulating the lignin biosynthetic pathway in *Acacia* species through real time PCR approach. Resequencing of *cinnamoyl coenzyme A reductase* (*CCR*), *caffeate O-methyltransferase* (*COMT*), *cinnamyl-alcohol dehydrogenase* (*CAD*), *cinnamate 4-hydroxylase* (*C4H*) and *caffeoyl-coenzyme A O-methyltransferase* (*CCoAOMT*) full length genes enabled the detection of 78 SNPs which were genotyped across 240 individuals of *A. mangium* and 240 individuals of *A. auriculiformis* using Illumina Golden Gate Bead Array. Fifteen SNPs (six for

*CCR*, three for *COMT* and six for *CAD*) were polymorphic in *A. auriculiformis* whereas eight SNPs (five for *CCR*, one for *COMT* and two for *CAD*) were polymorphic in *A. Mangium*.

The paucity of polymorphic gene based SNPs for QTL mapping was addressed by *de novo* transcriptome assembly using Illumina GAII sequencing. A total of 43,286 putative Single Nucleotide Polymorphisms (SNPs) were detected from 7,839 contigs assembled from four transcriptomes of parents for two full sib $F_1$ mapping populations (WD and FL). After stringent filtering and validation of a subset of the *in silico* detected SNPs, a total of 768 SNPs based on two-way pseudo-testcross strategy, even genome coverage and increased assay successful rate were used for linkage analysis. Four linkage maps were constructed for each parent using Joinmap. For WD population, 239 and 163 markers were mapped to paternal and maternal map where 13 linkage groups ranging from 22.9 cM to 156.6 cM were identified. The total lengths of WD paternal and maternal maps were 1086.7 cM and 822.3 cM with an average marker interval of 4.5 and 5.0 cM respectively. For FL population, 78 male and 45 female markers were mapped and total lengths of 498.2 cM and 237.1 cM spanning 10 and 7 linkage groups in male and female parent respectively were obtained.QTL mapping will be carried out after phenotypic evaluation of the mapping populations has been completed in October 2014. This collection of digital transcriptome and small RNA libraries will also provide a wealth of resources for further investigation of genes involved in lignin biosynthesis and wood formation. Better understanding of the structural and regulatory genes involved in the complex lignin biosynthetic pathway and the successful detection of pulpwood quality QTLs in *A. mangium*, *A. auriculiformis* and their hybrid will have immediate benefits to the pulp and paper and related industries.

**Keywords:** *Acacia species*, wood formation, lignin genes, expressed sequence tags, transcript profiling, small RNAs, transcriptome sequencing, single nucleotide polymorphisms, high density linkage map

# Acacia-rhizobium associations impacts on productivity and ecosystem processes

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Phyllodineous humid-zone acacias have become major plantation tree species in the last three decades, particularly *Acacia mangium* that is used for pulpwood in South-East Asia. As almost all species from the Mimosaceae family, *A. mangium* can fixes atmospheric $N_2$ due to its symbiotic association with rhizobium. Since it is able to grow on N-depleted soils, *A. mangium* is often used in agroforestry systems or as a fallow species to restore and maintain the fertility of soils. In this review, we report an overview of our results obtained since the 90's from several rhizobium inoculation experiments and field trials conducted on *A. mangium* in Africa, South-East Asia and South America under various edaphic and ecological conditions. Inoculation of *A. mangium* seedlings by selected *Bradyrhizobium* strains at the nursery stage had a positive effect on tree growth in most situations and was observed up to three to four years after tree transplantation. Molecular or immunological identification of the rhizobium strains present in the root nodules of trees confirmed the long-term persistence of the most efficient ones, up to twelve years after transfer of the inoculated trees to the field. Rhizobium strain efficiency has also been assessed by quantification of $N_2$ fixation using isotopic methods. The percentage of nitrogen derived from $N_2$ fixation (%Ndfa) in *A. mangium* trees was highly variable according to the pedoclimatic conditions and the rhizobium strain inoculated to a lesser extent. In Cụte d'Ivoire (West Africa) for example, %Ndfa evaluated in 2 year-old trees was correlated with soil fertility, varying from 20% in the most fertile plots to 90% in the poorest ones. Rhizobium inoculation can be easily implemented at low cost in the framework of large-scale plantation programs, but requires for each situation a preliminary selection step based on efficiency, persistence, and competitivity among local *Bradyrhizobium* strains adapted to the planting site conditions.

**Keywords:** Symbiotic association, Nitrogen fixation, legume tree, *Bradyrhizobium*, soil fertility.

## Concurrent session 10:40 - Risk Evaluation and Management

# Ceratocystis wilt - a new and serious threat to *Acacia* plantations in Vietnam: taxonomy and pathogenicity

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*Acacia mangium*, *A. auriculiformis* and Acacia hybrids are commonly planted on a 10-15 year rotation in Vietnam, where they are utilized for the production of pulp, MDF boards and saw logs. Recently, plantations of *Acacia* in Vietnam have experienced a serious disease problem with up to 20% mortality in many locations. The aim of this study was to consider the incidence of this disease and to better understand its causal agent. Wilt, crown die-back symptoms as well as discoloured wood were common features on 3-4 year-old trees. Forty-one *Ceratocystis* isolates obtained from discoloured wood specimens collected in 15 provinces were examined based on morphology and DNA sequence data. Based on a comparison of sequence data generated from 24 isolates using three gene regions, it was clear that a *Ceratocystis* sp. in the *Ceratocystis fimbriata* complex causes this disease, but the species-level identification remains contentious. The most closely related species are *C. acaciivora* and *C. maginecans* but there is evidence to suggest that there are hybrids between these species, resulting in incongruence in the gene trees. Pathogenicity of the isolates was assessed through artificial inoculation into the bark of 18-month-old *A. mangium* seedlings in a nursery. The aggressiveness of the isolates to *A. mangium* seedlings was variable suggesting that it will be possible to select planting stock with resistance to the disease. This Ceratocystis disease is the most serious problem to emerge in plantations of *Acacia* spp. in Vietnam and it represents a serious threat to the industries based on these trees.

**Keywords:** *Acacia* plantations, *Ceratocystis* wilt, pathogenicity, identification

# Rapid screening of a diverse *Acacia mangium* breeding population for *Ceratocystis acaciivora* tolerance

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Following a dramatic rise in disease incidence within *Acacia mangium* plantations in eastern Sabah that led to the replacement of thousands of hectares with other species, a *Ceratocystis* screening program was initiated to evaluate levels of disease resistance or tolerance in existing breeding populations. Resistance was evaluated as the presence or absence of external symptoms in two open pollinated progeny trials while tolerance was evaluated as the trees ability to restrain fungal growth following controlled inoculation with the causative fungus in one of these trials. Estimates of genetic parameters indicate a lack of genetic control for both resistance and tolerance in a diverse population of *Acacia mangium*. The implications for the development of *Ceratocystis* resistant or tolerant breeds of *Acacia mangium* will be discussed.

**Keywords:** Acacia mangium, Ceratocystis, Disease screening, Genetic parameters

# *Ceratocystis albifundus*: A serious threat to Acacia spp., in plantations and natural ecosystems

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The fungal genus *Ceratocystis* was first associated with a plant disease in the late 1800's. Since then, it has become known as one of the most important genera of tree killing fungal pathogens globally. In Africa, *Ceratocystis albifundus* can result in the wilt and death of 18-month-old Australian *Acacia mearnsii* trees within six weeks after infection. More recently, in South East Asia, *C. acaciivora* has resulted in the clear-felling of thousands of hectares of *A. mangium* trees. Importantly, both these recently discovered *Ceratocystis* species were unknown to science when they were first discovered, emphasising the fact that they are newly emerging pathogens. Our research has shown that *C. albifundus* is an African fungus that has adapted to infect Australian *Acacia* species. It has been recorded from approximately ten African tree families, on which it does not cause any apparent disease problems. Population genetic studies on the fungus have shown a high level of genetic diversity, typical of a native fungus in its native range. Currently, *C. albifundus* is known only from the African continent. *Ceratocycstis albifundus*, *C. acaciivora*, and other as yet unrecorded *Ceratocystis* species represent a significant threat to commercial plantation forestry using *Acacia* species. Australian *Acacia* species, in their native range, should be considered as particularly vulnerable to infection by *C. albifundus*. Thus, strict quarantine measures should continue to be enforced globally to prevent the movement and establishment of *Ceratocystis* species as well as other tree pathogens in new environments.

**Keywords**: Microascales, novel encounters, wilt disease

# Enhancing health and vigour of *Acacia mangium* by nursery inoculation with selected root-endophytic *Trichoderma* isolates

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Root-endophytic *Trichoderma* isolates were obtained from root samples taken from a wide variety of exceptionally healthy plants in the locality of the Samarakan Nursery, which supplies *Acacia mangium* seedlings for the Planted Forest Zone (PFZ) in Sarawak, Malaysia. Nursery trials based on approximately 50 single isolates and selected mixtures of these were conducted between 2008 and 2009. Root-endophytic *Trichoderma* isolates were inoculated by applying an aqueous suspension of conidia to the growing medium at the time of seed sowing. The most effective treatments resulted in an increase in productivity of >66% in seedlings meeting specification for planting out into the PFZ. These results were validated in large-scale trials conducted in 2010 which showed the same productivity increase from the best isolates. A trial examining the effects of mixing the *Trichoderma* inoculum into the growing medium before seed sowing compared with application of a conidial suspension (as in the initial trials) demonstrated that both delivery methods gave exactly the same results. Nursery inoculated trees have shown a reduction in mortality from diseases of more than 30% and increased growth; up to 15% greater tree height and stem diameter (DBH) in PFZ plantations. *Trichoderma* inoculation is now standard operating practice at the Samarakan Nursery, replacing multiple sprays of fungicide cocktails and reducing the time taken for seedlings to meet specifications for planting out into the forest from 108 to 90 days. This project is an ongoing collaborative venture between Grand Perfect Sdn Bhd, Sarawak, Malaysia, and the Bio-Protection Research Centre, Lincoln University, New Zealand.

**Keywords:** *Acacia*, Bioprotection, Increased productivity, Nursery trials, Plant health, Plant vigour, Plantation trials, Planted Forest Zone, Root endophytes, *Trichoderma*

# Screening for root rot tolerance in acacias

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Root rot is one of the most economically important diseases on acacias, especially *Acacia mangium*. Research on field control of the diseases has so far been focusing more on inoculum reduction, silviculture practices, and application of biological control agents. Incorporation of tolerant materials, a key component of integrated disease management, into the effort has not been adequately explored because of unavailability of reliable and quick screening protocols. Recently we developed a method of screening for root rot tolerance in acacia seedlings. Using the technique we are able to identify variations in tolerance or susceptibility to the root rot pathogens in a more consistent manner. Compared to the conventional pot screening system, the present screening procedure also reduces trial completion time significantly. Results of the screening and potential use of plant tolerance in root rot management in acacia plantation forests are discussed.

**Keywords**: acacia, disease management, plantation forest, root rot, screening for tolerance.

## Concurrent session 10:40 - Plantation management for sustainable wood production

# Environmental and ecological benefits of growing Acacias on problematic soils

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Fast-growing acacias were introduced to the tropics during the 1980's mostly for timber production especially *Acacia mangium* in Malaysia. These plantations are established on good mineral soils. Acacias are also planted for environmental conservation and some as ornamental species. Due to their symbiotic association with the nitrogen fixing micro-organisms and adaptive morphological properties to harsh environment, acacias are popularly used for rehabilitation and restoration of problematic soils. The role of acacias as timber species is well documented but little is known for their roles as site improvers. In addition, a mixed acacias stand as a man-made forest often also acts as a shelter and also to provide myriad food for the avian seed-dispersers which encourages natural regeneration. Hence, this paper aims to discuss the beneficial uses of acacias as a site improver and nurse-tree for enriching impoverished soil properties, remediating soil toxicity and ameliorating harsh microclimate to provide a better growing environment for rare, endemic and threatened species of tropical rainforest species. This paper underscores the usefulness of acacias in rehabilitation and restoration of problematic soils, e.g. ex-tin mines.

**Keywords**: Acacias, site improver, nurse-tree, tree diversity, problematic soils

# Quantifying nitrogen fixation in *Acacia mangium* Willd. plantation grown under different levels of phosphorus in Sumatra, Indonesia

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A field experiment was established at Lematang, South Sumatra (Indonesia) on acidic clay soils to quantify nitrogen fixation of *A. mangium* plantations from different provenances grown under different levels of phosphorus. The "N-15 natural abundance" method was applied with *Eucalyptus pellita* as reference plant. Foliar samples were collected at 12 and 18 months after establishment for isotopic analyses from treatments with provenances As (Cairns region, Queensland) and Ap (Muting provenance, Papua) at P rates of 0 ($P_0$) and 100 kg $ha^{-1}$ ($P_{100}$). The percentage of N derived from the atmospheric $N_2$ (%Ndfa) varied according to provenance and level of P treatment. Significant differences in %Ndfa were observed between provenances As and Ap with no P addition at both 12 and 18 months ($P<0.01$). A large effect of P addition on the %Ndfa was observed at provenance As at both ages ($P<0.01$). The results suggest that part of the mechanism for the increased productivity of provenance Ap is likely to be due to its capacity to better utilize soil P and fix atmospheric $N_2$.

**Keywords**: *Acacia mangium*, $N_2$ fixation, $^{15}N$ natural abundance, phosphorus, provenances.

# *Acacia spirorbis* a model plant to study the contribution of symbiotic root microorganisms in plant adaptation to soil constraints: news and prospects

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*Acacia spirorbis* is distributed mainly in New Caledonia where it ubiquitously grows on a wide variety of soils: metalliferous, calcareous, silty, sandy with among other, heavy metal toxicity. An important feature of *A. spirorbis* is its ability to form nitrogen-fixing nodules, arbuscular mycorrhizas (AM) and ectomycorrhizas. These symbioses are important in plant adaptation to soil stresses and the triple symbiosis is mentioned to explain the high adaptive plasticity of their hosts. Thus *A. spirorbis* and its symbiotic microorganisms in the context of New Caledonia with a great variety of soils constitute a model to analyze the importance of symbioses in plant adaptation to soil constraints.

Nine sites were selected with different soil characteristics, spread into three main classes: volcano-sedimentary, ultramafic and limestone. They were surveyed in New Caledonia for rhizobium, AM and ectomycorrhizas diversities and for nitrogen fixation, plant physiology and genetic diversity.

Our results showed that *A. spirorbis* could overcome soil nitrogen deficiency owning to its capacity to associate and fix nitrogen with large variety of *Bradyrhizobium*. AM fungi are present in roots with various frequencies depending on site; diversity varied according to soil types and is dominated by Glomeraceae. Ectomycorrhizas have also been described in all sites with various Basidiomycetous taxa. These symbiotic microorganisms showed adaptations notably to serpentinic constraints. Finally, a general approach including natural $^{15}N$ abundance, micronutrient content analyses and genetic diversity of *A. spirorbis* are under way to draw an overall picture of *A. spirorbis* development in function of soil characteristics and symbiosis contribution.

**Keywords:** Soil diversity, Symbiotic nitrogen fixation, Arbuscular mycorrhizas, Ectomycorrhizas, Plant adaptation, *Acacia*.

# Mixed-species plantations of *Acacia mangium* and *Eucalyptus urograndis* in Southeast Brazil: aboveground biomass, nutrition and soil fertility

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Mixed plantations of *Eucalyptus* genus with trees symbiotically associated with nitrogen fixing bacteria, have been studied in Brazil as a promising management to low fertility soils. To understand the potential benefits provided by *Acacia mangium* (acacia) over the growth and nutrition of *Eucalyptus urograndis* (eucalyptus) were evaluate, at early stage (24 months), mixed and pure stands of both trees species, in Southeast Brazil. The $^{15}N$ values (Ê) of leaves from acacia and eucalyptus differ significantly suggesting a high contribution from biological nitrogen fixation (BNF) to acacia (49-74%) at the first year, but this contribution decrease at the second year (20-29%). At the first year leaves from eucalyptus under mixed plantation (E100:A100) present the same N content in comparison to eucalyptus fertilized with N (E100+N), while no difference was observed between N content of eucalyptus without nitrogen fertilization (E100-N) and other mixed option (E50:A50). Pure and fertilized treatment of eucalyptus produced aboveground biomass (33 Mg $ha^{-1}$) at the same level (26.3 Mg $ha^{-1}$) of mixed treatment (E100:A100), while pure of acacia (10.8Mg $ha^{-1}$) produced the same quantity of eucalyptus without N fertilization. Soil pH, Ca and Mg (0-10; 10-20 and 40cm) tended to decrease under *A. mangium* influence, while C stocks to increase with time, especially under mixed plantations.

**Keywords:** biological nitrogen fixation, soil organic matter, biomass, soil fertility

# Genetic variation in growth, stem straightness, pilodyn and dynamic modulus of elasticity in second-generation progeny tests of *Acacia mangium* at three sites in Vietnam

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234 families from 5 different genetic groups of *Acacia mangium* were tested in three second-generation progeny trials planted at Tuyen Quang, Ba Vi and Bau Bang in 2008 and 2009. All trees were measured to estimate individual heritabilities and genetic correlations for growth traits, stem straigthness in these trials, pilodyn penetration in ba Vi and dynamic modulus of elasticity ($MoE_d$) in Tuyen Quang. There were significant differences between genetic groups and families were found for growth traits, stem straightness, pilodyn penetration and predicted $MOE_d$. Heritabilities of growth traits, stem straightness, pilodyn and dynamic modulus of elasticity were low to moderate ($h^2$=0.11-0.30). The coefficient of additive genetic variation for DBH, pilodyn and $MoE_d$ were high after age 3 years ($CV_a$=4.9-9.4%). Genetic correlations between stem straightness, pilodyn and growth traits were weak and favourable, while it was weak and unfavourable with large standard errors between growth and dynamic modulus of elasticity. The substantial coefficients of additive genetic variation and significant heritabilities for all traits indicate that it should be possible to use a selection strategy that combines improvements in growth, stem, and wood quality for *A. mangium* in Vietnam. The genetic correlations between Tuyen Quang and Binh Duong site were low for all studied traits, indicating that G ì E effects are of practical important for growth and that different deployment populations are required for different sites.

**Keywords:** Acacia mangium; genetic variation; progeny; pilodyn; modulus of elasticity

## Concurrent session 14:00 - Genetics and Breeding

# *Agrobacterium tumefaciens* mediated genetic transformation of *Acacia crassicarpa*

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It is necessary to establish a sustainable society depending on renewable resources. Wood or lignocellulosic biomass is the most abundant among renewable resources, and it has been receiving much attention lately. Tropical trees grow faster than temperate and boreal trees. Hence, wood biomass production in tropical zones is very important for establishing a sustainable society.

*Acacia crassicarpa* A. Cunn. ex Benth. is a fast-growing tropical legume tree. Nowadays, wood of this species becomes a potential fibre source for pulp and paper industries because of its rapid growth, high fibre quality, high pulp yield and its ability to grow in adverse soil conditions, especially acidic, saline and marshy lands. However, tree improvement programs of this species are still in primary stages. In this context, we tried to establish genetic transformation and plant regeneration systems for *A. crassicarpa* to achieve the objective breeding goals with a minimum period. Nodal explants of *A. crassicarpa* were co-cultivated with *Agrobacterium tumefaciens* strain EHA101 carrying pIG121-Hm harboring genes encoding - glucuronidase (*gus*), hygromycin phosphotransferase (*hpt*) and neomycin phosphotransferase II (*nptII*), and pBBR*acd*S harboring a gene encoding 1-aminocyclopropane-1-carboxylate deaminase. After co-cultivation, nearly 30% of explants produced shoots on a medium containing kanamycin. A DNA fragment corresponding to *nptII* was amplified from genomic DNA extracted from phyllodes of the regenerated plants. High level of GUS staining was also observed in phyllodes of thees plants. Moreover, Southern blot analysis revealed various hybridization patterns in the plants. These results indicate the transgenic nature of the regenerated plants.

# High-throughput SNPs genotyping of two Australian *Acacia* species

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High-throughput SNPs genotyping techniques along with improvements in bioinformatics, computing technologies and statistical methods in genetic analysis have expedited the discovery of genome wide SNPs phylogenetic, diversity and association studies. In this study, we designed an Illumina Golden Gate Assay (IGA) to genotype *Acacia mangium* and *Acacia auriculiformis* germplasm collections with a custom 2x384-SNP set for genetic diversity study. Ten individuals each from 10 natural populations each of *A. auriculiformis* and *A. mangium* were genotyped. After applying SNPs filtering requirements, we found 26% (101 out of 384) and 24% (95 out of 384%) polymorphic SNPs in *A. mangium* and *A. auriculiformis* respectively. These selected SNPs were tested for deviation from Hardy-Weinberg Equilibrium (HWE). The results from this study will be useful for genetic structure and linkage disequilibrium analyses for trait association studies.

**Keywords:** SNPs genotyping, Illumina Golden Gate Assay, HWE, genetic structure

# Effects of over-expressions of novel putative miRNAs 1(21), 2(21), 1(22) and 256(21) identified from secondary xylem tissues of *Acacia mangium* on lignin biosynthesis

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Lignin is a complex, natural phenolic polymer with several key functions which include thickening and strengthening plant cells (structural support), forms an integral part of the vascular transport system (xylem), and plays a role in plant defense during biotic and abiotic stresses. Our previous study based on deep sequencing of *Acacia mangium* secondary xylem tissue with naturally contrasting lignin content revealed novel putative miRNAs sequences implicated in the regulation of the monolignol biosynthetic pathway. Here, we employ the recently developed artificial microRNA strategy to study the functions of three significant novel microRNAs in *A. mangium*, namely 1(21), 2(21), and 1(22), plus 256(21) which targets the HD-Zip transcription factor.

Four amiRNA precursor constructs were generated by PCR based site-directed mutagenesis using the pRS300 plasmid DNA (containing Ath*MIR319a*) as template, together with a series of four specific oligonucleotides per transgene construct (designed by Web MicroRNA Designer). The four amiRNAs precursor constructs were then blunt-end cloned into pCR™- Blunt and each construct sequence-verified. Positive amiRNA precursors were directionally sub-cloned into the XhoI - XbaI sites of the vector pRNA69 which contains the 35S promoter. Precursor amiRNA fragments are then transferred into the pART27 binary vector in order to facilitate *Agrobacterium tumefaciens* (LBA4404) mediated plant transformation, following a modified genetic transformation protocol using *A. mangium* cotyledon explants. The effects of gene silencing by these amiRNAs on lignin biosynthesis will be characterized using attenuated ATR-FTR (metabolic profiling), RT-PCR of candidate genes and NGS to observe any changes in expression profiles of miRNAs in transgenic plants.

**Keywords:** *Acacia mangium*, miRNAs, artificial miRNAs, lignin biosynthesis

# *Acacia koa* Seed Orchard Management: Seed Protection and Insecticide Injection

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*Acacia koa* (koa), an endemic tree species of Hawaii, is a dominant forest canopy tree that is known for its cultural, ecological, and economic value, but koa has been relegated to a small part of its natural range, due to logging, land clearing, and pests. The Hawaii Agriculture Research Center (HARC) has been cooperating with the United States Forest Service and Hawaii Division of Forestry and Wildlife on a disease resistance breeding program and seed orchards are a primary method to produce improved seed. The availability of improved koa seed is hindered by predation, caused primarily by two insects: the nonnative koa haole seed weevil (*Araecerus levipennis* Jordon, Coleoptera: Anthribidae) and the native koa seed worm (*Crytophlebia illepida* (Butler); Lepidoptera: Tortricidae). Koa seed orchards were treated with two systemic insectices, emamectin benzoate and imidacloprid for their effectiveness against these pests. An effective method for controlling predation in seed orchards will reduce the costs of seed orchard management and increase the production of improved koa seed.

**Keywords:** Seed orchard management, Seed predation, Seed protection, Systemic insecticide, *Acacia*

# Operational Disease Screening Program for Resistance to Vascular Wilt in Hawaiian *Acacia koa*

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Koa (*Acacia koa* **A. *Gray***) is a valuable tree species economically, ecologically, and culturally in Hawaii. A vascular wilt disease of *Acacia koa* (koa) due to infection by *Fusarium oxysporum* f. sp. *koae* (FOXY) causes high rates of mortality in field plantings and threatens native koa forests in Hawaii. Landowners are reluctant to consider koa for reforestation and restoration in many areas due to the threat of FOXY. Producing seed or propagules with genetic resistance to FOXY is vital to successful koa reforestation and restoration. Virulent FOXY isolates were used in seedling inoculation trials to evaluate resistance levels among koa families in greenhouse experiments. Seedling survival varied by family, ranging from 3% to 92%, with an overall average of 46%. One clonal and three seedling field trials were established 2012 and 2013 using selections based on the inoculation trials. The greenhouse screening method serves as a powerful tool to rapidly evaluate koa families prior to outplanting, however the field trial data is needed to further validate the results and to monitor the durability of resistance over time. The field trials will also serve as a source of germplasm for selection of other commercial traits.

**Keywords:** *Acacia koa*, *Fusarium* wilt, disease resistance, tree improvement

# Study on bacterial endophytes from *Acacia mangium* for induced disease resistance and growth enhancement

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Bacterial endophytes reside in most healthy plants; they cannot be easily influenced by the external environment. Some bacterial endophytes are beneficial to host plants, such as growth promotion, disease prevention and nitrogen fixation. Therefore, it may be widely suggested that bacterial endophytes are the potential microbial fungicides. In this study, endophytic bacteria were isolated from *Acacia mangium*, which were collected from two different locations (Dai Lai - Vinh Phuc Province and Ba Vi - Hanoi City). The results indicated that the number of strains of bacterial endophytes from different parts of the specimens was different. It was 43.90% in bark, 24.39% in cambium and 31.71% in sap wood. The activities of 41 strains against the pathogenic fungus *Colletotrichum gloeosporioides* were assayed. 53.66% of them showed antagonistic activity against *C.gloeosporioides*. The seven best performing strains from three parts at two locations named DL2B5, DL1C1, DL3C3, DL1W1, BV1B4, BV3C, and BV2W1 were used for assaying with 7 main fungal pathogens to *A. mangium* (*Colletotrichum gloeosporioides; Pestalotiopsis neglecta; Pythium vexans; Corticium salmonicolor; Phytophthora cinnamomi; Ceratocystis acaciivora*), for testing auxin producing and P-solubilisation. The findings on the ability to antagonize fungal pathogens and to produce auxin, indole-3-acetic acid, plant growth hormones and to solubilize rocky phosphate were discussed.

**Keywords**: *Acacia mangium*, auxin -producing bacteria, bacterial endophytes, disease prevention, P- solubilisation.

# Screening Basidiomycete Fungi as Potential Biological Control Agents Against Rootrot Disease

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Root-rot diseases have become the most damaging to the majority of Indonesia's plantation resources, including those for palm oil, pulp wood and rubber. *Ganoderma philippii* has been reported as the most common causal agent for the majority of root-rot disease in *Acacia mangium* plantations. Projects supported by ACIAR in collaboration with FORDA and plantation companies have been investigating the potential of biological control. In various surveys undertaken of root rot disease in acacia and eucalypt plantations a suite of basidiomycete fungi have been isolated. These fungi have been tested in the laboratory for their potential as biological control agents (BCAs) against *G. philippii* and *Phellinus noxius*.

The most promising of these fungi as BCAs in preliminary studies in the laboratory, pot and field include a *Phlebiopsis* sp., a *Cerrena* sp. and several *Phlebia* species. The *Phlebiopsis* sp. is undetermined but is closely related to *P. gigantea* which is a proven BCA of the basidiomycete root rot pathogen *Heterobasidion annosum*. Current laboratory trials are studying the mechanisms of biological control and are developing suitable formulations for field application. Although isolates of both *Phlebiopsis* and *Cerrena* produce oidia, *Phlebiopsis* produces more abundant oidia. Pot trials are being carried out by plantation companies to investigate the efficacy of the BCAs and compare different isolates of the same species. Genetic population studies of *G. philippii* are being conducted in parallel to better understand the dispersal biology of the pathogen and to aid in the planning of field trials and the deployment of BCAs developed.

**Keywords:** BCAs, *Phlebiopsis* sp., *Ganoderma philippii*, *Phellinus noxius*, rootrot disease.

# Potential Contribution of *Acacia auriculiformis* in the Plantation Forests of Bangladesh

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Five *Acacia* species (*Acacia auriculiformis*, *A. mangium*, *A. holosericea*, *A. polystachya* and *A. crassicarpa*) were introduced from Australia and Papua New Guinea to Bangladesh in early eighties. The species were assessed in the experimental plantations for their growth and future inclusion in the plantation programs. Among them, *Acacia auriculiformis* and *Acacia mangium* was found successful for their adaptation, early growth and demand in the markets. But, due to heart rot disease, *A. mangium* was discarded from further large scale plantation programs. As a result *A. auriculiformis* remains the solo species for large scale plantation programs of Bangladesh. Meanwhile, *Acacia* hybrid (*Acacia auriculiformis* x *Acacia mangium*) appears as the most productive species and getting priority in short rotation plantation programs.

In recent years, Forest Department, NGOs and individuals use the species dominantly (>70%) in different plantation programs and the rate of inclusion of the species is increasing day by day. Restoration of the degraded forest lands through establishing a quick *Acacia* vegetation cover is successful in both the hill and plain land forest areas. Initiatives were also taken to find out the desired genetic resources of the species with straight, cylindrical bole. The paper describes the dominance and invasiveness of *A. auriculiformis* in plantation programs and contribution to the supply of forest produces along with the status, growth and rapid expansion of the species (*Acacia auriculiformis* and *Acacia* hybrid) in Bangladesh.

**Keywords:** Plantation forest, short rotation, restoration, invasiveness, vegetation cover, Bangladesh

# Market prospects for Acacia wood chips and pulp

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Asian imports of hardwood chips reached a record 14.7 million bone dry metric tons (BDMT) in 2008. After a brief collapse in 2009, woodchip imports set new record volumes in 2010, and again in 2011 and in 2012, with a total value of US$3.6 billion. In 2013, the traditional hardwood chip import markets of Japan, China, Korea and Taiwan have been joined by India, and imports reached yet another new record of about 19.3 million BDMT. RISI forecasts that the market will continue to expand, reaching close to 22 million BDMT by 2017-18.

The Asian hardwood chip markets have historically been dominated by supply from Australia, South Africa and Chile. However, the fastest growing supply region for the hardwood chip markets has been Southeast Asia, whose market share has jumped from 22% in 2008 to an estimated 61% in 2013. In particular Vietnam has emerged as the dominant supplier of hardwood chips, accounting for an estimated 38% of the Asian market supply in 2013. Vietnam's total exports of hardwood chips in 2013 were an estimated 7.2 million BDMT. The majority of hardwood chip exports are several species and hybrids of Acacia.

But Vietnam is not the only country supplying Acacia woodchips to the Asian markets. Exports from Indonesia reached a record 1.3 million BDMT in 2013, almost all of which was A. mangium. Exports *of A. mearnsii* from both South Africa and Brazil have also been an important source of supply.

## Abstracts - Friday 21th March Plenary Session

## Invasiveness in *Acacia*: Can we minimize environmental risks?

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Astralian *Acacia* species (1012 recognized species, previously grouped in Acacia subgenus Phyllodineae) have been moved extensively around the world by humans over the past 250 years. Many species have been widely planted for many reasons, including commercial forestry, sand stabilization and ornamentation. At least 23 Australian *Acacia* species are invasive, i.e. spread from planting sites in areas outside their native range. Some of these species are major environmental weeds and are listed among the world's most damaging invasive species. Other species are emerging invaders or are widely naturalized. Some species are both commercially or otherwise important and invasive within the same region, leading to conflicts of interest for managers.

Australian acacias have emerged as a model group for the study of introduced trees. The history of global movements of species and their dissemination in many regions is fairly well known, as is the history of naturalization and invasion. Many studies have been done to determine the factors associated in invasiveness in different species. The risk of Australian acacias becoming invasive can be quantified by combining data on ecological, evolutionary and human-use criteria. Valuable insights have emerged from studies of features of the natural distribution ranges of the species.

This presentation will review insights on the determinants of invasiveness and examine how this information can be applied to minimize environmental risks associated with invasiveness of acacias in different situations.

## Polyploid breeding: a new pathway for genetic improvement of acacias?

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Polyploidy is an important evolutionary mechanism and breeders of many plant varieties have used chemicals such as colchicine to develop neo-tetraploid (4X) lines which differ from their progenitors in economically interesting ways. 4X lines can be crossed with diploids (2X) to breed triploids (3X). 4X plants tend to have larger cells and may be more stress tolerant than 2X but do not grow as fast. Triploids however can be fast growing and also sterile. Sterility and larger fibres with improved papermaking properties would be of great interest to acacia growers and has provided incentive for research with *A. Mangium* in collaboration between scientists in Vietnam and Australia. Results to date are reviewed as a basis for discussion of future potential. 4X *A. mangium* clones were grown to rotation age in mixture with 2X in the hope of producing 3X by open pollination (OP). This was not successful because of changes to the fertility and breeding system of the 4X and strong barriers to inter-cytotype crossing.

The 4X trees are characterised by larger thicker phyllodes with large stomates, thicker more tessillated bark, and wood fibres which are longer and thicker walled than 2X with concomitant benefits in pulp and solid wood strength. Their OP progeny show varying levels of inbreeding depression with the best being quite uniform with stem form superior to 2X and a light canopy which might enhance wind resistance. However initial growth is substantially slower.

A set of 3X trees is now in the field with no seed set from the first flowering. The clones are in tissue culture preparatory to field testing on a larger scale. Most were naturally derived, probably from mating involving an unreduced gamete. Barriers to development of 3X seed and embryo rescue techniques are under investigation in the hope that we can increase production via controlled pollination.

In summary, there are sufficient positive indications that propagation and field testing of 3X clones is recommended. Further breeding and selection will be required before 4X lines can be recommended for commercial use. Field tests are needed in regions where wind and water stress are significant problems, and we need to quantify the benefits of improved form (less need for singling and higher merchantable volume %) and wood properties before we discount use because of the growth rate differential.

A set of 4X *A. auriculiformis* lines is now established in Vietnam providing opportunity to breed 4X and 3X hybrids in future and we are also testing 4X lines derived from elite hybrid clones.

# An overview of the *Acacia mearnsii* industry in South Africa: current status and challenges

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Black wattle *(Acacia mearnsii)* was originally introduced to South Africa in the eighteenth century for the high grade export-quality tannins present in the bark. The planted area expanded rapidly to a peak of 300 000 ha by late 1950's due to a high demand for leather products in the Second World War A subsequent international decline in demand for vegetable tannin agents led to the planted area being reduced to 130 000 ha by early 2000's. Changes in species in corporate land have further reduced the area to about 110 000 ha in 2012. The main growing areas occur in the summer-rainfall regions between latitudes 25 and 33° S and longitudes 27 and 30° E in the provinces of KwaZulu-Natal and Mpumalanga. The species grows better in areas with annual rainfall between 800 and 1200 mm and mean annual temperature of 16 to 20° C. Black wattle is harvested at 10-12 years producing an average of 15 tonnes of bark and around 165 $m^3$ of timber per ha. The bark is stripped and transported to the factories shortly after felling, as freshness and colour determine bark price and quality of the extract. There are three bark factories which produce a variety of solid and powdered extracts for the tanning industry of a number of countries. A proprietary brand of adhesives is also produced from the bark extract and is used for the manufacturing of exterior grade plywood, particle board, laminated timber, medium-density fibre board and corrugated cardboard.

Black wattle pulpwood has become increasingly important for the domestic and import markets due to its high wood density (550-850 kg $m^{-3}$) and pulp yield. A total of about 862 000 tons of wattle pulpwood were recorded in 2010-2011. Most of the marketing of wattle pulpwood is carried out by two timber cooperatives, one of which runs successfully a chip export scheme. Most wattle growers are affiliated to one or more bark companies and also to the timber cooperatives.

Current challenges for the wattle industry in South Africa include the reduced planted area and the difficulty on expanding the land base, and thus the need to improve both timber and bark/tannin yield on the existing resource. Frost damage is a major hurdle to grow wattle in some sites. Pest and diseases also pose challenges to the industry. The recent changes in minimum wages legislation will affect the wattle industry as bark stripping is highly labour intensive.

Research in black wattle started formally in 1947 with the inception of the former Wattle Research Institute (WRI), in the areas of silviculture, genetics, chemistry and entomology. Research into the uses of the black wattle extract has been conducted since 1941 by different bodies with the direct the support of the wattle Industry. Today, research at the Tree Improvement section of the ICFR is focussed on developing and implementing an advanced-generation breeding strategy for *Acacia mearnsii* with the aim of improving timber and pulp yield, bark quality and frost tolerance.

## Concurrent session 11:40 - Plantation management for sustainable wood production

# Veneer processing and utilisation of Acacia plantations in Vietnam

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Vietnam has a large expanding area of plantation forests consisiting of mostly 3.22 million ha (2011) of Acacia and Eucalyptus species. Currently, most plantation wood in Vietnam is being used for wood chip (pulp and paper feedstock) and construction materials (round wood and small sawn boards). A lesser proportion of plantation resource is being used for furniture and other value-added products such as veneer and veneer based products. With the growing demand of veneer based products worldwide the corresponding value-added potential of this resource and the economic flow-on effect to Vietnamese smallholders is not currently being realised.

Effective utilisation of Vietnam's plantation resource is a priority in the forestry sector's 2020 action plan that outlines a strategy to increase the use of wood material from domestic sources for furniture making up to 80% by 2020. Veneer processing and manufacture of veneer based products have been identified as the best opportunities to meet this plan for young, small stem plantation timbers, particularly for acacia species.

As the use of plantation acacias for this purpose is in its infancy, research and development is needed to assist the industry to produce high value veneer based products from this resource.

The current ACIAR project □*Enhancement of veneer products from acacia and eucalyptus plantations in Vietnam and Australia*□ aims is to promote higher value utilisation of Vietnam Acacia and Eucalyptus plantations by optimising veneer production from this resource, leading to higher returns to small holder farmers.

In the early stages of this project, analysis of the existing plantation resource and of the veneer quality from various stands have been completed. The veneer properties and features of young Acacia plantations from different stand age and sivilculture have generally attained a reasonable level to be suitable for veneer production from low cost spindleless lathe technology. The data generated provide relevant information on the potential value of the veneer depending on the origin of the log. Further investigation into the economic impact of harvesting age and silvilculture will provide critical information on

smallholder profitability; an objective of this project.

The current plantation veneer processing practices and efficiencies in Vietnamese companies have been identified and characterised through a series of onsite surveys. The outcome of these studies provide a broad assessment of opportunities to improve current primary wood processing practices and efficiencies in order to optimise the research direction required for subsequent activities. The main points generated from this survey show that the assessed companies have good potential to improve the quality of products and become more efficient by making modifications and changes to the veneer processing and manufacturing procedures and by applying rigorous quality control systems in their production processes.

Although improvements and developments are necessary to make the companies more efficient and competitive in national and international markets, numerous opportunities can be identified which indicate that the industry has a good chance of succeeding. One of the indicators is a strong commitment from the companies which are open to suggestions and willing to implement recommended changes and improvements. This commitment, combined with the enthusiasm of the companies to change and modernise their production processes promises positive outcomes.

Improving the competitiveness of Acacia plantation processors and manufacturers in Vietnam through improved efficiency and profitability should improve the livelihoods of farmers and processing workers.

**Keywords:** Acacia, Plantations, Vietnam, Processing, Veneer, Manufacturing

**Acknowledgements:** The author acknowledges the financial and in-kind support of all collaborators involved in the project and funding provided by the Australian Centre for International Agricultural Research (ACIAR), Canberra, Australia.

# Pulping and Papermaking Characteristics of *Acacia mangium*

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*Acacia mangium* grown in the Philippines was pulped by Kraft, neutral sulfite semi-chemical (NSSC) and chemithermomechanical (CTMP) pulping processes to determine its suitability for pulp and paper manufacture. The chemical charges were varied to determine the acceptable pulp yield and quality. The NSSC and CTMP pulps were refined with disc refiner. All the pulps were beaten at various revolutions with PFI mill and subjected for freeness testing and fiber fractionation using a Canadian Standard Freeness tester and Bauer McNett fiber classifier, respectively. The physical properties of unbeaten and beaten pulps were tested based on TAPPI and ISO standard methods and scanned with scanning electron microscope.

*Acacia mangium* responded well with Kraft, NSSC and CTMP pulping processes with average pulp yields of 49%, 78% and 85%, respectively. Kraft pulp obtained the highest strength properties while NSSC had the highest brightness with slightly lower strength properties than Kraft pulp but better than CTMP pulp. The CTMP pulp on the other hand had the highest pulp yield.

Kraft, NSSC and CTMP pulps produced are of good quality suitable for pulp paper production.

## Concurrent session 11:40 - Genetics and Breeding

# A history of polyploid breeding in Black Wattle (*Acacia mearnsii*) at the Institute for Commercial Forestry Research, South Africa.

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Black wattle (*Acacia mearnsii* de Wild) is a leading commercially grown forestry species in South Africa, however, it is also a classified invader of indigenous vegetation. One of the research aims at the Institute for Commercial Forestry Research (ICFR) is to restrict the spread of black wattle outside of plantation boundaries. The development of a seedless or sterile wattle variety would be beneficial to both the black wattle industry and the environment. One approach being investigated is the production of a triploid wattle variety. The long-term objective is to ultimately guarantee that all the seed sold or distributed to the growers will produce sterile or seedless trees, hence reducing the possible spread of black wattle from commercial plantations.

Triploid induction entails crossing diploids with chemically-induced tetraploids, in an attempt to produce triploid seed, which can be grown commercially. At the ICFR, tetraploids were successfully induced and cross-pollinated with diploids. As no triploids were produced from the controlled crosses, reproductive biology studies were conducted to investigate possible barriers preventing this. Fluorescent microscopy revealed that, in the cross between diploids and tetraploids, the pollen tubes were reaching the ovary and ovule, indicating that fertilisation was possible and that the barrier in preventing seed maturation was located within the ovary. Embryo rescue using tissue culture techniques was then attempted at varying stages of pod development post-fertilisation. However due to the small size of the pods it was not possible to identify and isolate a 'clean' embryo, devoid of maternal tissue, until 11 months post-fertilisation, at which stage embryo abortion would have already occurred. Based on the assumption that incompatibility within the ovary exists, necessitating embryo removal before six months after flowering, this approach for rescuing triploid embryos was not feasible and alternative techniques such as endosperm culture and isolation and fusion of gametes may provide the only methods of developing triploids.

This talk will provide an overview of the historical work conducted into producing triploid black wattle at the Wattle Research Institute (WRI), and focus on the past 12 years of research at the ICFR.

# Polyploid induction in *Acacia* and hop (*Humulus lupulus* L.): a comparison

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Ploidy manipulation is a useful technology for both plant and animal biologists in efforts to develop superior plants and animals for commercial applications. In every case, it is important to understand the biology of the target organism as well as the production system employed in industry to ensure the approach to ploidy manipulation is appropriate. This paper compares various approaches to incorporate polyploidy into research and breeding programs for number of *Acacia* species and hop (*Humulus lupulus* L.).

## Concurrent session 13:30 - Risk Evaluation and Management

# Australian acacias and sustainable development around the world: marginal livelihoods, commercial plantations and/or invasive legacies?

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A number of Australian acacia species (wattles; *Acacia* subgenus *Phyllodineae*) were introduced around the world during the past two centuries. Some are grown commercially for timber, pulp, or tanbark; others serve rural communities as fuelwood sources; others are promoted for agroforestry and land rehabilitation; others find favour as ornamentals. In some situations, acacia populations have become problematic biological invaders. This paper describes a conceptual model to explain these divergent current uses and perceptions of introduced acacias. It highlights historically and geographically contingent processes, including economic development, environmental discourses, political context, and local or regional needs. Based on qualitative case studies from fifteen countries, I identify four main patterns: (1) poor communities benefiting from targeted agro-forestry projects; (2) places where residents, generally poor, take advantage of a valuable resource already present in their landscape via plantation and/or invasion; (3) regions of small and mid-scale tree farmers participating in the forestry industry; and (4) a number of high-income communities dealing with the legacies of former or niche use of introduced acacia in a context of increased concern over biodiversity and ecosystem services.

Economic conditions play a key role shaping acacia use. Poorer communities rely strongly on acacias (often in, or escaped from, formal plantations) for household needs and, sometimes, for income. Middle-income regions more typically host private farm investments in acacia woodlots for commercialization. Efforts at control of invasive acacias must take care to not adversely impact poor dependent communities. Decisions over the diffusion and planting of acacias should be specific to the context of geography, society, and taxon, socially debated through participatory political process, and environmentally responsible.

**Keywords:** biological invasions, economic development, livelihoods, natural resource management, subsistence harvesting

# Managing invasions from old acacia plantings

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Invasive organisms tend not to be studied or managed until they are widespread or cause significant problems. However, one of the emerging lessons in invasion biology is that, at least for plants, the length of time that an organism has been in a new area is one of the strongest determinants of how widespread it is. Similarly, the cost of control rises exponentially with the size of the infestation.

Australian acacia species are among the most widespread (and arguably most damaging) invasive species in South Africa. However, many species were introduced for forestry trials or related activities to South Africa, but never widely utilised. Seven of these species (*Acacia adunca, A. fimbriata, A. implexa, A. paradoxa, A. retinodes, A. stricta, A. viscidula*) have recently been recorded as invasive. These invasions likely resulted from only a few individuals planted 50-150 years ago that have since spread.

We describe lessons learned managing these invasions, and provide recommendations for how to minimise the impacts the species pose. We argue that, given the substantial delay before such infestations cause noticeable impacts but the quick rate at which long-lived seed-banks can develop, it is vitally important to pro-actively manage historic plantings.

**Keywords:** invasions, arboreta, forestry trials, risk assessment, eradication.

## Genetic insights from invasive Australian acacias

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Woody tree species introduced for forestry often escape cultivation, representing a particularly interesting case to explore the genetic diversity and structure underlying successful biological invasions. A case in point is Australian *Acacia* species that, despite their huge economic benefits, are problematic weeds in many areas of the world. I will review our work on the phylogenetic and population genetic consequences of these sometimes impressive and large scale propagule movements of acacias. While genetic structure can provide valuable clues on the histories of species movements they also have important consequences for the adaptive potential of species in their new ranges. I will demonstrate that the relationship between propagule pressure and genetic diversity is not always straightforward, as is commonly assumed, demonstrating the value of accurate introduction records in reconstructing introduction histories when using genetic information.

I will also show that population genetic structure can be highly informative in ecological niche modelling approaches and how genetic bottlenecks may have little impact on fitness related traits in novel ranges.

I will further discuss the role of below-ground interactions between acacias and their mutualistic nitrogen-fixing rhizobia by drawing insights from comparative genetic diversity studies between rhizobia from native and introduced ranges. I will demonstrate how, in some instances, human-mediated movements also affected these mutualistic interactions and what the consequences are for native species diversity.

In conclusion, the impressive movement of Australian acacias globally makes them a promising system for studying the ecology and evolutionary biology of forestry species.

**Keywords:** acacia, forestry, genetic diversity, invasive species, propagule pressure, rhizobia

# Chlorophyll concentration and polyploid detection as well as early indications of solid wood properties of polyploids in Eucalyptus spp.

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A series of putative polyploid *E. urophylla* plants were evaluated for their chlorophyll leaf concentrations and then these values compared with the ploidy levels as determined by flow cytometry. A weak but positive relationship was found at with a Pearson's correlation of r=0.27 between chlorophyll content and mean ploidy level.

The solid wood properties of a free-growing 3.4 year old tetraploid eucalyptus hybrid tree (E. grandis x E. camaldulensis) were studied. The wood properties of these samples are presented, with comparisons to other diploid samples. No wood end splitting was observed in the tetraploid. The wood density was 433 kg/m3. The gluing and machining properties were of a high standard.

**Keywords:** Polyploid, *Eucalyptus urophylla*, wood properties, chlorophyll

## Methodological issues: Polyploid Breeding discussion group

Facilitator - Prof Rod Griffin

Griffin Tree Improvement Pty. Ltd

Adjunct Professor, University of Tasmania

## Plenary Forum - Synthesis of key outcomes

Chair - Lee Su See

IUFRO Vice President for Task Forces

Head, Forest Health and Conservation Programme

Biodiversity Division

Forest Research Institute Malaysia (FRIM)

# PART II
# Poster sessions
Wednesday March 19th 16:30 - 18:00

## Poster session: Wednesday March 19th 16:30 -18:00

| No. | Member | Corresponding author | Title | Poster location |
|---|---|---|---|---|
| **Session 1: Genetics and Breeding** | | | | |
| 1 | Atirah Abdullah Shah Aimin | Wicki@ukm.my | Evaluation on growth performances and wood quality traits of full-sib *Acacia auriculiformis x Acacia mangium* F1 hybrid progenies | Frame 1a |
| 2 | Arunachalam Shanthi | Shanthia@icfre.org | Application of molecular markers in first and second generation orchards of *Acacia auriculiformis* | Frame 1b |
| 3 | Jeremy T. Brawner | Jeremy.Brawner@csiro.au | Selection of *Acacia mangium* for the improvement of solid wood and pulp productivity | Frame 2a |
| 4 | Julian Moreno Chan | Julian.Chan@ukzn.icfr.ac.za | *Acacia mearnsii* tree improvement in South Africa: summary of past efforts and current breeding strategies | Frame 2b |
| 5 | Sapit Diloksumpun | sapit.d@ku.ac.th | Survival and early growth performance of *Acacia auriculiformis* A. Cunn. ex Benth. clones on two contrasting site conditions in Southern Thailand | Frame 3a |
| 6 | Do Huu Son | dohuuson@gmail.com | Development and testing of Acacia hybrid clones in Vietnam | Frame 3b |
| 7 | Jane L. Harbard | J.L.Harbard@utas.edu.au | Production of triploid Acacia seedlings in a polyploid hybridising orchard in Vietnam and early observations of sterility | Frame 4a |
| 8 | Jane L. Harbard | J.L.Harbard@utas.edu.au | Discrimination between induced autopolyploids and their diploid counterparts of *Acacia* using near-infrared reflectance spectroscopy-infrared reflectance spectroscopy | Frame 4b |
| 9 | Maheshwar Hegde | hegdem@icfre.org | Genetic Improvement of Phyllodinous Acacias in India -current status and future prospects future prospects | Frame 5a |
| 10 | Ha Huy Thinh | ha.huy.thinh@vafs.gov.vn | Vietnam's acacia breeding strategy | Frame 5b |
| 11 | Adeniyi A. Jayeola | adeniyi.jayeola@gmail.com / aa.jayeola@ui.edu.ng | Use of fruits and infructescence characters in the identification of the *Acacia* Mill. (Leguminosae) species in Nigeria | Frame 6a |
| 12 | Arumugam Karthikeyan | karthika@icfre.org | Establishment of Nitrogen fixing root nodules in rooted stem cuttings of *Acacia auriculiformis* A.cunn. Ex. Benth | Frame 6b |
| 13 | Nghiem Quynh Chi | nghiem.chi@vafs.gov.vn | Successful recovery of triploid seedlings from crosses between diploid *Acacia auriculiformis* and tetraploid *A. Mangium* | Frame 7a |
| 14 | Shinitiro Oda | Soda@suzano.com.br | Induction and identification of polyploidy *Eucalyptus grandis* and *Eucalyptus grandis x Eucalyptus urophylla* plants | Frame 7b |

| No. | Member | Corresponding author | Title | Poster location |
|---|---|---|---|---|
| 15 | Aina Price | aina.price@utas.edu.au | Ploidy stability in hedge plants of neo-tetraploid *Acacia* hybrid clones | Frame 8a |
| 16 | Sri Sunarti | narti_nirsatmanto@yahoo.com | Breeding Strategy of Acacia Hybrid (*Acacia mangium x A. auriculiformis*) in Indonesia to Increace Forest Plantation Productivity | Frame 8b |
| 17 | Paul Warburton | paul.warburton@csiro.au | Evaluating Clonal Family Forestry as a deployment strategy for *Acacia mangium* in Vietnam | Frame 9a |
| 18 | Harry X. Wu | Harry.wu@slu.se | Breeding against an adverse genetic correlation | Frame 9b |
| **Session 2: Plantation Management For Sustainable Wood Production** | | | | |
| 19 | Nelly S. Aggangan | aggangan@yahoo.com | Growth of *Acacia mangium* as affected by different formulations of mycorrhizal inoculants and rates of a slow release NPK fertilizer | Frame 10a |
| 20 | Nelly S. Aggangan | aggangan@yahoo.com | Growth and heavy metal tolerance of mycorrhizal and non-mycorrhizal of *Acacia mangium* and *A. aulacocarpa* seedlings grown in mine waste soil | Frame 10b |
| 21 | Roger Arnold | contactroger@yahoo.com.au | A new 2 métier for plantation acacias in China | Frame 11a |
| 22 | Chris Harwood | chris.harwood@csiro.au | Productivity of a second-rotation acacia hybrid plantation in central Vietnam: Effects of topographic position and P application at planting | Frame 11b |
| 23 | Maydra Alen Inail | alen_inail@yahoo.com | An evaluation of sawn timber from a 10 year-old stand of *Eucalyptus pellita* in South Sumatra | Frame 12a |
| 24 | Yani Japarudin | yanijaparudin@yahoo.com | *Acacia mangium* Tree Improvement at Sabah Softwoods: Lessons learned after three decades | Frame 12b |
| 25 | Takayuki Kaneko | aneko@kais.kyoto-u.ac.jp | Estimation of Organic Matter Accumulation on Short-Rotation *Acacia mangium* Plantations with Several Harvest Residual Management | Frame 13a |
| 26 | B. C. Nagaraja | nagenvi@gmail.com | Uses of Australian *Acacia auriculiformis* A. Cunn. (Ex. Benth.) for initialed establishment of Tropical Rainforest species of Western Ghats, South India | Frame 13b |
| 27 | Phan Minh Sang | sang.phan@sri.org.vn | Variable density yield tables for Acacia hybrid plantation management in Vietnam | Frame 14a |
| 28 | Pham Van Bon | pvbon.fssiv@yahoo.com | Effects of hedge plant age and fertilizer on growth and form of three Acacia hybrid clones | Frame 14b |

| No. | Member | Corresponding author | Title | Poster location |
|---|---|---|---|---|
| 29 | Caio T.C.C. Rachid | caiorachid@gmail.com | *Acacia mangium* affects soil nitrogen and microbial community and activity in mixed plantations with *Eucalyptus urograndis* | Frame 15a |
| 30 | Sabar T.H. Siregar | Sabar_siregar@aprilasia.com | Managing Acacia Pulpwood Plantation Productivity on Tropical Mineral Soils in Riau Indonesia | Frame 15b |
| 31 | Tran Lam Dong | dong.tran@utas.edu.au/ tranlamdong@gmail.com | Using *Acacia* hybrid as a nurse crop for re-establishment of the dipterocarp *Hopea odorata* Roxb. on degraded lands in Vietnam | Frame 16a |
| 32 | Suwanna Umphauk | Suwanna.rfd@forest.go.th | Durability of Five Treated and Untreated *Acacia* Wood Species in Thailand | Frame 16b |
| 33 | M.Gunawan Wibisono | mgwibisono@ugm.ac.id | Nitrogen mineralization in *Acacia mangium* and *Eucalyptus pellita* plantations in South Sumatra, Indonesia | Frame 17a |
| **Session 3: Risk Evaluation and Management** | | | | |
| 34 | Auro C. Almeida | Auro.Almeida@csiro.au | Modelling *Acacia* production in Vietnam under current and future climates | Frame 17b |
| 35 | Ayyapillai Balu | balu@icfre.org | Important insect pests and diseases of *Vachellia (Acacia) nilotica* (L.) Willd. ex Del. in Southern India | Frame 18a |
| 36 | Christina T. Liang | christinaliang@fs.fed.us | Associating climate variable with genetic variation in Hawaiian koa, Acacia koa | Frame 18b |
| 37 | Pham Quang Thu | B.Dell@murdoch.edu.au | Phytophthora an emerging threat to *Acacia mangium* plantations in Vietnam | Frame 19a |
| 38 | Dao Ngoc Quang | daongocquang@vafs.gov.vn | Insect pests survey on Acacia plantations in Vietnam | Frame 19b |
| 39 | Dong Hyeon Lee | Jolanda.Roux@fabi.up.ac.za | Comparative fitness of self-fertile and self-sterile isolates of the wilt pathogen *Ceratocystis albifundus* | Frame 20a |
| 40 | Nur Hidayati | inunghidayati@yahoo.com | Ganoderma steyaertanum as A Root Rot Pathogen of Forest | Frame 20b |
| 41 | Sri Rahayu | tatarahayu@yahoo.com | Pest and diseases of *Acacia decurrens* as invasive species at Merapi volcano national park in Yogyakarta, Indonesia | Frame 21a |
| 42 | Tran Thanh Trang | trangfsiv@gmail.com | Diseases associated with wounds in Acacia hybrids in Vietnam | Frame 21b |

## Poster session: Genetics and Breeding

# Evaluation on growth performances and wood quality traits of full-sib *Acacia auriculiformis* x *Acacia mangium* $F_1$ hybrid progenies

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Growth performance and wood quality traits of 75 full-sib *Acacia auriculiformis x Acacia mangium* hybrid progenies from age 8 months to 52 months after planting were evaluated. The survival rate of progenies decreased with age. The progenies differed significantly ($p < 0.05$) in their diameter breast height (DBH), total height (HT), and stem straightness (STR). There was no significant difference in mean clear bole height (CBH) among progenies. The mean annual increment (MAI) for DBH and HT were 3.5 cm $y^{-1}$ and 3.0 m $y^{-1}$ respectively. Fiber length and wood density values ranged from 0.6581 mm to 0.9561 mm and 0.4251 g $cm^{-3}$ to 0.7611 g $cm^{-3}$ respectively. The estimated mean trunk and branch biomass of top 29 full-sib progenies for 1-7 years old were 9.02 kg, 28.98 kg, 57.91 kg, 95.02 kg, 139.78 kg, 191.86 kg, 250.97 kg respectively. Results indicated that selection of top 29 full-sib progenies can produce 211.07 t/ha of total trunk and branch biomass at 7 years rotation. Generally, we found high variations in growth performance parameters among the progenies providing opportunities for identification of Quantitative Trait Loci (QTL) and development of markers for selection of high quality planting materials.

**Keywords:** *Acacia auriculiformis* x *Acacia mangium* hybrid, growth performance, wood quality traits, QTL

# Application of molecular markers in first and second generation orchards of *Acacia auriculiformis*

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*Acacia auriculiformis* A.Cunn.ex Benth. is an important fast growing species in plantation forestry programs and also used for pulp and paper production. Our Institute (IFGTB) has received bulk seeds from CSIRO, Australia and established seedling seed orchard in Tamil Nadu and Kerala during 1996 which served as first generation orchards. Progeny trials were laid in Kerala and Pondicherry during 2006 & converted in to second generation orchards. The main focus of our ongoing project activity was to estimate the out crossing rate in different orchards using microsatellite markers. The present study envisages the molecular and seed diversity in first and second generation orchards. The dominant and co dominant marker viz, ISSR and SSR were profiled in orchard progenies. The data were analyzed using popgen32 software. The SSR primers in *A. auriculiformis* were studied from the developed hybrid microsatellite markers of Acacia available in open source and were cross amplified. The putative loci were sequenced. New genomic sequences of *A. auriculiformis* were deposited in NCBI. The seeds of *A. auriculiformis* in random selection from first generation and second generation were screened using Image analyzer. Around two thousand individual seed progenies in both generation orchards were studied.

**Keywords**: ISSR, SSR, *Acacia auriculiformis.*

# Selection of *Acacia mangium* for the improvement of solid wood and pulp productivity

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An *Acacia mangium* genetic improvement program was initiated with the establishment of a large progeny trial in 2007 to support the development of plantation forests intended to supply a pulp and paper mill in Sarawak. The work summarises genetic parameter estimates from four progeny trials established over three years for the breeding program, which have proven useful for the guiding changes to the breeding strategy. Predictions of genetic gain that may be realised from the further development of this genetic resource are to be presented using the first and largest of these trials. The breeding strategy based upon populations that annually bring together genetic material from across the native range of the species, other genetic improvement programs and the local land race will be described. This on-going testing strategy has facilitated the selection of a diverse range of families so that estimates of improvement may be provided from the selection of breeding populations and deployment populations for both solid wood and pulp wood production scenarios.

**Keywords:** *Acacia mangium*, Pulp productivity, Near Infrared Spectroscopy, Genetic parameters, Genetic gain

# *Acacia mearnsii* tree improvement in South Africa: summary of past efforts and current breeding strategies

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Black wattle (*Acacia mearnsii*) was originally introduced to South Africa for the high grade export-quality tannins present in the bark. The base population and the bulk of the plantation resource originated from introductions into several farms of the KwaZulu-Natal province in the eighteenth century. A very intensive period of breeding took place during the 1950, 1960 and 1970 decades. Selection criteria in the early years of the programme focused on freedom from diseases, bark and tannin yield and tree volume. Two Australian introductions took place in 1957 and 1985 aimed to broaden the genetic base and to find frost tolerant material. The trial series that followed both introductions provided valuable information in terms of geographical variation for frost resistance, as well as properties of the Australian provenances for various traits including growth, stem form, gummosis incidence, bark thickness and tannin content.

One of the main challenges faced by the researchers from the 1980s was the increasing level of relatedness built up in the programme. Two different strategies were implemented in 1994 and 2002 to deal with relatedness and to continue improvement in black wattle. Recent realised gain results have revealed a lack of progression in improvement over the last two decades and therefore an advanced-generation breeding strategy has been recently formulated. The aim of the new strategy is to ensure short and long term genetic gains while maintaining relatedness within acceptable levels.

# Survival and early growth performance of *Acacia auriculiformis* A. Cunn. ex Benth. clones on two contrasting site conditions in Southern Thailand

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Field experiments were initiated to compare growth and wood properties of *Acacia auriculiformis* A. Cunn. ex Benth hybrid on two contrasting sites in southern Thailand: Phang Nga Forest Research Station (PN), Phang Nga province and Kasetsart University Educational Service Center (KB), Krabi province. Latinized Row-Column design consisting of 20 *A. auriculiformis* clones and four replications was employed on each experimental site. Tree height and diameter were undertaken at 24 months after planted and analyses of soil texture and chemical properties were undertaken in a soil laboratory following appropriate methods.

Significant differences in soil texture (percentage of sand, silt and clay particles), soil pH and some major nutrients (exchangeable K, Ca and Mg) but not in organic matter, total C and available P were observed between the two sites ($p<0.05$). The soil properties observed on the PN site, which is a mine rehabilitating area, were loamy sand and had significantly higher pH but lower K, Ca and Mg as compared with those of the sandy clay loam observed on the KN site. Preliminary growth performance also showed significant variations in height and diameter growth among clones and between sites but not their interactions. All tested clones planted on the PN site had greater survival rate and growth performance than those on the KB site. The findings reflect the influence of poor soil conditions on early growth and establishment of these clones. Further study on the growth and wood properties as selection criteria appropriate for specific site is of great importance.

**Keywords:** *Acacia auriculiformis* A. Cunn. ex Benth, Clone, Mine rehabilitation, Southern Thailand

# Development and testing of Acacia hybrid clones in Vietnam

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We describe a strategy to identify and test new acacia hybrid clones for Vietnam. Hybrid genotypes produced spontaneously from *Acacia mangium* and *A. auriculiformis* mothers under open pollination were selected, based on their morphology, from (i) seedlings raised from open-pollinated seedlots raised in the nursery, at age 8-10 weeks after germination and (ii) young (1- to 2-year-old) second-generation progeny trials. Maternal parent identities and seedlot origins of all selections were retained.

A total of 5000 putative hybrid genotypes selected in the nursery were planted in four seedling screening trials. At age 18-24 months each trial was assessed and hybrid individuals for clonal testing selected at an intensity of about 1 in 25, based on superior vigour, stem straightness and branching characteristics relative to their neighbours. This identified 210 candidates for clonal testing, with a further 340 hybrid candidates selected in the young pure-species progeny trials. Candidates were pollarded and propagated from resulting coppice shoots, giving a total of 550 candidate clones for testing in clone screening trials which included commercial acacia hybrid clones as controls.

Two-year results from four screening trials in northern, central and southern Vietnam showed that while the commercial controls grew faster than average, about 15% of new clones had growth rates equal or superior to the controls. Hybrids originating from *A. mangium* grew faster on average than those from *A. auriculiformis*. Phyllode morphology and crown characteristics varied widely among the clones. In addition to growth, selection criteria for follow-up testing of the best candidates will include disease resistance and wind-firmness, to reduce risk to acacia growers.

# Production of triploid Acacia seedlings in a polyploid hybridising orchard in Vietnam and early observations of sterility

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A clonal orchard of diploid *A. auriculiformis* and diploid and tetraploid *A. mangium* was planted in order to produce triploids by open pollination. Flow cytometry was used to screen a sample of 161 open pollinated seedlings from eight tetraploid mother trees. All were tetraploid and mainly selfed. Sampling was then focused on screening of seed from both diploid and tetraploid mothers. Two triploid (3x) seedlings were identified from two *A. auriculiformis* mothers and one from an *A. mangium*. These were propagated and field planted. A total of 758 seedlings from 49 seedlots were screened with a triploid frequency of 0.4%. None of the triploid seedlings were hybrid, based on morphology, and it is suggested that they resulted from the union of a normal reduced gamete and an unreduced gamete. In a related field trial one triploid was identified from a tetraploid *A. mangium* mother, so inter-cytotype crosses can occur at low frequency.

Two *A. mangium* triploid clones flowered for the first time in October 2013 and all aborted within one month. Triploid flowering spikes had fewer florets (123) than both diploid (217) and tetraploid (180) and a higher percentage of male florets / spike (48%). Male florets appeared normal but a high percentage (86%) of polyads were scored as abnormal and no pollen tubes were observed when germinated on nutrient agar. There were 13 ovules per triploid ovary with normal size and shape. Controlled crosses where made onto triploid flowers. Pollen tubes grew down the styles and into the ovaries in crosses with diploid and tetraploid pollen but none were observed after selfing.

We hope to expand observations after more general flowering in 2014.

**Keywords:** *Acacia auriculiformis, Acacia mangium*, tetraploid, flow cytometry, pollen tubes

# Use of near-infrared reflectance spectroscopy to discriminate between polyploid and diploid seedlings of *Acacia auriculiformis* following colchicine induction.

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Tetraploid (4x) plants were induced from diploid (2x) seed by applying the genome doubling agent colchicine to germinating seed of *Acacia auriculiformis,* with the aim of producing a population for polyploid breeding. Flow cytometry was used to classify the plants in the induction population as diploid, tetraploid or mixoploid. In order to increase the efficiency of screening we also explored application of near-infrared reflectance spectroscopy (NIRS). Calibration models were developed from spectra gathered from fresh, whole phyllodes in a subset of the induction population. A Partial Least Squares regression model of the spectral region 4600-7500 $cm^{-1}$ was developed to correlate the data against the classification of 2x and polyploid plants (4x and mixoploids) and was cross-validated using 20 random samples. Using the predicted ratios from the validation set we correctly classified 93% (or 40 out of 43) of the 2x plants and 89% of the polyploid plants (62 out of 70). NIRS may therefore be used to screen out most 2x genotypes, so reducing the number of plants for assessment by the more time consuming flow cytometry. A shift to routine use of NIRS would require repeated acquisition of spectra over time to all genotypes treated and at different plant age to build a robust, useable model.

**Keywords**: tetraploid, mixoploid, flow cytometry, calibration, NIRS

# Genetic Improvement of Phyllodinous Acacias in India - current status and future prospects

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Several Australian phyllodinous acacias namely A. *auriculiformis, A. mangium, A. melanoxylon, A. holosericea, A. crassicarpa, A. aulacocarpa, A. dealbata* and *A. mearnsii* have been introduced from Australia for raising plantations. Among these *A. auriculiformis* and A. *mangium* have been planted on larger scale for paper pulp wood production and afforestation of degraded forest land. Open pollinated natural hybrids between these two species are also being selected and clonal plantations of these hybrids are being taken up for paper pulp production in relatively higher rainfall areas in southern India. Few acacia species like *A. auriculiformis* and *A. crassicarpa* are also promising to be used as furniture timber alternative to other indigenous species because of their faster growth and superior wood properties under shorter growth period. However, planting of few acacia species like *A. holosericea* and *A. mearnsii* is being discouraged because of their invasiveness. Currently, it is estimated that phyllodinous Acacia species are being planted in India in more than 50,000 hectares by various agencies like Paper Mills, State Forest Departments, State Forest Development Corporations and farmers in Kerala, Karnataka, Maharashtra, Orissa, Jharkhand, West Bengal, Chattisgarh and North Eastern states.

Genetic improvement has been undertaken extensively in two Acaia species viz., *A. auriculiformis* and *A. mangium* in the country through large scale provenence testing and seed orchard development. The current status of improvemnt of Acacia species and future prospects in India are being reviewed.

**Keywords**: Phyllodinous Acacias, status, India, prospects

# Vietnam's acacia breeding strategy

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The strategy for genetic improvement of acacia species and hybrids in Vietnam is summarized, with information on breeding methods, population sizes and progress to date. Broad-based pure-species breeding populations of *A. auriculiformis*, *A. mangium*and *A. crassicarpa* are advanced by open-pollinated progeny trials. Improvement objectives have emphasized growth and stem form; and substantial gains in productivity have been demonstrated. Third-generation progeny trials of these species will soon be established. Elite *A. auriculiformis* selections can be planted as clones, whereas deployment of the other two species is seed based. Clonal family forestry techniques to multiply the best seed families of *A. mangium* and *A. crassicarpa* are under evaluation.

Breeding of the inter-specific hybrid between *A. mangium* and *A. auriculiformis* is a priority. Over 500 hybrid clones are currently under test. A hybridizing seed orchard incorporating elite selections of both pure species to generate superior hybrid genotypes has been established to produce elite candidate hybrid genotypes.

Polyploid lines of the three species have been developed and may confer advantages including improved stem form and wood properties and reduced seed production. Polyploid breeding is most advanced for *A. mangium*. Deployment of polyploid selections may be via clones or seed; tetraploid lines have been found to self under open-pollination.

Molecular markers are being increasingly employed to track clonal identities and paternal identities, important information for a largely open-pollinated breeding program.

# Use of fruits and infructescence characters in the identification of the *Acacia* Mill. (Leguminosae) species in Nigeria

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Fruits and infructescence characters of 31 *Acacia* Mill. taxa are described in this study. Three species, *Acacia auriculiformis* A.Cum. ex. Benth., *A. auricularis* A.Cum ex. Benth. and *A. schweinfurthi* Brenan. & Excell. represent new records for Nigeria while three taxa denoted as *Acacia* species unidentified *a, Acacia* species unidentified b and *Acacia* species unidentified c cannot be determined reliably using the available flora and resources of the herbarium. Morphometric variants were observed in *A. gourmaensis* A. Chev., *A. Sieberiana* and *A. dudgeoni* with the morphs temporarily identified as as *A. gourmaensis* A. Chev. variant *a* and *A. gourmaensis* Chev. variant *c*, *A. siebberiana* DC variant *villosa* A.Chev. variant *a* and *A. dudgeoni* Gaib. Ex. Hall variant *a*. It remains to determine through further studies if the variation is either genecological or basic plasticity.

Since *Acacia* pods serve as nutritious fodders for animals, particularly livestock, seasonal regional migration of nomadic cattle men in search of water and fodder could have been one of the factors responsible for the introduction and the prevalent new records in Nigeria. All taxa are graphically described.

# Establishment of Nitrogen fixing root nodules in rooted stem cuttings of *Acacia auriculiformis* A.cunn. Ex. Benth

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*Acacia auriculiformis* is associated with Nitrogen fixing bacteria called *Rhizobium* and fixes atmospheric Nitrogen through the symbiotic relationship with *Rhizobium*. The *Rhizobium* produces root nodules in the infected *A. auriculiformis* as the sites for Nitrogen fixation. However, the rooted stem cuttings of genetically superior clones of *A. auriculiformis* for pulp production have not showed the root nodules as they propagated in vermiculite where there is no nutrient, soil and microbial factors. Hence, the rooted stem cuttings always depend on water and humidity for survival. These factors may also cause the growth of rooted stem cuttings due to non availability of sufficient nutrients. To overcome this problem we made an attempt to establish root nodules in the rooted stem cuttings of *A. auriculiformis*. The *Rhizobium* was isolated from root nodules of *A. auriculiformis* tree and cultured in Yeast Extract Mannitol Agar medium. The rooted stem cuttings of *A. auriculiformis* were propagated by using 4000 ppm of Indole Butyric Acid and maintained under green house conditions for 15 days. After 15 days, 10 ml culture of *Rhizobium* was inoculated in the rooted stem cuttings and maintained in polytunnels with 35°C and 70 % relative humidity. The root nodules were developed in the rooted cuttings after 30 days and weighed up to 32mg/nodule and 10-14 nodule/plant. The total nitrogen content was also increased in the rooted stem cuttings due to *Rhizobium* inoculation. This early establishment of Nitrogen fixation in rooted stem cuttings of A. *auriculiformis* has increased the growth and bio mass.

**Keywords**: *Acacia auriculiformis*, Rhizobium, Nitrogen, Root nodules

# Successful recovery of triploid seedlings from crosses between diploid *Acacia auriculiformis* and tetraploid *A. mangium*

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The difficulty of obtaining viable triploid (3*x*) progeny by inter-cytotype (diploid x tetraploid) crosses has been termed the "triploid block" in genera such as *Solamun, Citrus, Populus* and *Oenothera*. Production of triploids is similarly difficult in *Acacia* species. Application of *in vitro* culture techniques to immature embryos may assist with recovery of triploid progeny from inter-cytotype crosses between diploid *Acacia auriculiformis* and tetraploid *A. mangium*. Imperfect (small and partly filled) seeds obtained from three crosses (Aa6 x Am44, Aa6 x Am36 and Aa156 x Am60) were cultured on Murashige and Skoog (MS) medium + Sucrose 30g $l^{-1}$ + Agar 6.2g $l^{-1}$ to promote germination. Eight of the 62 seeds germinated successfully in *in vitro* culture after 7 days. Subsequently, regeneration of adventitious shoots was achieved from MS + BAP 1mg $l^{-1}$ + $GA_3$ 0.05mg $l^{-1}$ + Sucrose 30g $l^{-1}$ + Agar 6.2g $l^{-1}$ with 2g $l^{-1}$ active charcoal added to the shooting medium to improve shoot quality. Good quality shoots were then excised and transferred onto half-strength MS + IBA 2mg $l^{-1}$ + Sucrose 30g $l^{-1}$ + Agar 6.2g $l^{-1}$ for rooting. Following *ex vitro* transplanting, plants were acclimatized over a period of 15 days in a greenhouse. *In vitro* germination, adventitious shoot regeneration and micropropagation as carried out in this preliminary experiment appear to provide an efficient method to recover triploid *Acacia* plants from imperfect seeds.

# Induction and identification of polyploidy *Eucalyptus grandis* and *Eucalyptus grandis x Eucalyptus urophylla* plants

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Polyploidization is a basic feature of plant evolution. The widespread occurrence of polyploidys are frequently found in habitats different from that of their diploid parents, so that it would seem to indicate that polyploidy is associated with colonization of new environmental niches. We developed an approach in which we induce polyploidy in plants of *Eucalyptus grandis* (2n=2x=22). The polyploidization was induced using colchicine by seed treatment. Visual identification and selection was conducted in greenhouses with 3-month plantlets. We selected thicker and broader leaves with darker color. The plants selected were cloned by cutting and were evaluated in number and size of stomas. The clones assumed to be potentially polyploidy were planted in the field. The results showed that the fruits in some clones were bigger than in diploid plants. The clones with the largest fruits were then evaluated according to chromosome number. The result showed autotretraploids with 2n=4x=44 chromosomes. Pollens from these tetraploid plants were crossed with diploid plants, obtaining triploid plants. We were able to confirm the DNA ploidy by flow cytometry. Polyploidy induction by colchicine treatment was effective and its use in breeding program and biotechnology will turn into a powerful tool.

**Keywords:** Polyploidy, *Eucalyptus grandis*, *Eucalyptus grandis x Eucalyptus urophylla*, colchicine, autotretraploid, tetraploid, flow cytometry.

# Ploidy stability in hedge plants of neo-tetraploid *Acacia* hybrid clones

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The utility of new polyploid varieties of tropical hybrid acacias is under investigation by the Vietnamese Academy of Forest Sciences (VAFS) in co-operation with Australian scientists and with funding from ACIAR.

As a possible fast track route to commercial deployment we generated tetraploid (4x) lines from *in vitro* cultures of *A. mangium x auriculiformis* clones using the genome doubling agent colchicine. Plants judged to be stable 4x by flow cytometry were managed as hedge plants for scale up of plant numbers. Ploidy testing of a sub sample of 45 cuttings from 4 clones revealed 13% were mixoploid. The mother plants were grown on and a phyllode from each branch was resampled. Only one of eleven mother plants was 100% tetraploid with the remainder mixoploid. The percentage of branches classified 4x ranged from 17% to 92%.

Origin of the mixoploid tissues is discussed together with implications for managing propagation of neo-tetraploid lines for breeding purposes.

**Keywords:** Tetraploid, mixoploid, *Acacia hybrid*, flow cytometry.

# Breeding Strategy of Acacia Hybrid (*Acacia mangium* x *A. auriculiformis*) in Indonesia to Increace Forest Plantation Productivity

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The superiority of *Acacia* hybrid (*A. mangium* x *A. auriculiformis*) as compared to the parent tree were fast growth, straight bole, light branching, good stem circularity, more tolerance to pest/desease and also better wood properties. Along this time, breeding strategy for *Acacia* hybrid were done through naturally hybrid selected from plantation area then vegetatively propagated by shoot cutting. This study was aimed to generate the effective and efficient breeding strategy of *Acacia* hybrid through control pollination to increase stand productivity. The strategy consists of understanding flower phenology, seed viability, morphologycal seedling identification, propagation abilit using shoot cutting technique and field clonal test. The results showed that flower synchronisation between *A. mangium* and *A. auriculiformis* provide probability for control pollination which produced sound seeds with mean seed viability as 48.1%. Leaf taxonomi development of seedling was proved effective to identify the Acacia hybrid seedlling with accuracy about 92.2% after verifying using molecular marker. The selected seedling were succesfully propagated using shoot cutting with rooting ability of 78.1%. The result of the clonal test at one and two years of age showed that the best 3 clones had rapid growth in height more than controls with the superiority ranging from 6% to 17% and predicted increase to stand productivity of 48 $m^3$ $ha^{-1}$ $y^{-1}$ from 41 $m^3$ $ha^{-1}$ $y^{-1}$. Fifteen of 44 two year old clones had stem volume above the total mean test (>0.005 $m^3$).

**Keywords**: *A. auriculiformis*, *A. mangium*, *Acacia* hybrid, control pollination, clonal test, breeding strategy

# Evaluating Clonal Family Forestry as a deployment strategy for *Acacia mangium* in Vietnam

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Production of superior *Acacia mangium* seed from Vietnam's seed orchards cannot meet national requirements. Clonal Family Forestry (CFF), the vegetative multiplication of selected family seedlots, is an option for expanding the production of superior planting stock based on best orchard seedlots. Seedlings in the nursery are hedged to enable multiple harvests of stem cuttings. A study was undertaken to investigate the feasibility of CFF system for northern Vietnam, which has a seasonal climate with cool, cloudy winters.

Rooting success remained high (> 82%) and stable for cuttings from hedge plants aged from five to 20 months. The best of three liquid fertilizers that were applied to hedges gave significantly ($p$ <0.05) greater shoot size, cutting production and rooting success. Hedges established in the autumn and harvested weekly had a multiplication rate of up to 12.2 rooted cuttings per hedge plant over the six-month period between April-September. Production rates are much lower than those achieved with similar systems in Sumatra, Indonesia which does not have the strong seasonal climate of northern Vietnam.

Examining the timing of cutting production in relation to the planting season shows that prospects for CFF in northern Vietnam are poor because the peak in seasonal production of plantable rooted cuttings and the field planting season are poorly matched. Prospects for CFF appear better in central Vietnam, where there is a better seasonal match.

**Keywords:** Clonal family forestry, hedge management, Acacia mangium, deployment, seasonality

## Breeding against an adverse genetic correlation

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The simultaneous genetic improvement of adversely correlated traits constitutes a major challenge in tree breeding program. Population subdivision strategies have been proposed to deal with breeding objective uncertainty, to reduce inbreeding depression in production populations and to reduce genetic correlation adversity. We used Monte Carlo simulations based on a finite locus model to study the effect of a two breeding population strategy applying selection for each trait in each breeding population on the genetic correlation and on genetic gains in breeding (BP) and production populations (PP) within a time frame of ten generations. A single breeding population and a two sublines strategy both applying multitrait index selection with equal trait weights were used as references. Two BP strategy simulations indicated that simultaneous genetic gain for the two traits could be achieved in the PP despite adverse pleiotropy. The adversity of the genetic correlations decreased in BPs of the two BP strategy, in contrast to single BP and subline strategies, but the adversity reduction came at the cost of a lower rate of aggregated (summed) genetic gain in the PP for the two BP strategy compared to the single BP or sublines strategies. The sublines strategy exhibited increased genetic gain in the PP at equal levels of inbreeding as intended. Two BP strategies could be useful to develop breeds specialized on different traits and to simultaneously reduce adverse genetic correlations. However, if the aggregated genetic gain should be maximized, the single BP strategy appears a better choice.

# Growth of *Acacia mangium* as affected by different formulations of mycorrhizal inoculants and rates of a slow release NPK fertilizer

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A nursery experiment was conducted to determine the growth response of *Acacia mangium* on different formulations of mycorrhizal inoculants and rates of a slow release (Osmocote, 14-14-14) NPK fertilizer.

Aseptically pre-germinated *A. mangium* were either uninoculated or inoculated with mycorrhizal fungi in two formulations (coded as Myk or SC) during pricking. Mycorrhizal inoculants comprised of eight species under the genera: *Glomus*, *Gigaspora*, *Scutellospora*, *Acaulospora* and *Entrophosphora*, mixed together after mass producing them separately. Mycorrhizal spore counts in Myk#00, Myk#1 and Myk#4 were 85±14, 38±5 and 23±8, respectively, while that in SC#00, SC#1 and SC#4 were 230±62, 74±7 and 24±6, respectively. Seedlings were grown in polybags containing 250g oven sterilized mixed soil and sand. Two weeks after pricking, five (0, 0.25, 0.5, 1.0 and 2.0 g/plant) rates of NPK fertilizer were applied one to two inches below the soil surface. Three months after transplanting, the control (no mycorrhizal and fertilizer) plants still had three to four intact false leaves whereas mycorrhizal plants had true leaves. Without fertilizer treatment, mycorrhizal plants grew better than the non-mycorrhizal control counterpart. Inoculation with Myk#00 increased height and stem diameter by 30% while SC#1 increased shoot biomass by 173% relative to the control. Growth of non-mycorrhizal plants at 2.0g NPK/plant was similar to that obtained at 0.25-0.5g NPK/plant plus mycorrhiza. Growth of mycorrhizal plants declined at 2.0g NPK/plant. In conclusion, mycorrhizal formulations coded as Myk#00 or SC#1 in combination with 0.25-0.5g NPK/plant can be effective in producing healthy *A. mangium* in the nursery for rehabilitation programs.

**Keywords:** arbuscular mycorrhizal fungi, *Glomus*, *Gigaspora*, *Acaulospora*, *Entrophospora*, osmocote

# Growth and heavy metal tolerance of mycorrhizal and non-mycorrhizal of *Acacia mangium* and *A. aulacocarpa* seedlings grown in mine waste soil

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Soil pollution due to high contamination of heavy metals (HMs) is a worldwide very depressing environmental issue. HMs contaminated areas are often barren and plant growth is stunted. Phytoremediation is one of the solutions to clean up contaminated soils.

A nursery experiment was conducted to determine the growth and heavy metal tolerance of *Acacia mangium* and *A. aulacocarpa*. Two-week old aseptically germinated *A. mangium* and *A. aulacocarpa* were either uninoculated or inoculated with arbuscular mycorrhizal fungi: *Gigaspora margarita*, *Glomus etunicatum*, a commercial mycorrhizal inoculant Mykovam™ (mixture of *Glomus* and *Gigaspora* species developed at the University of the Philippines Los Baños) and mycorrhizal fungi from mine site (contains mixture of *Glomus*, *Acaulospora*, *Scutellospora* and *Entrophospora* species coded as Paracale isolates) and grown in a mine tailing soil collected from abandoned mine waste sites in Paracale, Camarines Norte. The mine waste soil has acidic pH (3.5), 1,262 mg Pb/kg, 12.87 mg Cd/kg, 3.51 mg Cu/ kg and 1.44 mg Zn/kg.

Four months after inoculation, mycorrhizal *A. mangium* and *A. aulacocarpa* seedlings generally grew better and absorbed more Cu than the non-mycorrhizal counterpart. Mykovam™ inoculated seedlings had 100% mycorrhization, heaviest biomass and highest P and Cu concentrations. P and Cu were greatly accumulated in the leaves and roots, respectively. These results imply that inoculation with mycorrhizal fungi particularly Mykovam™ can enhance growth and heavy metal tolerance of *A. mangium* and *A. aulacocarpa* and possibly with other fast growing tree species for a successful rehabilitation and reforestation of heavy metal contaminated areas.

**Keywords:** fast growing legumes, arbuscular mycorrhizal fungi, Mykovam™

# A new métier for plantation acacias in China

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Research and plantation development for exotic acacia species have checkered histories in China. A series of international collaborative projects starting from the mid-1980s sponsored and encouraged a substantial amount of acacia research and these were followed by many Chinese domestic initiatives. Promising outcomes from some of this research led to the expansion of acacia plantations from the 1980s through to the late 1990s, possibly to a peak of around 200,000 ha or more. Since then, the acacia plantation resource in China has declined markedly to less than 50,000 ha due to a complexity of factors. The rise and decline of the acacia plantation resource in China is examined in this paper, and key factors that led to the decline are discussed. An overview of past of acacia research in China is provided and some key shortcomings in this are identified.

Many plantation growers and investors currently view future prospects for acacia plantations as being severely limited in China, but selected species/varieties still have good potential to provide alternative fast-growing pulpwood (and possibly veneer log) plantation species for sites in southern regions. They could also have an important role in this region to underpin the sustainability of nitrogen-demanding, fast-growing eucalypt plantations. The issues and challenges that need to be addressed for acacia species to successfully fulfill such roles are examined in this paper it is in such roles that acacias' true métier may lie in southern China.

# Productivity of a second-rotation acacia hybrid plantation in central Vietnam: effects of topographic position and P application at planting

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A second-rotation plantation of clonal acacia hybrid was established at Dong Ha in Central Vietnam on a heavily disturbed site with a gravelly, shallow soil where part of the A-horizon had been lost to erosion under previous land use. Mean annual increment (MAI) of the previous rotation of acacia hybrid, harvested at age 9 years, was 19 $m^3 ha^{-1} y^{-1}$. After harvest, slash was left on site and was not burned. The second rotation used a mix of six acacia hybrid clones including the three planted in the first rotation. Mean MAI of the second rotation at age 4.6 years was similar at 20 $m^3 ha^{-1} y^{-1}$. The effect of P application on growth was significant ($p<0.05$) but modest, with MAI of 18.0 $m^3 ha^{-1} y^{-1}$ and 21.9 $m^3 ha^{-1} y^{-1}$ respectively for a control and the highest rate (60 g P per tree). The site had a slope of about 10-15°. To account for possible slope effect, the four replicates, each testing five experimental treatments, were laid out down the slope over a total distance of 200 m. Productivity of replicates increased significantly downslope from MAI 16.5 $m^3 ha^{-1} y^{-1}$ for the replicate at the top of the slope sequentially to 16.7, 22.0 and 25.0 $m^3 ha^{-1} y^{-1}$ for the lowest replicate. Soil organic carbon and nitrogen in the surface 10 cm increased downslope in parallel. Results show the surprisingly low requirement of applied P for acacia and the importance of recognising slope effects in such terrain in experimental designs and in productivity evaluations in general.

# An evaluation of sawn timber from a 10 year-old stand of *Eucalyptus pellita* in South Sumatra

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Sawn timber was processed using logs harvested from a 10-year-old stand of *Eucalyptus pellita* - a back-up species from a plantation area historically dominated by *Acacia mangium*. The stand had been established at a stocking density of 1111 trees ha-1 using seedlings from a first generation seedling seed orchard of Muting (Papua, Indonesia) origin. The stand had not been thinned and pruned. Twenty logs were selected and sawn into boards using a vertical band saw. The standard log length was 4 m and minimum small-end diameter 15 cm. All of the boards had good colour and there was no rot. The most important defect was dead knots, the distortion in the green boards was dominated by bow. End splits and wane were present but not severe. After air-drying for 30 weeks in the dry season under shade the boards had the following properties: shrinkage of width but not thickness; distortion dominated by bow, with some spring (both not severe) but no twist; free of surface checks except for boards originating from the centre of the tree. The moisture content of the board surface ranged from 12.0 to 14.7%, and at 15-mm depth from 13.9 to 16.9%. It was concluded that *E pellita* grown in a wet tropical environment can yield acceptable sawn boards at age 10 years. However, pruning is required for knot-free high quality appearance-grade timber and thinning to promote diameter growth.

**Keywords**: Eucalyptus pellita, sawn timber, board properties

# *Acacia mangium* Tree Improvement at Sabah Softwoods: Lessons learned after three decades

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The local landrace of *Acacia mangium* in Sabah originated from a narrow genetic base in the North of Queensland. A breeding program based on the Sabahan land race provided seed to support the SSB plantation program through the 1980s and early 90s. However a focus on hybrid production and clonal evaluation led to little new material being infused into these original orchards and inferior seeds of *A. mangium* resulted. More recently new germplasm was captured from ACIAR trials, CSIRO's Australian Tree Seed Centre and in collaboration with other companies, resulting in an expanded genetic base. Trials have provided clear evidence that *A. mangium* has broad adaptability and is highly productive.

Pests and diseases are the biggest threats to the sustainability of *A. mangium*. The recent rapid spread of *Ceratocystis acaciivora* coupled with ongoing losses due to Ganoderma root rot have resulted in converting *A. mangium* into other species. Poor genetic material, inadequate silviculture and large scale animal damage were the principal contributors to disease infestation. While *A. mangium* is no longer planted at scale by SSB, there is still cooperative research into the species especially to broaden the genetic base while screening for pest and disease tolerance.

Currently, results and germplasm are shared with other forestry companies in Borneo so that we may make comparisons across different environments and generate more robust research outcomes. A co-operative R & D approach is our chosen way to do this. This will ensure the continuity of a long-term tree improvement program and the incorporation of pest and disease screening.

**Keywords:** *Acacia mangium*, germplasm, Pest and diseases, *Ceratocystis acaciivora*, disease tolerance, cooperative research

# Estimation of Organic Matter Accumulation on Short-Rotation *Acacia mangium* Plantations with Several Harvest Residual Management

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Spreading fast wood plantations are concerned about degradation of their stand productivity in tropical regions, because the soil is low chemical property, and the short rotation harvesting management and its naked land environment at the harvest, may accelerate decomposition of their harvest residuals and soil organic. It will verify the sustainability of the short rotation management to estimate the amount of organic matter accumulation, changed by the difference of the rotation length and putting harvest residuals on the floor with simulation methods. This study was conducted at *Acacia mangium* stands of PT. Musi Hutan Persada (MHP) industrial plantation company in South Sumatra, Indonesia. Amounts of biomass and the estimated harvest residuals were determined by cutting trees survey. To determine the parameters for calculation of biomass, woody debris, and soil organic matter fluctuations, the continual census survey, reaping survey and decomposition test had been conducted for 4 years. Estimating of the annual production and the decomposition of each component for 4, 6, 8, and 10-year rotation length and for several harvest residual management determined the accumulations of the organic matter by the simulations. The accumulation was the highest with the longer rotation length and more preserving woody debris, and the annual wood production was the highest in 6 years rotation (14.8 Mg/ha/y). The shorter rotation caused decreasing accumulation of the organic matter because of the smaller size class and lower amount of woody debris. The attempt use of unused resources should be considered not to decrease accumulation of organic matter.

**Keywords:** *Acacia mangium*, Harvest Residues, Rotation Period, Carbon sequestration, Biomass production, Decomposition rate

# Uses of Australian *Acacia auriculiformis* A. Cunn. (Ex. Benth.) for initial establishment of Tropical Rainforest species of Western Ghats, South India

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The Western Ghats of South India is considered as one of the 'biodiversity hotspots' of world and forests of Kudremukh National Park are relatively intact hill rainforests. Most of the land surrounding these forests has been converted to plantations of areca, tea and coffee. Much of the degraded land bordering these protected areas can be described as abandoned open pasture and is now dominated by invasive weed species such as *Lantana camara* and *Cromolaena odoratisima*. The Australian *Acacia auriculiformis* has been extensively planted on degraded lands of the southern Western Ghats from last four decades under Social Forestry and Joint Forest Management programmes, its proportion has risen to 70% to meet the ever-increasing fuel and timber requirements of local people.

Generally shade-tolerant climax rainforest tree species seedlings are not able to tolerate the harsh microclimate and competition by grass prevailing in open degraded wastelands. So far, no attempt has been made to use the existing *A. auriculiformis* plantations as nurse crops to establish shade loving endemic tree species of Western Ghats region. Our experiments for over a period of three years under twenty years old *A. auriculiformis* show that shade loving species such as *Vateria indica, Hopea parviflora, Dipetocarpus indicus, Garcinia gummi-gutta and Calophyllum apetalum* exhibited more than 60% survival rate and significant improvement in growth compared to the same species planted in open wasteland plots. Hence it is very important to conduct more extensive trails of reforestation under the shade of existing *A. auriculiformis* plantations in Western Ghats region India.

**Keywords:** *Acacia auriculiformis*, Western Ghats, Reforestation, Social forestry, Rainforest, Biodiversity hotspots

# Variable density yield tables for Acacia hybrid plantation management in Vietnam

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Acacia hybrid plantations are the largest plantation species in Vietnam. Growth models and yield tables are essential tools for predicting plantation productivity and help to guide silvicultural practices for better productivity and quality of planted forests. Traditional yield tables in Vietnam are based on modeled best-case scenarios of plantation production for specific purposes such as for timber or biomass. However, most commercial plantations in Vietnam belong to small scale holders with a significantly high diversity of silviculture practices applied, especially planting density. This brings difficulty in producing a standard yield table for each site class. Additionally, a yield table based on a single density dynamic would minimize applicability to a wide range of plantation characteristics of the same site class.

We developed yield tables for Acacia hybrid plantation by variable density method. Data collected from temporary plots and tree stem analysis of 350 stands in the whole country were used for developing empirical stand growth and yield models. At each of the five site classes there are five density classes represented by the stand's basal area. In total, 25 yield tables are established for nationwide Acacia hybrid plantations.

Testing yield tables established by other collected data sources reveals that the models can cope with a high diversity of site conditions and silvicultural practices. Yield tables are designed as straightforward tools which small holders are able to use. The use of variable density yield tables as a robust management tool for high yield and sustainable forest management are also discussed.

# Effects of hedge plant age and fertilizer on growth and form of three Acacia hybrid clones

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We examined the effects of planting stock type and fertilizer at planting on growth, stem form and branch size of three *Acacia* hybrid clones. Two fertilizer-at-planting treatments (P0; nil fertilizer, and P50; 50 kg of P $ha^{-1}$ applied as superphosphate) and two types of cuttings (tip cuttings taken from 1-year-old hedges and from 4-year-old hedges) of three *Acacia hybrid* clones, BV10, BV32 and Bv33, were tested in a trial in Southern Vietnam that used a split-plot factorial design. Two years after planting, there were no significant differences in growth or branch size between different cutting types, or between the clones. Fertilizer application was found to significantly increase diameter at breast height ($Fpr < 0.001$), from a mean of 7.9 cm in P0 to 9.2 cm in P50. Basal area in the P50 treatment was 5.9 $m^2$ $ha^{-1}$, 20.5% greater than in the P0 treatment. However, fertilizer application also significantly increased the size of the largest branch in the 1-2 m height range, from a mean of 1.7 cm in P0 to 2.2 cm in P50, and negatively affected stem form. The percentage of broken trees in the P50 treatment was 16.9%, significantly greater than 5.6% broken in the P0 treatment. This appeared to be a consequence of the fertilized trees with heavier branches being more susceptible to breakage by wind storms.

**Keywords:** *Acacia* hybrid, growth, branch size, stem form.

# *Acacia mangium* affects soil nitrogen and microbial community and activity in mixed plantations with *Eucalyptus urograndis*.

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Mixed-species plantations of *Eucalyptus* spp. and *Acacia mangium* which can symbiotically associate with nitrogen-fixing bacteria have potential to improve the soil quality and biomass productivity in comparison with a conventional eucalyptus monoculture. An experiment was established in Southeast region of Brazil to study the effects of mixed plantation (50E:50A, 1,111 trees $ha^{-1}$ and 100E:100A, double density) and tillage intensity over soil quality and microbial diversity in comparison of *Eucalyptus urograndis* monoculture (E100 and E100+N). Superficial soil layer (0-10cm) showed an increase of the soil nitrate content in both *A. mangium* (acacia) and mixed stands. The soil microorganisms (fungi and bacteria) have been significantly impacted by the treatments, with mixed area showing an integration of the microbial population present in the pure plantations. The molecular study of the soil microbiology demonstrated that the introduction of the acacia in the eucalyptus plantation significantly increased the number of fungi genera and the diversity index introducing or changing the frequency of several genera that could not be found in the monoculture cultivation. The C associated to microbial biomass and β - glucosidase activity were reduced under intensive the tillage. Our results suggest an increase of the soil quality in the mixed plantation compared to the *Eucalyptus* monoculture, especially in minimal tillage.

**Keywords:** microbial diversity, N cycling genes, soil quality, enzymes

# Managing Acacia Pulpwood Plantation Productivity on Tropical Mineral Soils in Riau Indonesia

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PT. Riau Andalan Pulp and Paper (RAPP) manages pulpwood plantations on tropical mineral soils in Riau Province Indonesia where *Acacia mangium* is the main species grown on a 5 year rotation. The plantation productivity is managed through long term tree improvement program and by applying suitable silvicultural regimes that optimize cost of wood production by appropriate stocking, fertilization, slash management and regeneration techniques. Initial stocking is important in affecting final yield. Initial stocking of 1333 to 1667 trees $ha^{-1}$ is commonly optimal for such short rotation plantation. However, stocking can also be improved by utilizing naturally regenerated seedlings. Nitrogen application is not required for *A. mangium* but application of 23 kg P $ha^{-1}$ at planting is adequate for good growth. There is no significant response to higher rate of P at age 2 years. P fertilization increased biomass significantly, however it reduced root: shoot ratio. P fertilization increased P and K foliar nutrient re-translocation significantly. Retention of slash during harvesting on good potential site increased growth insignificantly compared to complete removal of biomass. There is no indication of soil fertility decline during 8 years in second rotation and until 2 years in third rotation of *A. mangium* in both slash retention and removal treatments. We recognize the challenges from soil born pathogens, animal damages and soil compaction by heavy machineries during harvesting in achieving the desired productivity. Since there is very little heritable resistance within the breeding population then management response is necessarily silvicultural. Therefore various site preparation and planting techniques are under study and demonstration including rotation with different genus such as eucalyptus.

**Keywords**: *Acacia mangium*, silviculture, plantation productivity

# Using *Acacia* hybrid as a nurse crop for re-establishment of the dipterocarp *Hopea odorata* Roxb. on degraded lands in Vietnam

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*Acacia* hybrid (*A. mangium* ì *A. auriculiformis*) is a potential nurse crop for re-establishing native trees on degraded lands. Soil change under two or three consecutive short rotations of *A.* hybrid plantations on degraded lands was examined in the context of matching site requirements for regeneration of *Hopea odorata* in its natural habitat. A trial of planting *H. odorata* under 22-m diameter gaps in a 3-yr old *A.* hybrid plantation was established to validate the anticipated growing requirements. Sandy soils with low nutrient concentrations did not constrain the growth of *H. odorata* in natural forests. *Acacia* hybrid plantations led to recovery of total C, total N and some cations, but not potassium or phosphorus. It was also associated with retention of high levels of soil acidity; however vigorous growth of *H. odorata* observed between $pH_{H2O}$ of 5.7 in the natural forest and 4.3 in the plantation, indicated its adaptation to a wide range of soil acidity. Per cent transmitted photosynthetically active radiation (PAR) at seedling level of around 11% was necessary for active seedling development in the natural forest. However, a positive response of seedling growth and photosynthetic rate up to a transmitted PAR level of 60% observed in the gaps of plantation indicated that *H. odorata* had plasticity in adaptation to various light environments. In the dry season, competition for water uptake was probably an important factor limiting growth *H. odorata* adjacent to the nurse crop. Successful re-establishment of *H. odorata* on degraded sites using *Acacia* hybrid as a nurse crops should be possible provided that high levels of shading and competition for water are managed.

**Keywords:** Gap regeneration, gas exchange, native species planting, shade tolerant, soil amelioration

# Durability of Five Treated and Untreated *Acacia* Wood Species in Thailand

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Many *Acacia* species have been introduced to Thailand for commercial plantation and to support the wood based industries. Because of their fast growing properties, these exotic species are under question in regard to wood durability and protection techniques. To investigate this suspicion, five 18 year old *Acacia* wood species (*Acacia mangium*, *A. aulacocarpa* , *A. crassicarpa*, *A. auriculiformis*, and *A. hybrid*) were selected for this study. The *Acacia* wood species were dried and cut to a specific size and then separately treated with six wood preservatives (Chromated Copper Arsenate (CCA), Ammoniacal Copper Quat (ACQ) , Copper Azole (CA-B), Boron, Cypermethrin and wood vinegar) using 4 different treating methods (vacuum and pressure, soaking , dipping and brushing). The treated wood specimens and the untreated ones were then randomly subjected to field tests in order to determine their durability in the Chiang Mai province. The damage of these specimens was evaluated and recorded every 6 months. After 36 months of exposure, statistical results revealed that the five Acacia species showed significantly different durability properties. *A. auriculiformis* and *A.hybrid* showed the best performance, whereas *A. aulacocarpa* and *A. crassicarpa* were the weakest. Moreover, wood preservative treatment led to improved durability in the specimens, except with Boron and wood vinegar which showed the same severe damage as the untreated controls. Furthermore, the effect of the treating methods is also discussed in this study.

# Nitrogen mineralization in *Acacia mangium* and *Eucalyptus pellita* plantations in South Sumatra, Indonesia

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The influence of tree species on soil nitrogen mineralization was assessed at three sites in South Sumatra with paired *Acacia mangium* and *Eucalyptus pellita* plantations: Subanjeriji (age 5-years), Gemawang (age 11 years) and Banding Anyar (age 17 years). Soil samples were taken from the upper 10 cm of the soil using cores constructed from 50 mm PVC. Three sampling plots were taken for each species and site. A total of 9 pairs of soil cores (for initial mineral-N pools and mineral-N pools extracted on day 28) were collected per plot. Aerobic soil incubation at 30°C was made over a period of 28 days. Mean concentrations of ammonium and nitrate-N were highest in the 17 year old stand of *A. mangium* and lowest in the 5 year old stand of *E. pellita*. N mineralization rate was found to be higher in the plantation of *A. mangium* than that of *E. pellita* at all sites ($P<0.05$). N mineralization rate was highest in the 5 year old stand of *A. mangium* and lowest in the 17 year old stand of *E. pellita*. Higher content of organic matter, total N and low C/N ratio in the soil seems to contribute to the higher rate of N mineralization in *A. mangium* plantation than that of *E. pellita*.

**Keywords**: N mineralization, *Acacia mangium*, *Eucalyptus pellita*.

# Modelling *Acacia* production in Vietnam under current and future climates

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*Acacia mangium* and other commercial acacia species have been planted in Vietnam and they are an important source of wood production. There are, however, uncertainties about the sustainability of yield over successive rotations, the potential threats from pests and diseases, and the effects of climate change. Estimating the effect of climate on forest productivity requires the development, adaptation and validation of spatial models that can realistically analyse scenarios at a range of scales. Regional forecasts of climate change predict increasing temperatures, and changes in precipitation and the frequency and severity of extreme climatic events; both are likely to affect acacia forestry in Vietnam. The spatial process-based growth model 3-PG2S was used to predict growth variables, leaf area index and evapotranspiration of planted acacias using historical spatial and temporal variations in climate, and future climate for 2020, 2050 and 2080. Soil texture, fertility, and water holding capacity supplied locally were also used as model inputs. Future climates in Vietnam will be associated with a reduction in precipitation and increase temperature though this varies between regions. While the effects of increasing $CO_2$ remain uncertain, increased water-use efficiency should reduce the effects of reduced soil water availability on acacia productivity. The further application of 3-PG2S as a practical and effective tool for decision making in environments where plantations are already affected by climatic seasonality and where this will be reinforced by changing climates is presented.

# Important insect pests and diseases of *Vachellia (Acacia) nilotica* (L.) Willd. ex Del. in Southern India

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*Vachellia nilotica* (syn. *Acacia nilotica*) is a valuable multipurpose tree occurring naturally and grown widely in arid and semi-arid regions of India. It is gown largely in social and agroforestry plantations for timber, firewood, fodder, bark tanning, gum etc. There are nine recognized subspecies under *V. nilotica* and among them the subspecies *indica*, *tomentosa* and *cupressiformis* occur in Southern India. Surveys for insects and diseases of the three *V. nilotica* subspecies were conducted from 2009 to 2012 in 72 plantations located between the Latitudes 8° 43' 09.8" to12° 50' 29.4" and Longitudes 076° 40' 50.3" to 079° 59' 17.4" in the states of Tamil Nadu and Karnataka. A total of 89 insects and 14 pathogens affecting flowers, seed pods, foliage, shoot and root were recorded. Based on the incidence, abundance and intensity of infestation, insects and diseases were categorized into major and minor. The major insect pest species include 23 species of flower, foliage and shoot feeders, 8 species of sapsuckers, 3 species of live wood borers and a species of seed feeder. The scale insect *Anomalococcus indicus* Ramakrishna Ayyar; the lepidopteran defoliators such as *Selepa celtis* Moore, *Isturgia disputaria* Guenée, *Phyctia* sp. (A), *Eumeta crameri* Westwood, *Pteroma plagiophleps* Hampson, *Phycita* sp (B); the coleopteran defoliators viz., *Dereodus denticollis* Boheman, *Pachnephorus* sp., *Diapromorpha turcica* Feb. *Cryptocephalus insubidus* Suffrain, *Myllocerus* spp.; the bark feeder, *Niphona* sp. and the stem borer, *Celosterna scabrator* Feb. were the prominent pest species. The flower feeder *Mylabris* sp. and the seed feeder, *Caryeodon serratus* Olv. also affected the flowers and seed productions of subspecies *indica* and *tomentosa*. Two species of rust fungi (*Ravenelia acacia-arabicae* and *R. evansii*) affecting the foliage and immature seed pods and shoot tips drying and premature fall of green seed pods were reported as major diseases. Geographic range, seasonal incidence, field host range, biology and damage potential of these major pests species and the rust fungi were investigated.

**Keywords:** *Vachellia indica*, *Insect* pests, foliage feeder, rust fungi, field host range, biology, seasonal incidence

# Associating climate variable with genetic variation in Hawaiian koa, Acacia koa

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Landscape genomics is a powerful approach for identifying genetic variation under natural selection by climate through directly associating genetic variation with climate variables. This is important for understanding adaptive genetic variation, and can be used to predict how plant populations will respond to projected climate change. Our project focuses on the landscape genomics of koa (Acacia koa) in Hawaii to identify genes that are important in adaptation to current climate variation and thus important in response to changing climate. We are sampling trees across the geographic, elevational, and climate range of A. koa on the islands of Kauai, Oahu, Maui, and Hawaii. We are using a second-generation sequencing technology, genotyping-by-sequencing (GBS), to generate single nucleotide polymorphisms (SNPs) and obtain sequence data for a large number of DNA fragments. Climate data are associated with the SNP allele frequency data, and we hypothesize that many SNPs will be found to have frequencies that are associated with climate variables, i.e., temperature and precipitation. This information will be useful for identifying populations at risk as well as populations that may be adaptable in future climate scenarios.

**Keywords:** Acacia koa, landscape genomics, climate variables, genetic variation

# Phytophthora an emerging threat to *Acacia mangium* plantations in Vietnam

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Several *Phytophthora* species are major pathogens of agricultural and horticultural crops but have not been reported as problems in plantation forestry in Vietnam. In 2012, *P. cinnamomi* was detected from soil baiting under declining *Acacia mangium* plantations in Tuyen Quang province. The pathogen was identified from morphological traits and DNA analysis. Additional isolates of *Phytophthora* have been obtained in Yen Son, Tuyen Quang province and molecular characterization indicates a suite of taxa may be implicated in acacia decline. Pathogenicity tests conducted so far show that *A. mangium* is susceptible to *P. cinnamomi* in the nursery. Testing is now underway to determine the extent of *Phytophthora* -associated health issues in acacia nurseries and plantations in Vietnam. As *Phytophthora* is soil and water bourne, the potential for wide distribution of this group of pathogens via forest nurseries is high.

**Keywords:** *Phytophthora cinnamomi, Acacia mangium,* Tuyen Quang province

# Insect pests survey on Acacia plantations in Vietnam

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Acacia spp. have been selected for planting on such a large scale and is becoming one of the main species for industrial plantations in Vietnam, due to its rapid growth and tolerance of unfertile soils where it is very difficult to establish other tree species. With fast-growing Acacia plantations have been raised annually in the whole country for production of pulp for paper, chip, finger join boards and MDF boards. Like all tree plantations, however, acacia plantations are vulnerable to pests and diseases, significant new pests have emerged to reduce their productivity. From health survey conducted by Forest Protection Research Centre in 2012 and 2013 in Acacia plantations, there are 99 main insect pest species associated with *A. auriculiformis*, *A. mangium* and Acacia hybrid in Vietnam, with the following orders represented: Coleoptera (29), Orthoptera (26), Lepidoptera (25), Hemiptera (15), Isoptera (2), Homoptera (1), and Phasmida (1) and. In all, 99 species are listed, some species such as: *Acanthopsyche* sp., *Dasychira checkiangensis*, *Ericeia* sp., *Holotrichia sauteri*, *Hypomeces squamosus*, *Phalera grotei*, *Stauropus fagi*, *Xylosandrus crassiusculus*, ***Xystrocera festiva*** *are the most* serious pests of *A. auriculiformis*, *A. mangium* and Acacia hybrid. Recently, some new insect pests of trees in acacia plantations in Vietnam has emerged: ***Chlorophorus sp.,*** *Ericeia* sp., *Euwallacea fornicatus*, *Indarbela quadrinotata*, *Phalera grotei*, *Sinoxylon anale*, ***Xystrocera festiva***. This paper presents an alphabetical list of insects associated with Acacia plantations in Vietnam and includes information on their distribution and the type of damage to the host.

# Comparative fitness of self-fertile and self-sterile isolates of the wilt pathogen *Ceratocystis albifundus*

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Various species of Australian *Acacia* are intensively planted, particularly for solid wood and pulp products in various parts of the world. In this regard, *A. mearnsii* is an important commercial plantation species in various countries of Africa. However, its sustainability is threatened by the canker and wilt pathogen *Ceratocystis albifundus*. *Ceratocystis albifundus* is a homothallic fungus capable of uni-directional mating type switching, producing either self-fertile or self-sterile offspring. As a result of mating type switching, the *MAT 1-2-1* gene is lost, eventually producing self-sterile isolates. Previous studies have shown that self-sterile isolates tend to grow more slowly than self-fertile isolates and the aim of this study was to investigate other possible ecological differences between these two isolate forms. We thus examined germination rate of spores representing each of the mating types, growth rates of cultures and relative aggressiveness of different isolates of *C. albifundus*. Our results showed that all self-sterile isolates tested were less aggressive and had slower growth rate compared to self-fertile isolates. Self-sterile isolates also had ascospores displaying a lower germination rates. Overall, the results showed that self-fertile isolates have greater fitness than those that are self sterile. These results provide a basis for better understanding of the biology and ecology of an important tree pathogenic fungus.

**Keywords:** *Ceratocystis albifundus*, *Acacia mearnsii*, Mating type, Fitness, Germination rate, Growth rate, Aggressiveness

# *Ganoderma steyaertanum* as A Root Rot Pathogen of Forest Trees

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Indonesia's forest industry contributes 3.5% of the country's GDP, and provides high levels of employment, particularly in rural areas. The majority of this plantation estate is for pulpwood which is largely based on species from two non-indigenous genera, acacias and eucalyptus. These species are increasingly threatened by pests and pathogens as the estate ages. *Acacia mangium* plantations in Sumatra and Kalimantan suffer heavy losses from root rot caused by *Ganoderma philippii.* Two *Acacia* seed orchards on the island of Java are associated with a different species of *Ganoderma. Ganoderma steyaertanum* was consistently isolated from roots of affected trees and pathogenicity tests confirmed Koch's postulates. The spread of tree deaths has been monitored for a decade and spatial analyses indicate that, after an initially random disease distribution, the pattern of tree deaths was clustered. This is consistent with spore colonisation of thinned stumps followed by vegetative spread through root-to root contact, as has been observed for other root pathogens such as *Heterobasidion annosum.* Somatic incompatibility tests demonstrated high genetic variability of the pathogen and failed to confirm root-to-root spread. The importance of *G. steyaertanum* as a pathogen of forest trees has not been previously highlighted. Economically feasible options to manage root rot disease in hardwood plantations are often limited and may rely on host selection. Two hundred and fifty seedlings from eight Papua New Guinean families and 813 from eight Australian families of *A. mangium* were tested for resistance to *G. Steyaertanum.*

**Keywords:** *Ganoderma steyaertanum*, root rot, *Acacia mangium*

# Pest and diseases of *Acacia decurrens* as invasive species at Merapi volcano national park in Yogyakarta, Indonesia

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*Acacia decurrens* is one of the invasive species in the Merapi Volcano National Park (MVNP) in Yogyakarta, Indonesia. The seeds and leaves of Acacia are less attractive to the Merapi wildlife, so it is feared it could reduce wildlife diversity. The Acacia plant is also fast growing and can inhibit the growth of native species of Merapi. Actions are taken by MVNP management to overcome the spread of Acacia. Simple measurements were taken in some areas, such as in Glagaharjo, Resort Cangkringan, Sleman, on March 2012. The results showed that density of *A decurrens* at the seedling and sapling stage were 16.166,7 and 11.813,3 per hectare, respectively. DBH of Acacia can reach to 26 cm in 18 months. (MVNP, 2012). The aim of the research is to observed the associated pests and diseases that may potentially reduce the growth and development of *A. decurens* at MVNP area. Survey research with 10% sampling intensity have been conducted in MVNP area on January to September 2013. The result showed that the incidence of stem wound associated with *Ceratocystis* Spp., was 80%, while gall rust disease incidence with very small intensity associated with *Uromycladium tepperianum* was 60%. Number of associated insects pests such as white grubs, grasshoppers, cutworms and caterpillar were occurred at about 40% in some seasons, particularly in the hot season.

**Keywords**: *Acacia decurens*, pests and diseases, Merapi Volcano National Park

# Diseases associated with wounds in Acacia hybrids in Vietnam

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*Acacia* hybrid clones between *A. mangium* and *A. auriculiformis* are widely planted in Vietnam. Hybrid clones are increasingly being managed for solid-wood production applying silvicultural techniques such as pruning and thinning. Poor planting stock and high rates of fertiliser application can lead to the formation of poor form and lack of stem straightness and large branches. Pruning large branches led to the development of heart rot at southern sites which makes logs unacceptable for sawn timber. High growth rates and large crowns were associated with branch breakage during storms and decay entry. Better choice of planting stock, timely and correct pruning techniques and management of canopy size are therefore essential if these problems are to be minimised. Tip pruning which removes approximately one-half of the length of competing leaders and branches is necessary to control branch size and can be used throughout the year. Surveys and experimental data suggest that in addition to heart-rot fungi there are other significant biotic agents that may impact on wood quality. *Ceratocystis acaciivora* causing acacia wilt and die-back is one such threat. This pathogen has been found on *A. mangium*, *A. auriculiformis* and acacia hybrids thoroughout Vietnam. A pot trial with different clones of acacia hybrids, *A. auriculiformis* and *A. mangium* has been established in Binh Duong province to investigate clonal responses to heart rot fungi and *Ceratocystis acaciivora*.

## Plenary Speaker

**Dr Nguyen Duc Kien**
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**Title:** The Acacia as a national resource in Vietnam

Dr Nguyen Duc Kien is currently vice-director of the Institute of Forest Tree Improvement and Biotechnology, Vietnam Academy of Forest Science, a leading research institute in forest tree breeding, gene conservation, propagation and application of biotechnology in forest tree improvement in Vietnam and South East Asia.

He has been working as a tree breeder for almost fifteen years and has long term experience in genetic improvement of *Eucalyptus* and *Acacia* for increased growth and improved wood quality as well as the domestication of native species. He has been involved as senior scientist in numbers of research and development forestry project funded by Vietnam government and international donors and published more than twenty papers in Vietnamese and international scientific journals. He has also been working as consultant for numbers of plantation companies in Vietnam and Lao PDR.

**Mr Stephen Midgley**
Salwood Asia Pacific - Services in Forestry
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**Title:** Worldwide uses of Acacia species

Stephen Midgley is Director of Salwood Asia Pacific Pty Ltd, a company which offers a professional commitment to partnerships between Asian and Australian forest industries and organisations through a range of services relating to the commercial use of Australian trees, forest industries, market opportunities and rural development.

He is a senior professional forester and project manager with a strong commitment to partnerships across complex social, institutional and scientific disciplinary boundaries, particularly in Asia and the Pacific. He has a prime professional interest in forest genetic resources and domestication of Australian trees, with long-term field experience in community forestry and smallholder engagement, tropical hardwood plantations and selection of tree species to meet commercial and community needs. He was a long-term member of FAO's Panel of Experts on Forest Genetic Resources and his work has been recognised through several Australian and international awards.

**Dr Eko Hardiyanto**
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**Title:** Challenges for acacia breeders

Dr Eko B. Hardiyanto is a Senior Lecturer in Forest Genetics at the Faculty of Forestry Gadjah Mada University in Yogyakarta Indonesia. He has been working with *Acacia mangium* for over 20 years focusing on genetic improvement, silviculture and inter-rotation site management. He has also an interest in the genetic improvement and silviculture of other species including *Pinus merkusii*, teak, *Paraserianthes falcataria* and *Anthocephalus sp.* For the last 20 years he has been doing consultation work with a number of forestry companies in Indonesia. He received his PhD at Michigan State University.

**Dr Sadanandan Nambiar**

CSIRO Ecosystem Sciences, Canberra. GPO Box 1700, ACT, Australia

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**Title:** Challenges for sustainable production: science and application

Dr Nambiar is now retired from CSIRO but still most actively engaged in forest science. He is internationally recognised as a leader in research on sustainable productivity and management of forests. His multi-disciplinary approach to this complex science and committed advocacy to sustainability has had a profound impact upon efficient, science-based plantation management in Australia and overseas. He has been a tireless advocate of the potential of man-made forests, agro-forests and woodlands as land use systems that can foster both economic prosperity and environmental benefits for society. Dr Nambiar has received a number of prestigious awards in the USA, from the Commonwealth Forestry Association (CFA) and from the International Union of Forest Research Organisations (IUFRO) which recognised Dr Nambiar as a "pre-eminent Australian forest scientist of contemporary times". He was also recently awarded a Medal by the Government of Vietnam for his service to their forestry and rural development.

**Dr Trevor Booth**

CSIRO Ecosystem Sciences - Black Mountain

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**Title:** Planting domains of key species in a changing environment

Dr Booth is a Senior Principal Research Scientist at CSIRO Division of Ecosystem Sciences. His early work at CSIRO was concerned with developing and applying new bioclimatic analysis methods, particularly to assist the introduction of acacia and eucalypt species outside Australia. He led the Natural Ecosystems Theme in CSIRO's Climate Adaptation Flagship from 2008 to 2011 and his 2013 publications include a paper in Forest Ecology and Management on 'Eucalypt Plantations and Climate Change'a paper considers planning for climatic change in relation to biodiversity, including forests across all of Vietnam.

**Dr Antoine Galiana**

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Campus International de Baillarguet, TA A-82/J, 34398 Montpellier Cedex 5, France.

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**Title:** Acacia-rhizobium associations impacts on productivity and ecosystem processes

Dr Antoine Galiana has more than 25 years experience as plant physiologist and microbiologist in tropical forestry and is the author of over 40 peer-reviewed scientific publications, 30 book chapters and 60 communications in international congresses and conferences.

Dr Galiana has been working at the Forestry Department of the International Center of Agricultural Research for Development (CIRAD) since 1985 where he developed expertise in plantation forestry, soil microbiology and tree micropropagation. He worked and lived for several years in Ivory Coast, French Guyana and Malaysia and is currently assigned to the Laboratoire des Symbioses Tropicales et

Méditerranéennes (LSTM) in Montpellier, France.

In recent years, his main research interests have been focused on the genetic and functional diversity of symbiotic microorganisms (rhizobia and mycorrhizal fungi), plant-microbe interactions, quantification of nitrogen fixation in legume trees including tropical Acacias by isotopic methods, and management of microbial symbionts in the framework of reforestation or rehabilitation programs. His research areas have been recently extended to the study of mycorrhizal symbioses of natural forests. He is currently managing research projects in North Africa and Southeast Asia along with FRIM (Forest Research Institute of Malaysia) and FORDA (Forest Development Agency, Indonesia) studying the role and diversity of ectomycorrhiza on the regeneration and sustainability of dipterocarp forests.

**Prof Wickneswari Ratnam**

National University of Malaysia (UKM), Malaysia Plant Genetics and Biotechnology. 43600 Bangi, Selangor, Malaysia

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**Title:** Advances in *Acacia* genomics and molecular biology

Dr Wickneswari Ratnam is a Professor at the School of Environmental and Natural Resource Sciences, Faculty of Science and Technology, Universiti Kebangsaan Malaysia. She has been working on genetic diversity and breeding system of forest tree species using molecular markers, inheritance of traits and genes, molecular biology of flowering in Calamus, functional genomics of wood formation in Acacia hybrid and QTL mapping in rice and Acacia. She is the Chief Editor of Malaysian Applied Biology and Associate Editor of Forest Genetics, Tree Genetics and Genomes and Plos One. Currently, she heads the Research Cluster on Genomics and Systems Biology of the university and the University, Industry and Community Partnership office of the Faculty of Science and Technology, UKM. She is an elected fellow of the Academy of Sciences Malaysia since 2012.

**Prof Rod Griffin**

School of Plant Science - University of Tasmania. Private Bag 55, Hobart TAS 7001 Australia

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**Title**: Polyploid breeding: a new pathway for improvement of acacias?

Prof Rod Griffin is an Adjunct Professor at the School of Plant Science, University of Tasmania. He is also Managing Director of Australian based consulting company Griffin Tree Improvement Pty. Ltd. and a partner in the Chilean company Seed Production Technologies Ltd.

For many years he worked for CSIRO researching reproductive biology and breeding systems of both pines and eucalypts. He then moved to the UK to manage tree improvement and supporting research for the worldwide portfolio of forestry companies owned by Shell International Forestry Ltd.

On return to Australia he worked as Director of the Hobart based CRC for Sustainable Production Forestry and CEO of its successor CRC for Forestry. This wide experience of research management and applied forest science formed the platform for his current businesses which provide tree improvement technologies and support for companies in South America and Asia growing both Eucalypt and Acacia plantations.

He has lead 2 ACIAR projects on the domestication of tropical Acacias and his talk is based on collaborative research with colleagues in the Vietnamese Academy of Forest Sciences.

**Prof Mike Wingfield**
Mondi Professor of Forest Protection
Director Forestry and Agricultural Biotechnology Institute (FABI) South Africa
President Elect IUFRO 2014
Email: Mike.Wingfield@up.ac.za

**Title:** Biological risks of Acacia and prospects for managing impact

Michael (Mike) Wingfield, Ph.D., University of Minnesota (1983), Harvard Business School AMP175, has conducted research on tree pests and pathogens especially concerning their global movement for more than thirty years. Amongst his most important contributions to forestry has been his role that as an advisor to more than 60 Ph.D. students, many of whom now hold very senior positions globally.

He was responsible for establishing the Tree Protection Co-operative Programme (TPCP) in 1990, which became the catalyst for the establishment in 1998 of the Forestry and Agricultural Biotechnology Institute (FABI; www.fabinet.up.ac.za) of which he is the founding director.

He has published widely on the topic of tree health in more than 700 research papers, seven books and in numerous prestigious invited presentations globally. He serves / has served in many prestigious positions and based on his research, has received numerous awards and honours, in South Africa and elsewhere in the world. He has been elected as a fellow of scientific societies including the Royal Society of South Africa, Academy of Sciences of South Africa the Southern African Society for Plant Pathology and the American Phytopathological Society. He has received honorary doctorates from the University of British Colombia, Canada (2012) and North Carolina State University (2013) and received the highest scientific award (Kwame Nkrumah Scientific Award) from the African Union in 2013. Mike has been involved in IUFRO for more than 30 years, currently serving as Vice President responsible for Divisions and will assume the role of IUFRO President in October 2014

**Prof Dave Richardson**
Centre for Invasion Biology, Stellenbosch University, South Africa
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**Title:** Potential for invasiveness: ecology and management responses

Professor David M. Richardson - Centre for Invasion Biology, Stellenbosch University, South Africa

Prof Richardson obtained his BSc in Forestry and Nature Conservation from Stellenbosch University in 1981 and then completed MSc and PhD degrees in Botany at the University of Cape Town while working as a Researcher at the South African Forestry Research Institute and the CSIR Division of Forest Science and Technology. He then served as Chief Research Officer and Deputy Director of the Institute for Plant Conservation at the University of Cape Town, and in 2001 was a Visiting Professor at the University of California, Los Angeles. Since 2004 he has been Professor of Ecology at the University of Stellenbosch and is currently Director of the DST-NRF Centre of Excellence for Invasion Biology.

Prof Richardson's research focuses mainly on the ecology of biological invasions and the dynamics of plant invasions, especially trees. His work has centred oninvasive species in South Africa as well as in other parts of the world, and on global patterns and trends in biological invasions. Much of his work is directed at providing guidelines for the improved management of invasions as well as contributing to a theoretical framework for understanding invasions. He has also formulated objective risk-assessment protocols for managing introduced organisms such as amphibians and reptiles.

In addition to publishing more than 250 articles in refereed journals, including *Science*, *Proceedings of the National Academy of Sciences of the USA*, *Trends in Ecology and Evolution* and *Ecology Letters*, he has written numerous book chapters and has edited four books, including *Fifty years of invasion*

*ecology* (Wiley Blackwell, Oxford; 2011). He is Editor-in-Chief of the journal *Diversity and Distributions* (2012 Impact Factor: 6.221) and serves on the editorial boards of four journals and two book series for Cambridge University Press. Twenty Masters, 9 PhD, and 1 DSc students have graduated under his supervision, and he is currently supervising seven post- graduate students.

Prof Richardson is a member of the Academy of Science of South Africa and a Fellow of the Royal Society of South Africa. He won the Hans Sigrist Prize from the University of Berne in 2006 (the first time this award was awarded in organismal biology). He was also the recipient of the 2007 Rector's Award for Excellence in Research from Stellenbosch University, the 2009 National Science and Technology Forum Award, and the 2012 John FW Herschel Medal from the Royal Society of South Africa. In 2013 he was listed as a Highly Cited Researcher by Thomson Reuters.

## Lead Speaker

**Dr Ang Lai Hoe**
Senior Researcher, Forest Research Institute Malaysia
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Dr Ang is Head of Ecophysiology and Branch Chief of Plantation Silviculture and Management, Forest Biotechnology Division and also Co-ordinator & Manager of Bidor Field Station, Perak/ Tin Tailings Afforestation Centre. He obtained his Ph.D. in the Department of Plant and Soil Science, University of Aberdeen.

Dr Ang's Major research interest is in ecophysiology and rehabilitation of mine sites and other problematic soils. He is responsible for greening 120 ha of ex-tin mine into a mixed man-made forest at Bidor Field Station, FRIM, Perak. He participates in both local and internal consultative works on rehabilitation of problematic soils.

**Dr Chris Harwood**
Senior Principal Research Scientist with CSIRO Sustainable Ecosystems.
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Dr Chris Harwood is a Senior Principal Research Scientist with CSIRO Sustainable Ecosystems. Since 1988 he has worked for CSIRO on the genetic resources, genetic improvement, plantation development and utilisation of Australian tree species. He has authored/co-authored over 50 scientific papers and five books. He has led major development assistance projects in Asian and African countries and has extensive experience in training and capacity building of forest scientists. He specialises in species and provenance evaluation, the design and implementation of tree breeding strategies to support forest plantation development, and more recently has focussed on tree breeding and silviculture to develop plantations for solid-wood products.

**Dr Daniel Mendham**
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Dr Daniel Mendham has over 15 years experience in plantation productivity and sustainability research, particularly focussing on fast growing plantations in Australia and Asia. His skills are in forest plantation nutrition, modelling and integration with water dynamics for maximising sustainable productivity and profitability. He has lead and conducted research in acacia plantations in Vietnam, Indonesia and Australia.

**Dr Henri Bailleres**
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Dr Henri Bailleres has been studying and working in forestry and forest products since 1984. Currently he leads the Forest Product Innovation

team in the Department of Agriculture, Fisheries and Forestry, Queensland. His focus is on developing and improving products produced wholly or partly from wood fibre or timber and on assessment of plantation species and genetic material for high-value products. His main interests and expertise include understanding the relationships between physical and chemical composition of wood, use of NIRS for rapid screening of wood performances, influences of growth characteristics, environment and genetic selection on production processes, wood based composite products and systems, innovative conditioning and drying technologies (frying and vacuum drying) and innovative products specific to plantation resources

**Dr Lee Su See**
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Dr Lee Su See obtained her PhD at the University of Aberdeen, Scotland, and for some years was a lecturer in forest pathology in the Faculty of Forestry at UPM Kuala Lumpur. From 1990-2009 she was a researcher at the Forest Research Institute of Malaysia (FRIM) where she worked on diseases of tropical forest trees, root-fungal symbiotic associations, inventory and survey of tropical fungi producing an extensive publication record. She is currently Head, of Forest Health and Conservation Programme and of the Mycology & Pathology Unit, in the Division of Forest Biodiversity at FRIM. Dr Lee has received numerous awards including a IUFRO Scientific Achievement Award in 2000 for her contributions to forest pathology and dipterocarp mycorrhizal research and the Ahli Mangku Negara (A.M.N.) from the Yang DiPertuan Agong (King of Malaysia) in 2007 in recognition of services to the nation. She has held various positions within IUFRO since 2001 and is currently Vice President for Task Forces, Special Programmes, Projects and IUFRO-led Initiatives, 2010-2014.

**Dr Julian Moreno Chan**
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Julian obtained a PhD (Forestry Science) in 2007 at the University of Canterbury, New Zealand. His professional experience has mostly been within the private sector in Mexico, Australia and South Africa. This work included tree improvement as well as plantation silviculture and management for a range of tropical, subtropical and temperate species. Research interests include understanding the biological principles driving adaptation and productivity of different genetic populations and genotypes, breeding strategies, the role of silviculture and plantation management for maximising realised gain, wood quality, acoustic tools and other methods for screening wood properties. Julian joined the ICFR in 2012 and is now responsible for the development and implementation of an advanced-generation breeding programme for Acacia mearnsii with the aim of improving timber yield, bark quality, pulp yield and frost tolerance.

**Dr Neil Byron**

Adjunct Professor, Institute of Applied Ecology,University of Canberra

The Contribution of Tropical Acacias to the Economy of Viet Nam

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Neil is an environmental economist and policy analyst, currently an Adjunct Professor at the Institute of Applied Ecology at University of Canberra.

He was Productivity Commissioner specializing in the environment and natural resources management issues, for 12 years to 2010. Previous employment was with Bureau of Agricultural Economics, the Forestry School at the Australian National University, a team-leader for UNDP/FAO in Bangladesh, AusAID Community Forestry in Nepal, Director of the Graduate Program in Environment and Development at ANU, and Assistant Director General of the Center for International Forestry Research, based in Indonesia. He was a Director of a large New Zealand plantation forestry company 2007-11.

Neil has an Honours degree in Forest Science from the ANU and a masters and doctorate in resource & environmental economics from University of British Columbia, in Vancouver, Canada.

**Ass/Prof Dr Pham Quang Thu**

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Dr Pham Quang Thu is a Senior Principal Research Scientist and currently Director of the Forest Protection Research Centre (FPRC), Vietnamese Academy of Forest Sciences, a leading research institution in Forest Health in Vietnam. Since 1991 he has worked for VAFS on forest protection and participated teaching activities for undergraduate and post graduate students in the Forestry University of Vietnam, Thai Nguyen Forestry and Agriculture University, University of Science and Technology of Hanoi and VAFS. He has been project leader in numbers of research projects on forest health funded by Vietnam government and international donors and has been as senior scientist in projects on screening disease resistance and fast growing of acacia and eucalypt clones and has co-authored over 20 technical advanced varieties of acacias and eucalypts. He has authored/co-authored over 80 scientific papers and five books and text book.

**Mr. Robert Flynn**

Director, International Timber, RISI

Outlook for the markets for acacia woodfiber in Asia

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Robert (Bob) Flynn is Director, International Timber for RISI, the leading information provider for the global forest products industry. He is responsible for helping clients to understand the international forest products markets and to explore opportunities for timberland investment around the world.

Mr. Flynn has more than 35 years experience in the forest industry, including 9 years as a forester for Champion International in Oregon. He has spent the past 26 years as a consultant to the industry, with a focus on analysis of timber supply and demand in the global forest sector; international trade of logs, woodchips, and biomass; and analyzing opportunities in international timberland investment.

He joined RISI in April 2006, and has published four reports on China's timber supply and demand; two global comparisons of planted forest economics and investment attractiveness for tree farm development; two profiles of India's forest products industry (and forecast of import demand); an analysis of the impact of Russia's log export tax on Asian log markets; and a report on South American plantation forestry investments and bioenergy markets. In addition he is co-author (with Mr. Dennis Neilson of New Zealand) of a well-known annual report on the international trade in woodchips and biomass, now in its 20th edition. He holds a BA degree in geography from the University of Texas, a BS degree in forest management from Northern Arizona University and an MS in economics from the University of Oregon.

**Dr Sascha Beck-Pay**
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Dr Sascha Beck Pay investigated the micropropagation of black wattle (Acacia mearnsii de Wild) for her PhD (Botany) from the University of Natal. She was then employed by the Institute for Commercial Forestry Research (ICFR) as the Project Leader for the Sterile Wattle project from 2000 until 2012 and is now leading reproductive biology and vegetative propagation research efforts within the main breeding programme of black wattle at the ICFR.

Sascha's research interests lie in ensuring a constant supply of improved germplasm, in the form of seed, to the South African Forest Industry. Much of her recent research efforts have concentrated on developing a sterile black wattle to help restrict the spread of wattle outside of plantation boundaries, through gamma irradiation techniques and through the production of a triploid variety and this will work will form a major part of her presentation at Acacia 2014

**Toshiaki Umezawa**
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Toshiaki Umezawa received his Ph.D. from the Graduate School of Agriculture of Kyoto University (1987). The thesis title was "Mechanisms for chemical reactions involved in lignin biodegradation by Phanerochaete chrysosporium", supervised by Professor Takayoshi Higuchi. He has been working mainly in the area of wood chemistry and biochemistry since 1982, and more recently, focusing on biosynthesis of lignans and norlignans and metabolic engineering of lignification, with publications of over 140 research articles since 1982. 1982-1993: Instructor in Wood Research Institute, Kyoto University, 1989-1990: Postdoctoral fellow in Dept. of Forestry and Biochemistry, Virginia Polytechnic Institute and State University, 1993-2005: Associate Professor in Wood Research Institute, Kyoto University, 1999: Visiting Scientist in School of Forestry and Wood Products, Michigan Technological University, 2005-present: Professor in Research Institute for Sustainable Humanosphere, Kyoto University, 2006-present: Research fellow in Institute of Sustainability Science, Kyoto University. In 1992, he was awarded the Japan Wood Research Society Prize for 1991 for the work entitled "Mechanisms for chemical reactions involved in lignin biodegradation". He was elected as a fellow of International Academy of Wood Science in 2000.

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The theme: *"Acacia 2014: Sustaining the future of Acacia Plantation Forestry"*

Hue, Vietnam, 18 - 21 March, 2014

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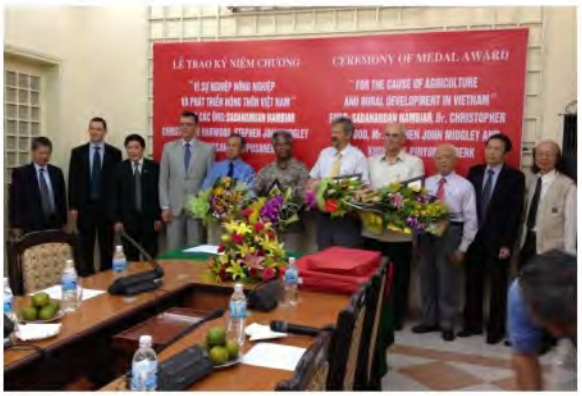


The Forest Research Institute was precursor of the Forest Science Institute of Vietnam, which was established in 1961. The Forest Research Institute developed from 1961 to 1971, then divided into three institutes (Forestry Institute 1972-1988, Forest Industry Institute 1974-1988, and Forest Economic Institute 1981-1988); and finally consolidated in to The Forest Science Institute of Vietnam from 1988 to now.

On Nov. 25th 2011, the Prime Minister issued Decision No. 2099/QĐ-TTg on the structure and operation of the Vietnamese Academy of Forest Sciences (VAFS) as a special scientific organization under the Ministry of Agriculture and Rural Development (MARD).

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