Tea tree oil breeding program II
2017-2019

Building on the foundation
Final report summary

by Mervyn Shepherd and Jos Mieog
Southern Cross University

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The Tea Tree Breeding Program II (TTBP II) project represents the beginning of a new era in tea tree breeding, with the transition of breeding from a NSW DPI/CSIRO lead program to a Southern Cross University (SCU) managed program commencing in July 2017. The two year project described in this report facilitated the transition of operations from NSW DPI to SCU during Year One (2017/18), and the implementation of the first year (Year Two 2018/19) of the five year breeding plan. Tea tree breeding is considered a key strategy for delivering increases in oil yield, quality and pest resistance, to assist in achieving objective one “improving supply” (Taylor 2018) in Tea Tree Oil Program RD&E Plan 2018–2022. This Project Summary outlines two years of activity, a transition year from July 2017 to July 2018, plus the first year of the five year plan (July 2018 to May 2019) conducting tea tree breeding. It is structured according to activities concerned with the transition year, the main activities related to the breeding (advancement of an elite and main population), related pre-breeding research, and communication.

This project has allowed the second era of tea tree breeding to get off to a solid start. Legacy seed and data have been transferred, stabilised and secured at SCU, enabling TTBP II to build on the foundation of germplasm resources and plant performance information acquired during the first three cycles of breeding carried out in the 25 years of TTBP I’s operations. A key platform resource for TTBP II was established in March 2018: an orchard for controlled pollination of elite lines identified in TTBP I. Progress toward the establishment of the fourth generation (ATTIA 5 seed) of the main breeding population for tea tree is ahead of schedule, which should allow the benefits of future projects to be realised earlier than planned.

Industry profile

Tea tree (Melaleuca alternifolia) oil is an iconic Australian natural product, marketed and sold throughout the world for use in a range of healthcare, cosmetic, pharmaceutical and veterinary products. Tea tree oil is rich in terpenoid compounds which are produced in the leaves and stored in specialised oil glands. The entire above ground shoot biomass is harvested and steam distilled to produce a purified essential oil.

In 2018 the Australian industry achieved an all-time production record of just over 1,000 tonnes of oil with 957 tonnes exported. (Larkman 2018; Taylor 2018). Oil is produced from a plantation estate of 4,500 hectare (ha) owned by around 140 growers/distillers with farms varying in size from a few to over 700 ha. Most tea tree is produced on the North Coast of NSW, around Lismore, Casino, Coraki, Grafton and Port Macquarie, with some tea tree also grown in North Queensland around Atherton and Dimbulah and contributes $42M (in farm-gate value) to these regional economies.

Most (90+%) tea tree oil produced in Australia is sold overseas. As a commodity for trade, tea tree oil is defined physically and chemically according to the International Standard (ISO4730: 2017). The standards allow for oil to be produced from M. alternifolia and M. linariifolia but in practice almost all oil produced in Australia is from M. alternifolia. Oil sold in a number of countries, including major markets in Europe and America must also meet specific regulatory requirements for safety reasons. Australian growers may also choose to conform to a producer Code of Practice, which gives assurance in regard to the quality of the oil by specifying how the oil is harvested, distilled and stored.

Demand for tea tree oil has increased strongly in recent years, with sales compounding 25% per year from 2013/14 (Taylor 2018). Prices for bulk oil remain high
which has encouraged existing growers to expand production and new growers to enter the industry. The demand for tea tree oil (and other essential oils) is driven by recent unprecedented interest in natural therapies across the globe and this is boosted by rising affluence in many Asian countries. The cosmetics, biocidal and healthcare markets in Europe, Asian and North America represent the major market expansion opportunities for Australian growers.

Since 1986, the industry has been served by a not-for-profit representative body (Australian Tea Tree Industry Association (ATTIA Ltd)). ATTIA currently has around 120 members representing over 90% of the production of tea tree oil in Australia. It has a voluntary board of directors, a dedicated CEO and is responsible for the advocacy and promotion of the industry. ATTIA also provides governance and oversight of RD&E activities. Historically, these activities were funded through voluntary grower contributions, sales of seed from the breeding program and AgriFutures Australia’s New Plants Program (then trading as Rural Industries Research and Development Corporation). The industry is now considered an established industry and in July 2017 growers introduced a compulsory statutory research and development (R&D) grower levy of 25c per kilogram of oil sold. This levy is matched by Commonwealth co-investment and RD&E investment is managed by AgriFutures™ Tea Tree Oil Program (Taylor 2018).

**RD&E aims and objectives**

ATTIA and AgriFutures™ Tea Tree Oil Program Advisory Panel periodically set aims and objectives for the Program’s RD&E investment (Taylor 2018). These include:

1. A prosperous industry with sustainable pricing and production in long term balance with supply
2. Strong defensibility against foreign and adulterated product.
3. Long term sustainability of production.
4. An RD&E program to underpin a prosperous tea tree industry.
5. Strong well resourced, well governed industry association with well-defined polices.
6. Regulatory risks identified and managed.

TTBP II is a key strategy in order to deliver increases in oil yield, quality and pest resistance, addressing the first objective improving supply in AgriFutures™ Tea Tree Oil Program’s five year plan (Taylor 2018, p.14).

This objective has the following key performance indicators:

1. Industry production to reach 1500 tonnes in five years.
2. New plantings resulting in 1000 kg yield per ha.
3. 80% of industry adopts a new Code of Practice for quality assurance. Reduced input costs through improved agronomy, water use and fertiliser use efficiency.

**The breeding program**

Tea tree breeding commenced formally in May 1993 during the industry’s transition from a cottage industry where oil was mainly produced by harvesting natural stands (“bush harvesting”), to one based on harvest of purpose-grown plantations. The move to plantation grown oil provided both the opportunity and the challenge for the breeding program to generate genetically improved trees capable of producing more oil of higher quality than stock from wild trees (seed harvested from native stands). Breeding was conducted by NSW DPI and CSIRO (key staff and/or consultants included Gary Baker, John Doran and Emlyn Williams) and operated from NSW DPI Wollongbar Agricultural station. Breeding was carried out in a contiguous series of projects over a 25 year period until July 2017 (referred to here as Tea Tree Breeding Program I (TTBP I)). Following the acceptance of an expert-reviewed full project proposal by the ATTIA board in June 2017, tea tree breeding operations were transitioned to a Southern Cross Plant Science managed project in July 2017. Southern Cross Plant Science is a research centre at Southern Cross University which provides genetics, agronomic and plant chemistry expertise and services to a number of industries including macadamia, rice, brassica, passionfruit, coffee and tea tree (https://www.scu.edu.au/southern-cross-plant-science/).
Tea Tree Breeding Program II aims

1. Contribute to the ongoing viability, growth, and competitiveness of the tea tree oil industry in Australia by continuing the supply of progressively improved cultivars for deployment.

2. Provide more regular returns on investment by adopting a strategy where cultivars are released more frequently than was possible in TTBP I, which relied on recurrent selection in an open pollinated breeding population as the principal method of achieving genetic gain.

3. Secure and conserve the legacy foundations of Intellectual Property now fully owned by ATTIA in the form of data and germplasm repositories managed to persistent international standards.

4. Lower the operational risk of the breeding program by releasing cultivars more frequently than in the past.

5. Maximise possible genetic gains by adoption of a strategy that focuses effort on a small elite population which is advanced using full pedigree control.

6. Provide a breeding program that is responsive to market and opportunities arising from pre-breeding R&D and open to new technological developments and innovations.

7. Adopt a strategy that is compatible with clonal deployment – consistent with supporting industry aspirations to roll this out once technological and economic factors are favourable. This will ensure ready adoption and access to the benefits that clones may offer, such as: increased productivity, product uniformity and greater flexibility to respond to changing market demands.

Methods used

Tea tree breeding program II adopted a two tiered strategy to breeding:

1. Controlled pollination in a small (elite) population of the very best individuals intensively managed to maximise genetic gains.

2. The progression of a larger main population by open pollination to provide a low risk source of improved seed and a broad genetic base for future selection.
Results/key findings

The objectives for the transition year and first year of operation of the five year breeding plan were all addressed and largely achieved except where climatic or biological constraints arose. Transition year objectives, including the transfer of key legacy data, germplasm and knowledge relating to trial locations and access were achieved.

• Commercial and research seed stocks have been catalogued and rehoused in a secure, climate controlled environment at SCU.
• Legacy data from TTBP I is now stored on secure servers at SCU.
• Key legacy data on trials and phenotypic data for more than 10,000 trees has been curated into a new database to support tea tree breeding.
• Site visits have been carried out and trial commencement reports generated for 18 key living germplasm resources from TTBP I (genetics trials and orchards).

Main activities fall under elite population and main population breeding.

Elite population breeding

• The founding population for the key germplasm resource used for conducting the elite population breeding component, a controlled pollination orchard (Seed orchard), was established in March 2018. These lines were selected from elite trees identified in the 3rd Generation breeding population produced in TTBP I.
• This intensively managed potted orchard is central to the elite population strategy and should be ready to conduct the first pollinations in the 2019 flowering season (October and November).
• A training workshop on controlled pollination techniques in tea tree was conducted in October 2018 to prepare staff for the first pollination season.
• Progress towards the introduction of additional breeding lines into the Seed orchard was carried out during 2018 and 2019 by cloning elite trees from earlier generations of the tea tree breeding program.
• Elite breeding lines were also planted in a clonal archive as a risk management initiative to ensure security of access to these important breeding resources into the future.
Main population breeding

- An analysis of multi-generational breeding values for 3805 trees from TTBP I was used to identify prospective seed parent trees for production of a fourth generation of the main breeding population.
- Open pollinated seed was collected from legacy orchards or taken from the seed store and sown to provide material for new progeny trials.

Other breeding related activities

- Commercial seed storage and management. Seed is processed and stored at the international-quality seed bank facility at SCU. SCU has managed new collections and the dispatching of production seed to growers and propagators since July 2107.
- A three year, $2.2 million dollar CRC-Project “Enhanced market agility for the Australian tea tree oil industry” has been undertaken in parallel to activities in the TTBP II since July 2017. The aim of the project is to produce new low methyl eugenol cultivars and develop a commercially viable clonal propagation system for tea tree. The activities of the CRC-Project have strong synergies with the breeding program and its outcomes may ultimately influence how the breeding program will operate.
- A project investigating the potential of Raman microscopy for rapid phenotyping of oil content and composition was undertaken with funding support from ATTIA and the NSW Government.
- A project investigating the extent of diversity of terpene component chiral ratios in the chemotypes of *Melaleuca alternifolia* and *M. linariifolia* was undertaken with funding from SCU and ATTIA during 2017/18.

Table 1 Origins of parent trees (n=110) selected for the fourth generation progeny trial. Counts of parent trees per source are shown. Sources include native forest origins (provenance shown) or from an “Industry select” seedlot or parents had an unspecified origin.
Implications for relevant stakeholders

Tree breeding is a long term activity determined by the generation time and breeding cycle, in tea tree this is at least seven years (DORAN 1992). This is the timeframe needed for a breeding program to generate new cultivars for release to industry. By utilising legacy germplasm and data from TTBP I, TTBP II has a head start but the soonest cultivar releases are expected to be available from TTBP II is December 2023.

This objective should still be achievable despite several setbacks (i.e. failure of 2018 clonebank planting to establish, and absence of flowering in the Seed orchard in 2018). A first release of a new cultivar from TTBP II is still feasible by December 2023 but has been set on a much tighter timetable by the lack of flowering in the Seed orchard in the 2018 season. The establishment of the first progeny trial should occur around one year earlier than initially planned due to bringing forward of that activity by one year. This will mean that a 4th Generation seed orchard should also be available to produce a new open pollinated cultivar one year earlier than planned, if necessary.

Recommendations

Recommendations are made to fund pre-breeding and other research in the areas of databasing, yield testing, rapid phenotyping and molecular tool development, to support the breeding program.

References


