Australian Strawberry Breeding Program

Outcomes from project BS17000 and overview of new project BS22000

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- The overall objective is to produce varieties that reduce production costs, enhance profitability, and elevate consumer experience
- DNA-informed breeding presents an opportunity to boost breeding efficiency
- Breeding outcomes will be further improved with an increased number of seedlings per generation for the Mediterranean region

The Australian Strawberry Breeding Program (ASBP) is dedicated to developing new strawberry varieties specifically adapted to Australia's three major production climates: temperate, subtropical, and Mediterranean.

These new varieties should not only exhibit superior production traits for increased grower profitability, but also possess exceptional quality to drive repeat purchases among consumers.

Having recently concluded the five-year Hort Innovation-funded project BS17000, ASBP has embarked on a new project, BS22000. In this article, we will provide a comprehensive overview of the breeding activities and outcomes from the previous project while outlining our plans for BS22000.

Outputs and outcomes from breeding project BS17000

Released Varieties

During the course of project BS17000, ASBP released two temperate varieties ['Tahli-ASBP' (Figure 1) and 'Tamara-ASBP'], one subtropical variety ('Susie-ASBP', Figure 2), and two specialty varieties ['SB17-230-ASBP' (Figure 3) and 'SW20-317-ASBP']. Furthermore, an additional subtropical accession (2017-040) has been flagged for probable commercial release following an additional year of trialling on farms, as requested by the Subtropical Reference Group.

Two Mediterranean accessions were identified as potential candidates for commercial release. However, due to COVID-19 travel restrictions that prevented breeders from visiting the 2021 trials, a final decision on these accessions was postponed by a year.

Figure 1. Fruit of temperate variety 'Tahli-ASBP'
Photo credit: Jodi Neal

Figure 2. Subtropical variety 'Susie-ASBP'
Photo credit: Katie O'Connor

Figure 3. Fruit of specialty pink variety 'SB17-230-ASBP'
Photo credit: Phill Jackson

Variety Uptake

For the 2021-22 financial year, ASBP varieties represented a record high of 47% of all plant sales nationally.

The most popular ASBP variety was 'Red Rhapsody', followed by 'Sundrench' and 'Scarlet Rose-ASBP'.

'Red Rhapsody' saw extensive planting in both subtropical and Mediterranean regions in 2022, while 'Scarlet Rose-ASBP' has been reported to perform well in Mediterranean climates.

New varieties 'Tahli-ASBP', 'Tamara-ASBP' and 'Susie-ASBP' have all seen increasing sales in the short time since they've been released.

Genetic Gain

Steady progress has been made in all three production regions for major selection traits. Genetic gain over time for the key profitability traits 'average fruit weight' and 'yield per plant' are shown in Figures 4 to 7 for temperate and subtropical trials. Mediterranean gain isn't shown due to small trial sizes.

Particular progress has been made for fruit truss architecture in the temperate breeding population, transitioning from highly branched trusses in the older material to very few branches in recent cohorts. This change has been implemented to support larger, more consistent fruit sizes across the season, addressing a major limitation to profitability in temperate regions.

Our economic modelling has indicated that these traits are critical in reducing the cost of production, resulting in fewer picks (and therefore less time) needed to fill a punnet. Fruit size consistency has historically been problematic in commercial temperate varieties and is one of the main reasons for higher costs of strawberry production in temperate regions compared with other areas.

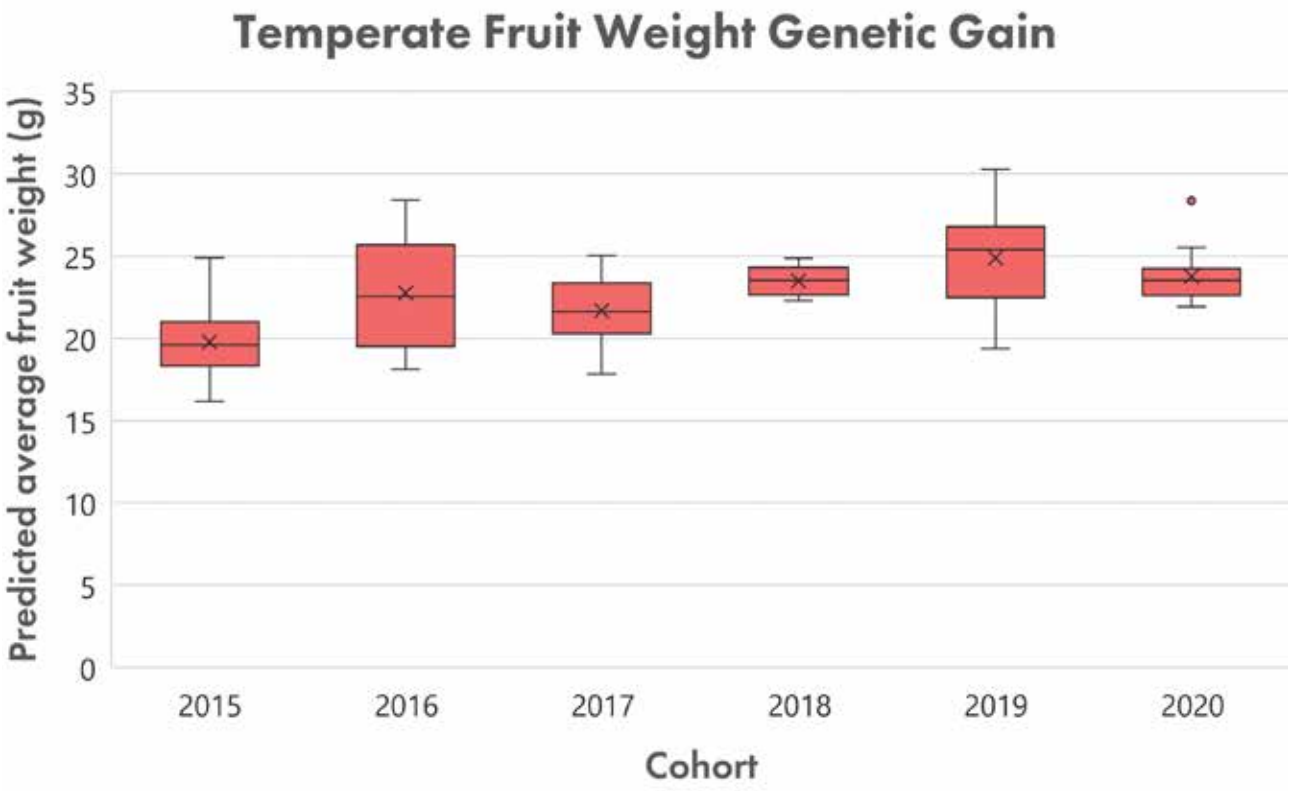

Figure 4. Temperate genetic gain in average fruit size in advanced-stage trials at Wandin Research Centre

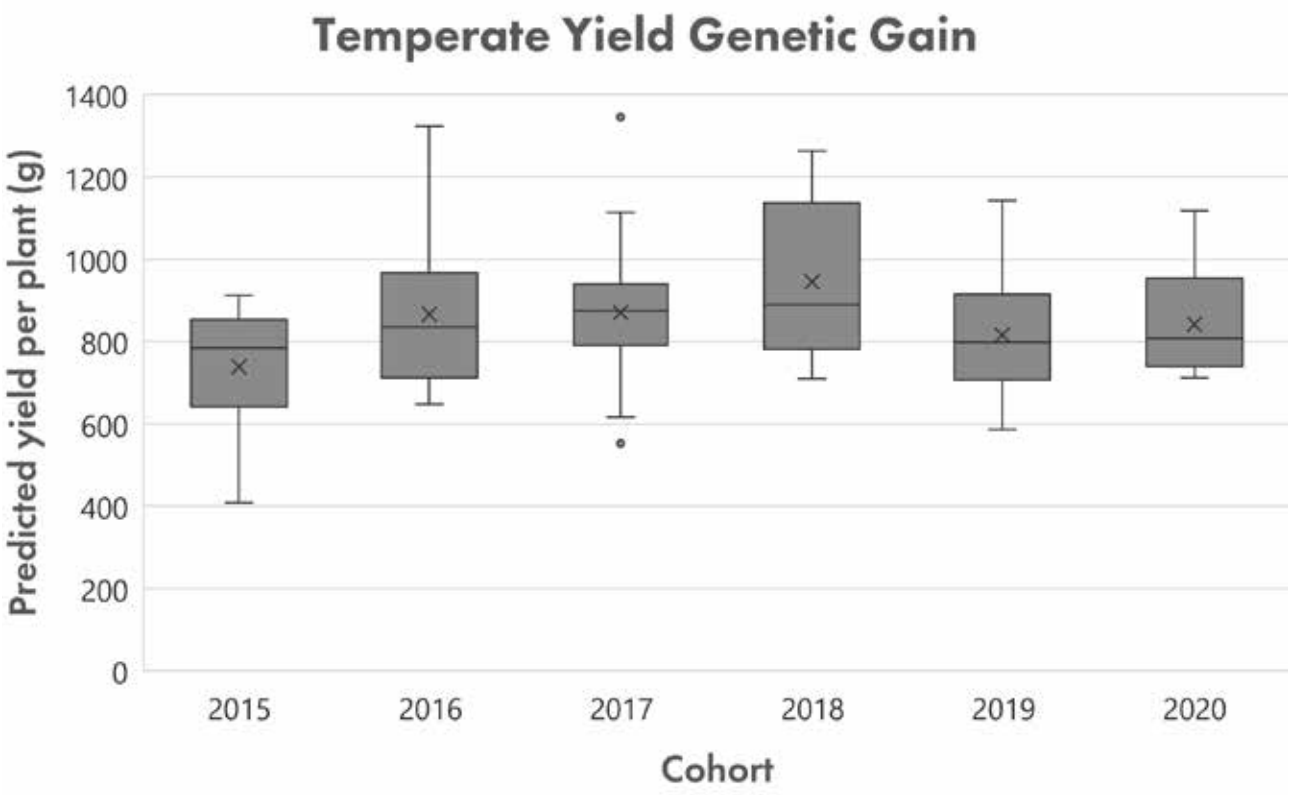

Figure 5. Temperate genetic gain in yield per plant in advanced-stage trials at Wandin Research Centre

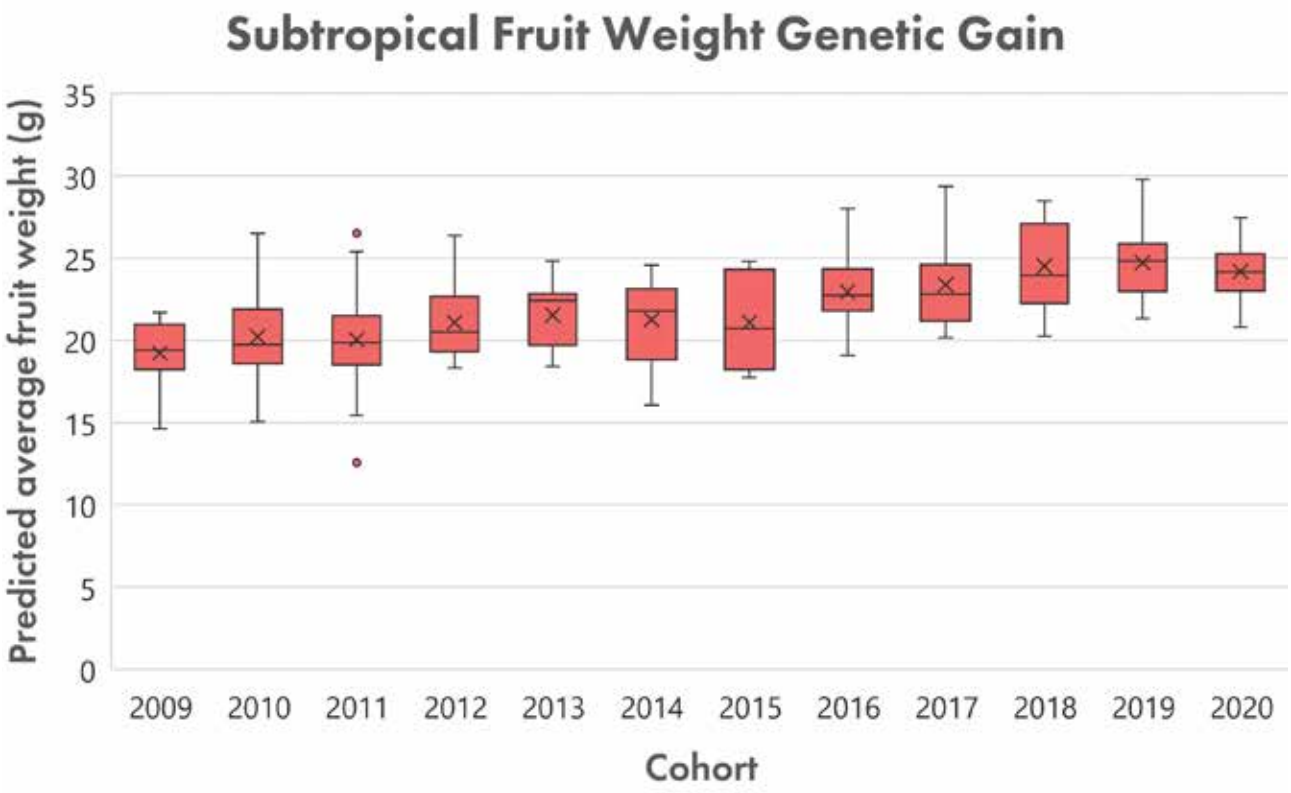

Figure 6. Subtropical genetic gain in average fruit weight in advanced-stage trials at Maroochy Research Facility

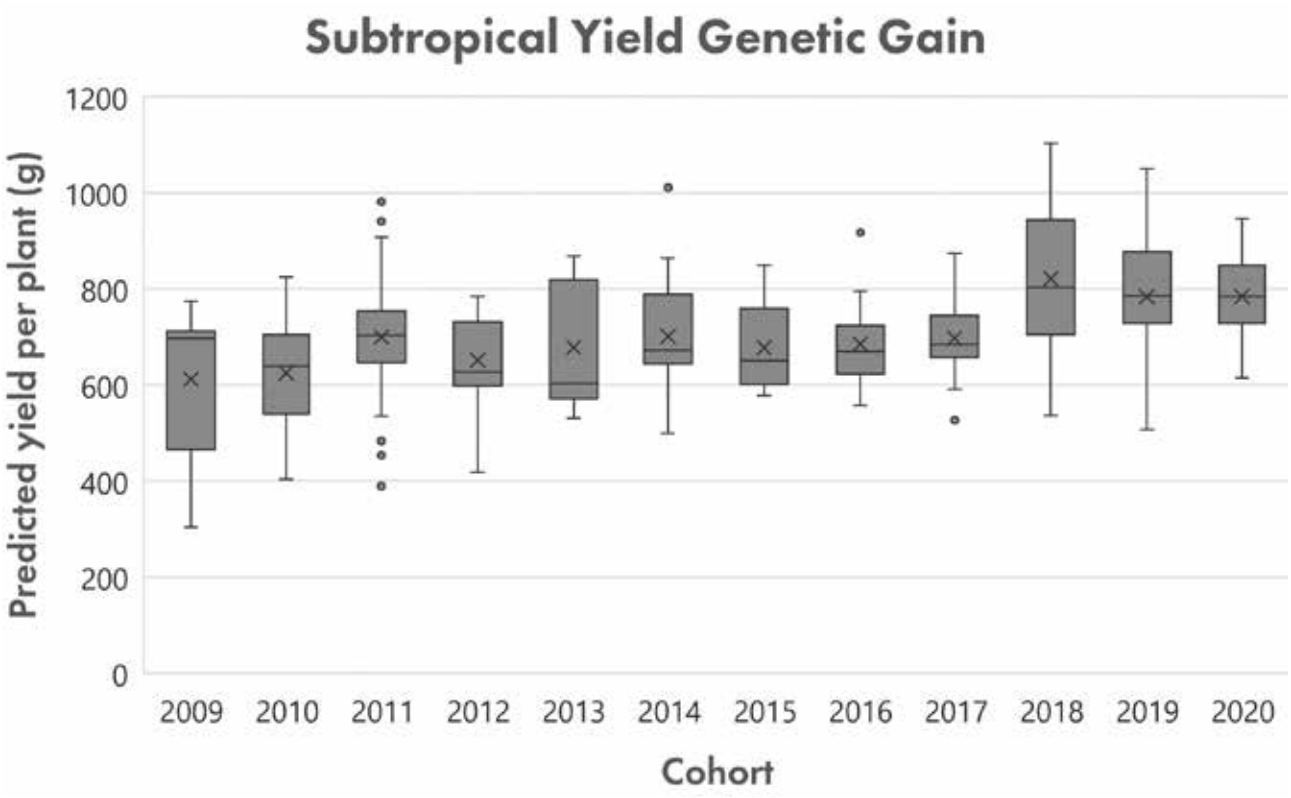

Figure 7. Subtropical genetic gain in yield per plant in advanced-stage trials at Maroochy Research Facility

Breeding Trials

The numbers of seedling and clonal accessions assessed in the project are summarised in Table 1. The breakdown of seedling accessions assessed for each region was: 49% temperate, 46% subtropical, and 5% Mediterranean, which approximately matches the relative size of each industry.

Enhancing Disease Resistances

Screening for disease resistance has been conducted on commercial and pre-commercial accessions from all three production regions, focusing on three major crown wilt diseases: colletotrichum crown rot (caused by *Colletotrichum gloeosporioides*), fusarium wilt (caused by *Fusarium oxysporum* f. sp. *Fragariae*), and charcoal rot (caused by *Macrophomina phaseolina*), as well as powdery mildew (caused by *Podosphaera aphanis*). The tested material showed varying levels of resistance to these four diseases, ranging from highly tolerant to highly susceptible.

Findings from these disease screening trials inform cross-pollinations aimed at producing seedlings with enhanced disease resistance. Advanced accessions demonstrating good tolerances have been utilised as parents in controlled crosses to introduce resistance genes into the wider breeding population. Accessions with high tolerance but subpar performance in other traits, such as fruit size and firmness, have been used as parents in pre-breeding crosses to maintain tolerance while gradually improving other characteristics.

Research into the genetic aspects of disease resistance is currently underway for powdery mildew and will soon commence for other diseases. These studies may enable the identification of disease tolerances through the genetic fingerprint of strawberry plants, allowing resistances to be determined for a significantly larger number of accessions each year.

Genomics-aided breeding

Leveraging genomics for DNA-informed breeding presents an opportunity to boost breeding efficiency, an approach already applied to numerous crops, including strawberries.

A major benefit of genetic marker testing and genomic prediction is the ability to pinpoint individuals with elite predicted performance early in the breeding cycle, which can then be used as parents to form the next generation of the breeding population.

Two genetic markers, perpetual flowering/day neutrality (DN) and flavour volatile γ-decalactone, have been consistently screened in advanced material and parents of the Australian Strawberry Breeding Program in BS17000.

Genomic prediction was employed to identify top-performing subtropical seedling selections based on statistical predictions using genome-wide markers. These selections were then used in cross-pollinations to accelerate genetic advancements within the population.

Table 1. Cumulative number of accessions assessed each year in trials across project BS17000

Region	Seedlings	Early-stage accessions	Advanced-stage accessions	On-farm accessions
Temperate	69,202	365	147	54
Subtropical	65,268*	468	129	23
Mediterranean	6,682	80	17	16

* Subtropical numbers include foundation (pre-breeding) work for specialty varieties (white, pink, dark fruit). Non-specialty (i.e. standard red) seedling total for subtropical was 51,425. Now that quality specialty selections have been generated these genetics are being used in crosses for the other regions.

Project BS22000: Future plans

The new project, BS22000, will build upon the successful strategies and tools established in the previous project. Additionally, genomics tools will be expanded to enhance selection efficiency for both parents and candidate varieties across all regions. This will accelerate the development of varieties exhibiting improved disease resistance, consumer satisfaction, and overall performance.

Regional outcomes and objectives

The primary goal of the breeding program is to create varieties with traits that optimise profitability, sustainability, and consumer satisfaction for each of the three production regions, taking into account their unique strengths and needs. The overall objective for all regions is to produce varieties that reduce production costs, enhance profitability (including minimising plant and fruit losses through improved disease and environmental resistance), and elevate consumer experience.

The project will build on previous work to develop at least two superior varieties for the temperate, subtropical, and Mediterranean production regions. Ongoing consultation with regional Reference Groups will ensure that breeding targets remain relevant to the specific needs of each production region, season, and growing system. Breeding targets will be continually updated throughout the project, guided by regional Reference Groups and local growers at various events.

In the Mediterranean region, additional emphasis will be placed on developing varieties suitable for international export, featuring better bruise and abrasion resistance.

Temperate breeding activities will focus on lowering production costs and improving charcoal rot tolerance while preserving the exceptional flavour profiles currently present in this breeding population.

The subtropical region will prioritise enhanced flavour and red leaf disorder tolerance, alongside ongoing efforts to improve cost-effectiveness and profitability.

Breeding outcomes will be further improved with an increased number of seedlings per generation for the Mediterranean region. In the previous project, the number of seedlings assessed for this region was proportional to the relative size of the Mediterranean industry, with 6,700 seedlings assessed. In the new project, seedling numbers will be increased by 280%, to 20,000 seedlings over the life of BS22000, significantly raising the likelihood of generating superior genetics.

Substrate Culture and Protected Cropping

As substrate culture and protected production continue to grow in Australia, there is an ongoing need to develop varieties adapted to these production systems. The project will create varieties suitable for both substrate and protected cropping systems, incorporating traits such as long unbranched trusses, high bruise resistance, and powdery mildew tolerance.

Specialty Varieties

To support product differentiation in the strawberry market, the project will also continue breeding activities for specialty varieties across all three production regions. This will encompass white, pink, and dark fruit colours, new flavours, and added health benefits. These value-added products will be defined and prioritised in consultation with each of the regional Reference Groups.

In conclusion

The project's outcome will be the adoption of new varieties specifically developed for each of the three commercial growing regions (temperate, subtropical, and Mediterranean) using advanced breeding and evaluation methodologies.

Ultimately, this project is expected to boost productivity and profitability for national strawberry producers while maintaining strong consumer appeal.

The ASBP is guided by the principle of fostering idea exchange.
If you would like more information, please contact Jodi Neal

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Your thoughts and feedback are highly valued by the project team.

Acknowledgements

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The Australian Strawberry Breeding Program team members include Jodi Neal (project lead), Maddy Betts (laboratory technical assistant), Mitchell Gates (Nambour lab assistant), Apollo Gomez (pathologist), Joanna Gillespie (genetics and virus indexing), Dale McKenna (Nambour field technical officer and hydroponics), Lauren Stirling (Nambour field assistant), Alan Noon (Wandin field assistant), Katie O'Connor (breeding and genomics), Michelle Paynter (virus indexing, tissue culture, and pathology), Sandy Shaw (Wandin field assistant), Karen Spencer (Wandin operations manager), and Louella Woolcock (Nambour field and glasshouse operations manager).

Queensland Government

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