

Varieties and plant breeding update

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Sugar Research
Australia™

Importance of quantitative genetics research to improve sugarcane breeding

By Xianming Wei and Bert Collard

Plant breeding is based on fundamental principles in genetics. Plant breeding programs also generate large amounts of data and so statistical methods are routinely used by breeders during the breeding process to analyse data.

A specific area of genetics research called quantitative genetics is important. This topic refers to the study of the genetic control of traits considering multiple genes, environmental factors and using appropriate statistical methods.

In sugarcane, breeding methods used are more advanced because of the complexity of the genome and because the breeding system is unlike other related grass crops like corn or wheat. In fact, in sugarcane, the genetic system is more like animals rather than cereals. Therefore, advanced methods in quantitative genetics and statistics are needed in sugarcane breeding.

The first stage of any plant breeding program is to make a cross between selected parents to develop a new breeding population. The objective is to create new clones that are better than both parents. Ultimately breeders search to identify new clones that are superior to standards (i.e. currently-used varieties) in addition to the parents used in the cross combination.

A critical activity for sugarcane breeders is to determine which parents to use for crossing and making new populations. A very important point to emphasise is that **the best varieties do not necessarily make the best parents for crossing** (i.e. they are not necessarily the best mothers or fathers from a genetic perspective). This is widely-known and you may be familiar with this concept in horse breeding.

Breeders try to determine the quality of an individual as a parent by 'breeding values', which are calculated by measuring the trait performance in the offspring (children) from crosses. Pedigree information is also essential for this process. Another important activity of breeders is to develop new and improved parents before making varieties (sometimes referred to as "parent building").

Project details

Project name

Maximising the rate of parental improvement in the Australian sugarcane breeding program

Project number:

2008/319

Principal provider:

SRA

Chief Investigator:

Xianming Wei

A research project was recently conducted to improve and explore ways to improve our understanding of key traits such as cane yield and CCS in a research project titled *Maximising the rate of parental improvement in the Australian sugarcane breeding program*.

This work was also initiated to explore the usefulness of DNA (or molecular) markers for parental selection.

Key findings from this research indicated:

1. Important options to improve how to calculate and use breeding values.
2. Especially for improving cane yield, how sugarcane parents are combined in crossing is more than important than how each of the parents is selected.
3. That using DNA markers led to significant improvements in accuracy of selecting parents and a possible new way to determine superb parent combinations, which were the first such findings in sugar in the world.

Plans are now underway to apply these findings to enhance SRA's breeding program.



Imported varieties proceeding through the SRA Post Entry Quarantine Facility at SRA in Brisbane.

International quarantine activities in 2016

By Dr Nicole Thompson

The past year has been very busy for the SRA Post Entry Quarantine Facility (PEQF) at Indooroopilly. We facilitate the safe import and distribution of foreign varieties into Australia and the export of elite Australian varieties as part of variety exchange programs. Exchanged varieties are assessed and used in breeding programs for germplasm improvement.

Importing Foreign Varieties

Foreign varieties are sent to Australia as treated setts and ordered into Quarantine at SRA PEQF by the Department of Agriculture and Water Resources (DAWR).

The varieties are grown, assessed and tested for disease freedom over about 12 months. Provided no disease is found, a single stalk is selected, hot water treated and replanted.

We seek permission for quarantine release from DAWR and grow the released cane in a separate chamber for propagation.

We use tissue culture to propagate about 200 plantlets per variety and distribute them for inclusion in disease-resistance trials at Woodford and selected trials at SRA stations across the industry.

The best performing foreign varieties and those with desirable traits are used as parents in the SRA breeding program. The import cycle is a continual one, with no downtime between imports, testing, release, propagation, and distribution.

Foreign varieties in 2016:

- Distributed varieties for propagation and assessment in Australia (imported in 2014):
 - > Six varieties from USA (Louisiana varieties); nine varieties from Barbados; seven varieties from Reunion; and four varieties from Guatemala.
- Released varieties imported in 2015, to be propagated for distribution in 2017:
 - > Eight varieties from Barbados; 10 varieties from Brazil (RIDESA varieties); and six varieties from Japan (Okinawa varieties).
- New varieties arrived in 2016 to undergo quarantine:
 - > Twenty varieties from Vietnam (two consignments); five varieties from Reunion; 10 varieties from Brazil; 10 more varieties from Vietnam; 16 varieties from USA.
- Expected varieties for 2017: Guatemala, Reunion, Japan, Argentina and China.

Exporting Australian varieties

SRA exchanges elite Australian varieties with overseas partners in return for the varieties we receive. To facilitate this, we maintain a collection of tested and verified Q and SRA varieties in glasshouses at SRA Indooroopilly.

In 2015-2016 we have exported 15 varieties to China, 10 to France (two consignments), 10 to Brazil, eight to USA, 20 to Vietnam (two consignments), six to Japan, and five to Mauritius.



In the next few months we will be exporting 10 to Brazil, six to Japan and six to USA.

There will be about 40 different varieties exported in 12 consignments, totalling about 100 varietal exports. The most commonly exported varieties were Q208^h and Q232^h, both being exported to five countries.

Summary

In 2015-2016 SRA distributed 26 foreign varieties, released 24 foreign varieties and has imported 51 varieties. In exchange, we have sent 40 varieties in 12 consignments (total ~100 varietal exports) to our partners overseas.

Summary of variety exchange and quarantine distributions for 2016:



The PEQF is run by Dr Nicole Thompson and Elizabeth Wilson, and the variety exchange is coordinated by Dr George Piperidis.

Country	Partner	Distributed in 2016	Completed quarantine in 2016	Imported in 2015-16	Exported in 2015-16
Brazil	RIDESA		10	10	10 + 10 pending
France	Reunion	16	8	5 + 5 pending	5 + 5
Japan	NAFRO		6	6 pending	6 + 5 in 2017
Vietnam	SRI			10 + 10	10 + 12
USA	USDA-ARS	6		16	6 pending
Guatemala	CENGICAÑA	4		5 pending	TBA
China	YSRI			15 (late 2017)	15
Argentina	CHACRA			10 pending	10 pending



Vivien Dunne (right) and Renae Ligasacchi at the SRA Meringa Research Station.

Plant breeding team profile with Vivien Dunne (Meringa)

What is your role within the plant breeding team at SRA?

My main role is to co-ordinate the field and photoperiod cross pollination activities each year.

Crossing is the first step in the plant improvement process and runs from May to June for the field and July to September for the photoperiod facilities.

Both involve labelling of the parents so when flowering occurs they are easily identified (approx. 2,000). I also supervise census activities which includes assessing daily flower numbers available, and sampling each parent for laboratory testing to determine if the parent is male or female.

I work together with the four 'love doctors' (aka the plant breeders) to create the perfect partners (crosses). This process is based on economically important traits including cane yield, sucrose content, disease resistance, as well as parentage (we actively avoid inbreeding) and gender of parents, and breeding objectives.

Once the best available crosses are made, I oversee the collection of the flowers from the field or photoperiod facilities, their correct placement into lanterns, and their ongoing and loving care until they set seed up to six weeks later.

Once crossing is finished my role changes to being responsible for the drying, testing, packaging, and maintenance of both seed stores at SRA Meringa.

This enables the plant breeders in all four regions to select seed for germinating and establishing their seedling populations (first stage of the selection program).

What are the major challenges associated with your job?

On average, variable and only moderate flowering occurs at SRA Meringa, due to fluctuations in weather conditions. This obviously has a huge impact on the amount of crosses made each field crossing season, but this is complimented by the photoperiod facilities where temperature and other environmental conditions are controlled. This allows us to increase the amount of crosses made each year.

I was the first female technician, hence one of the longest serving, and therefore I have seen many changes in my time in terms of the male to female ratio in employees, the use of technology versus manually writing everything down as well as changes to our selection process. Although it may have been perceived as a challenge, I have embraced the role and believe it has shaped me into the technician I am today.

Where are the main opportunities and areas of interest for growers from the breeding program for the years ahead?

Being at the forefront of the breeding program, I have the privilege to be able to start the breeding process, watching the seedlings evolve and progress into varieties that are then released to growers and millers.

Better disease resistance, ratoonability and productivity are all driving factors to create new and profitable varieties through our field and photoperiod facility cross pollination program ensuring the industry has a sustainable future.