NEW BIOSPHERE AGRICULTURE

Sorghum

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Pascas Foundation is a not for profit organisation


BEST DRYLAND CROP
MILLET(SORGHUM) FARMING


Sorghum

NEW BIOSPHERE AGRICULTURE SORGHUM

Sorghum, also called milo, is truly a versatile crop. It’s one of the top five cereal crops in the world and can be grown as a grain, forage or sweet crop.

Sorghum, also known as milo, is an ancient grain with a mild, earthy flavour similar to wheat berries. The sustainable gluten-free grain is a flexible ingredient that is used in a variety of preparations by chefs around the world.

4 Major Types of Sorghum

Grain Sorghum
Grain sorghum can take many shapes and sizes from a tight-headed, round panicle to an open, droopy panicle that can be short or tall. Grain sorghum comes in red, orange, bronze, tan, white, and black varieties. Red, orange or bronze sorghum are very versatile and can be used in all segments of the sorghum industry. Tan, cream and white coloured sorghum varieties are typically made into flour for the food industry. Black and burgundy varieties contain beneficial antioxidant properties and are used in other food applications.

Forage Sorghum
Depending on which species and variety is selected, sorghum can be used for grazing pasture, hay production, silage and green-chop. Forage sorghum typically grows 8-15 feet tall and is most popular for use as silage for feeding livestock.

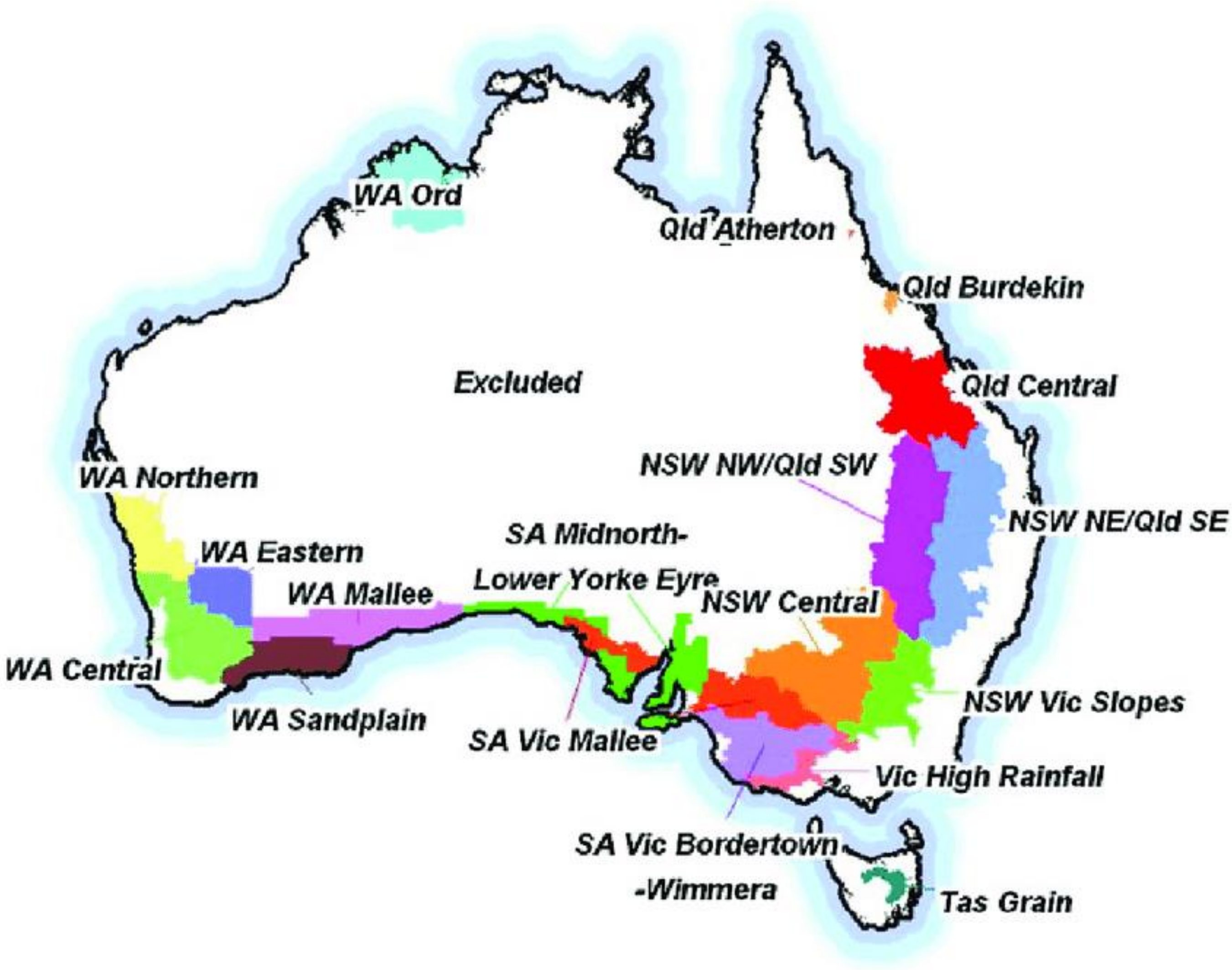
Biomass Sorghum
Did you know sorghum can be used to make ethanol?

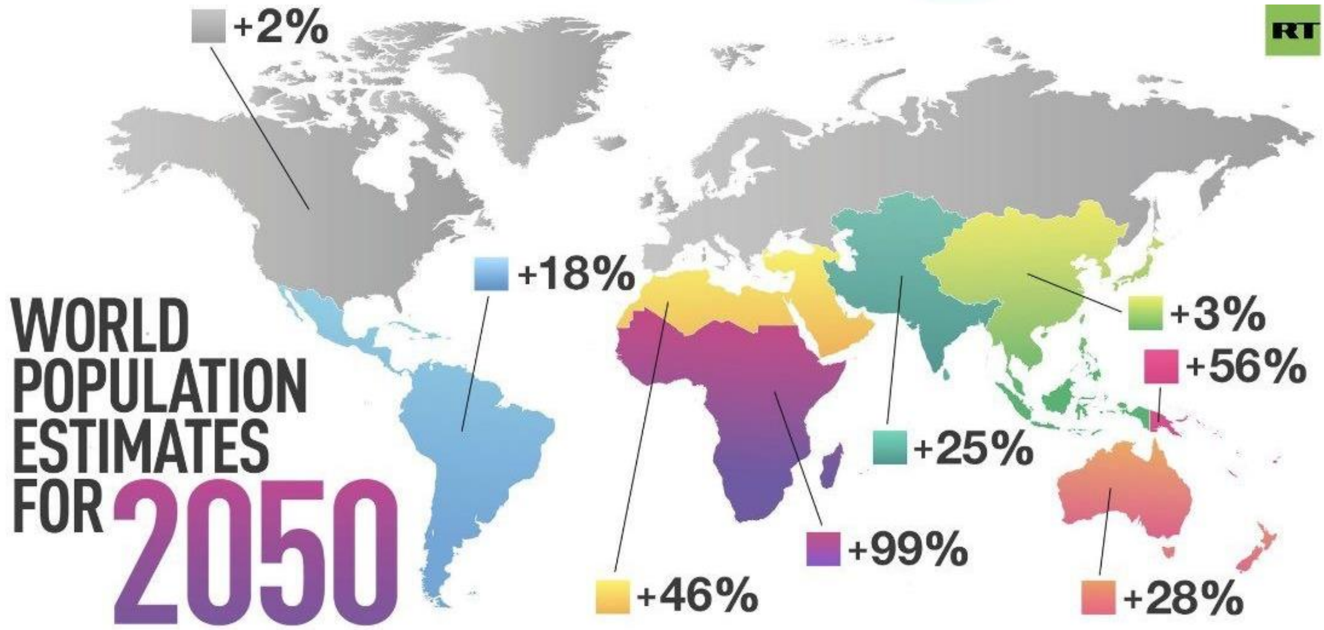
Biomass sorghum has the largest stature of all the sorghum varieties, reaching a height of 20 feet in a normal growing season. Biomass sorghum has been bred to produce a large amount of non-grain biomass. These hybrids are used primarily for the production of bioenergy.

Sweet Sorghum
Sweet sorghum is predominantly grown for sorghum syrup. Unlike grain sorghum, sweet sorghum is harvested for the stalks rather than the grain and is crushed like sugarcane or beets to produce a syrup. Sweet sorghum was once the predominate table sweetener in the U.S. Today, sweet sorghum is used as a healthy alternative sweetener to produce whiskey and rum type products and for biofuel and chemical production.

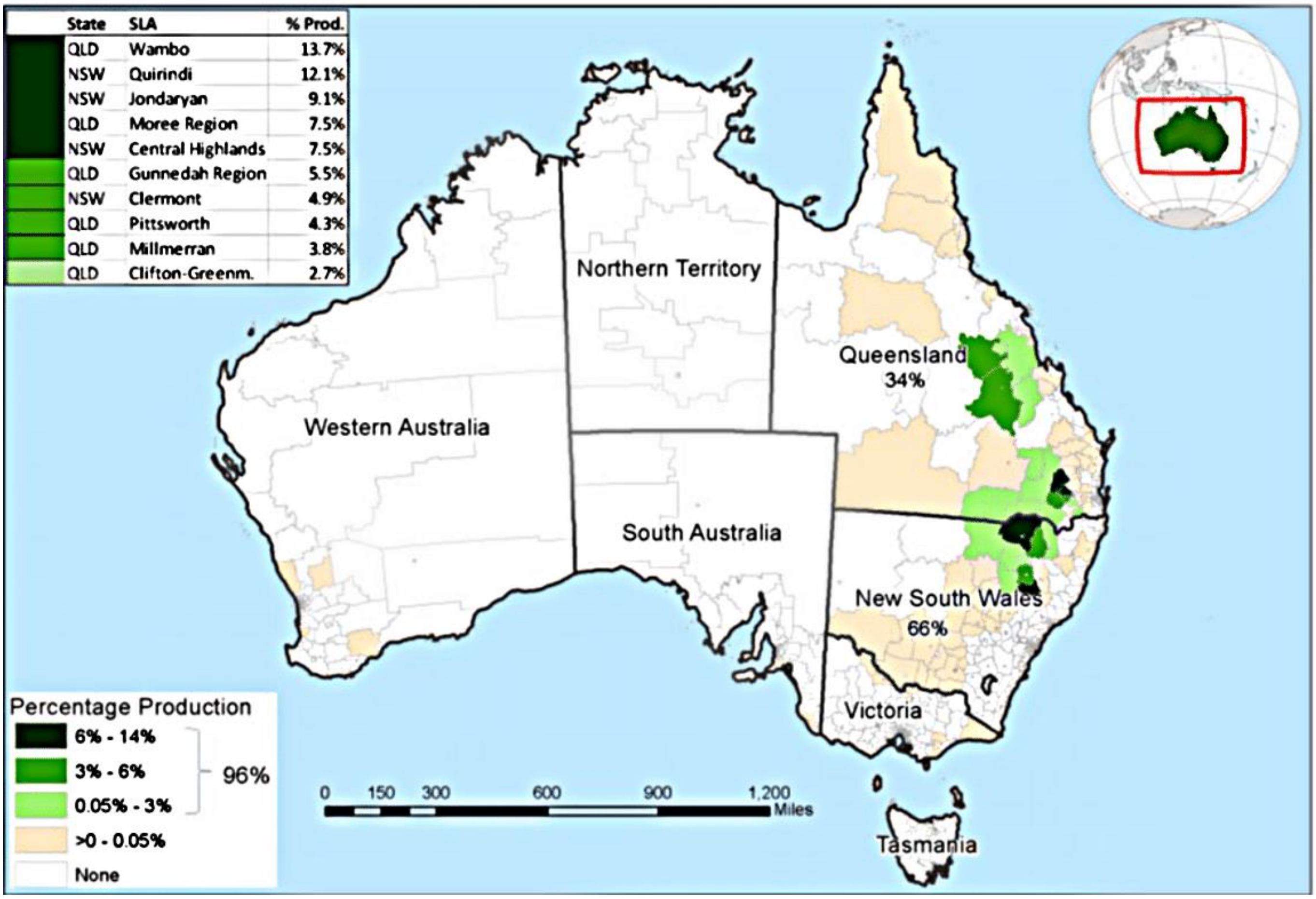
Almost all grain sorghum in Australia is produced in northern New South Wales and Queensland. The other small but important area of production is at Kununurra in the north of Western Australia: Steam flaked sorghum, where most of the hybrid seed is produced.

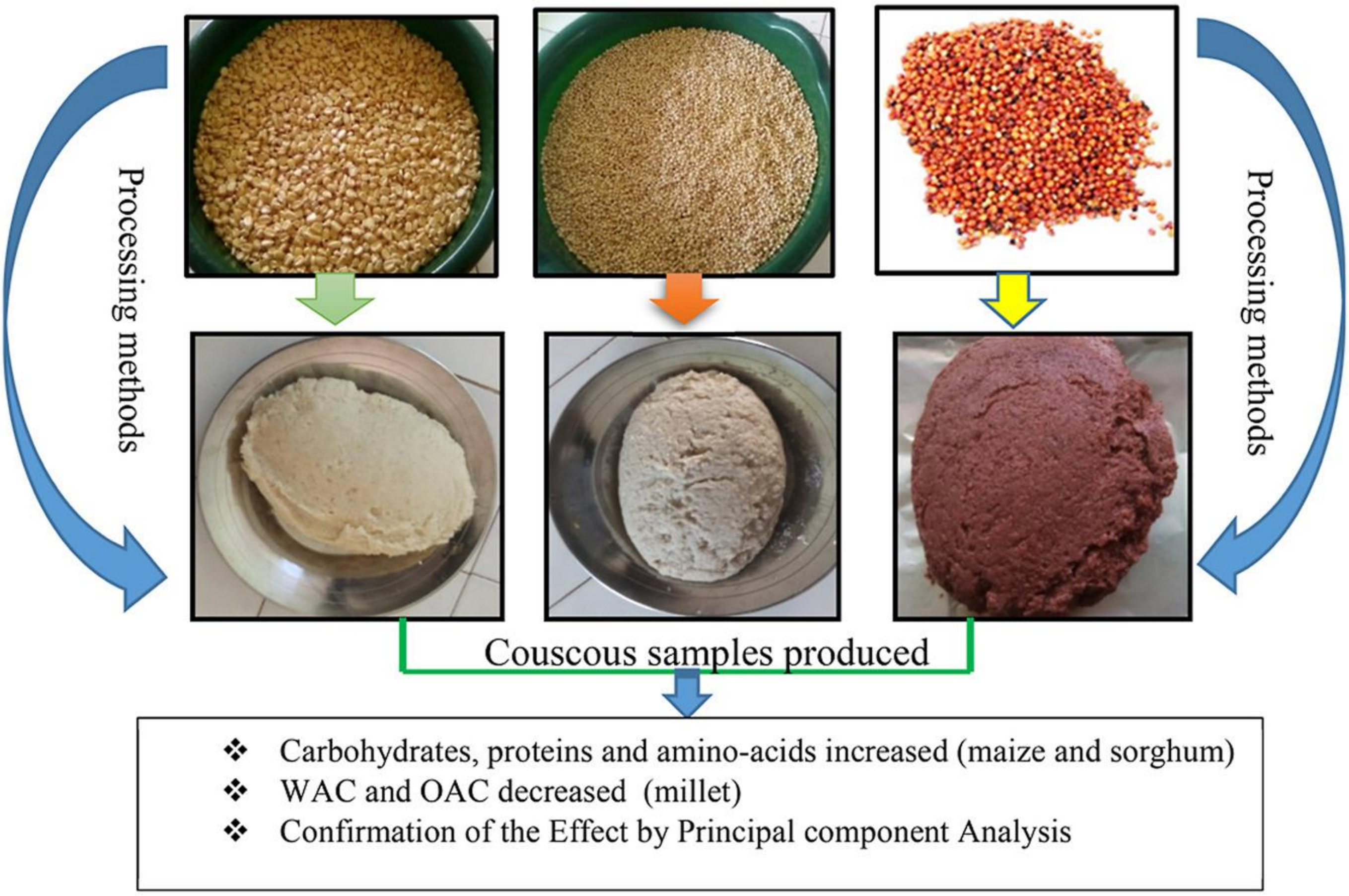
Location of grain-growing regions in Australia used in the national survey of precision agriculture adoption:





Australia Sorghum Production Distribution Map





What is sorghum?

https://www.sanitarium.com/au/health-nutrition/nutrition/sorghum

For many sorghum is a new food, however it's been an ancient grain native to Africa for many thousands of years. Today, sorghum is grown and used worldwide and is Australia's third largest crop.

Sorghum uses

Sorghum can add a delicious nutty flavour and texture to your breakfasts, salads, or meals. Try starting your day with a sorghum-containing breakfast cereal or cook sorghum grains into a warm creamy porridge.

Sorghum can be cooked like rice, popped into popped sorghum (it looks like popped corn but smaller), and sorghum flour can be made into sorghum flat bread or tortillas.

Subscribe to Wholicious Living to stay up-to-date with the latest health and nutrition advice.

How to cook sorghum

Sorghum grain can be prepared just like rice, barley, quinoa or other wholegrains. You can cook it in a rice cooker, slow-cooker or on your stovetop. Cooked sorghum grains can be easily stored in a sealed container in your fridge or freezer to reheat and reuse later.

Where to buy sorghum

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Where to buy sorghum

Sorghum cereal biscuits, sorghum grains and sorghum flour are becoming more available in local supermarkets across Australia and New Zealand, especially in the breakfast or health food isles. But if you're struggling to find it, try buying your sorghum from health food stores or an African or South African food store.

Reasons to try sorghum

1. Wholegrain goodness

Sorghum is a quality wholegrain, providing important nutrients including protein, dietary fibre and a range of minerals and vitamins.

2. It's gluten free
Sorghum is gluten free and provides a fantastic option for those with coeliac disease or gluten sensitivities.

3. Low GI
It keeps you fuller for longer and helps with blood glucose control and weight loss.

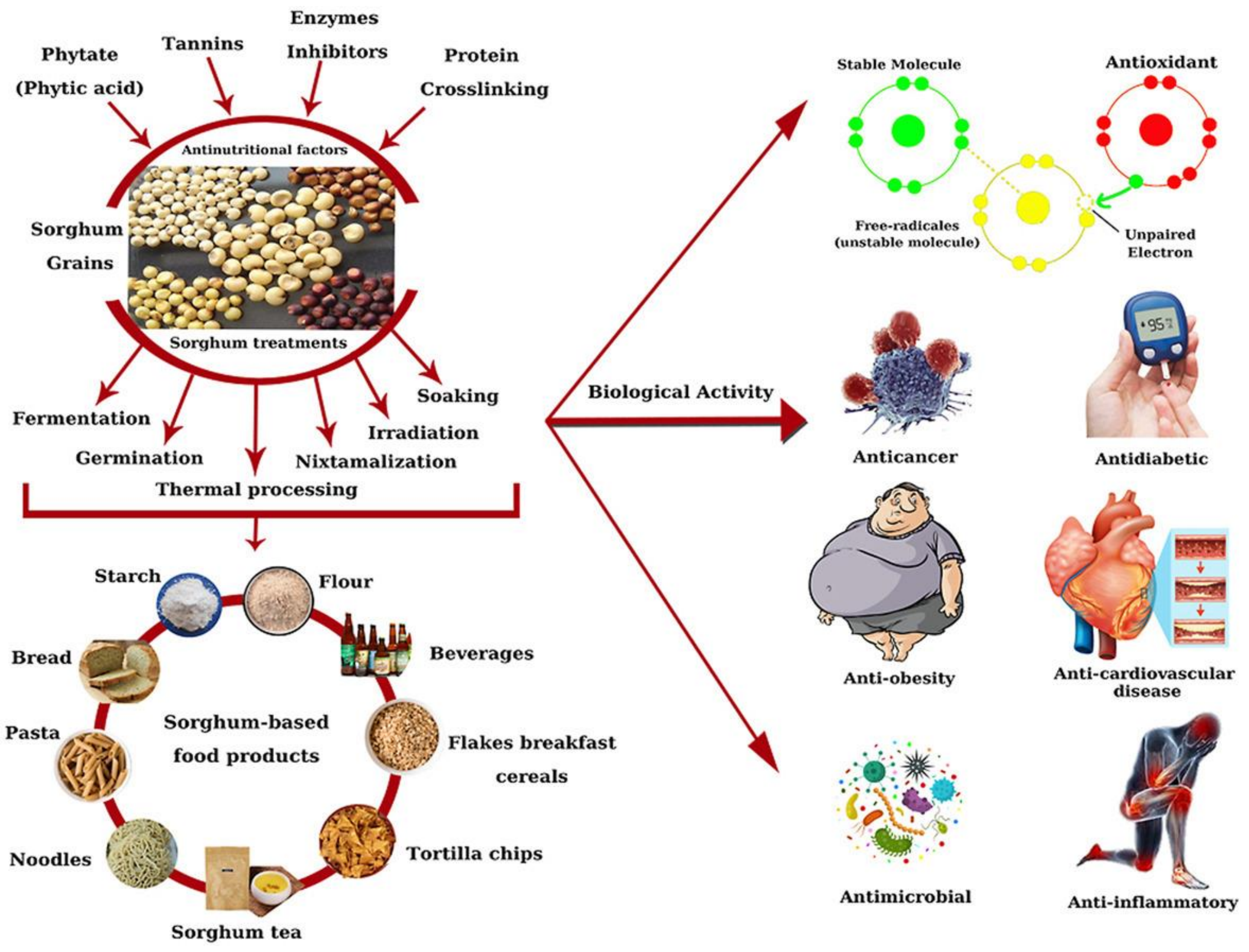
4. Low in saturated fat
It helps to keep your cholesterol low and reduce your risk of heart disease.

5. Fibre
For a healthy gut and reduced constipation.

6. Packed with nutrients
These include B vitamins, iron and zinc.

7. Antioxidants and phytochemicals
They're rich in phenolic compounds, flavonoids, and tannins, which can help to protect your body from chronic diseases like heart disease and diabetes.

Looking for healthy recipes? Explore our collection of over 500 healthy, dietitian approved recipes and subscribe to Recipe of the Week for free weekly recipe inspiration!



What Is Sorghum?

https://www.thespruceeats.com/what-is-sorghum-and-how-to-use-it-5080020

A Guide to Buying, Cooking, and Storing Sorghum

By Linnea Covington 02 January 2023

Getty Images / Romualdo Crissi

IN THIS ARTICLE

Gluten-free, hearty, tasty and easy to grow: these are all reasons sorghum has become more prominent on the plate. Chefs and home cooks from around the world are enjoying this ancient grain, using it in dishes from grain bowls to pancakes to risotto. It has a traditional association with Southern cooking, and is a versatile cereal that's easy to use. Sorghum is available in a sweet syrup and can even be popped like popcorn.

What Is Sorghum?

Sorghum is a tasty ancient grain that's shaped like a little ball coated with an edible hull. It's versatile: sorghum can be broken down into flour for baking, boiled to make a side dish, and popped like popcorn. This ancient grain is touted as the fifth most important cereal crop grown and is eaten around the world. The sorghum plant has a natural drought tolerance, which means it can grow just about anywhere it's cultivated. It's also gluten-free, making it a great alternative to other grains. It's also used in a variety of ways that may surprise, such as feed for animals, fuel for machines.

In fact, sorghum has been a part of a balanced diet for a very long time. The first recorded use of sorghum originated over 8,000 years ago in Africa. Ethiopia, Sudan, and Egypt are the areas where researchers believe the grain was first harvested. Sorghum was imported to India during the first millennium BC, where it's still used to make *dosa* and a thick porridge eaten at any meal. The name sorghum comes from the East Indies word "sorgi," which first appeared in writing around 1542. Eventually, sorghum traveled to the United States on the trade ships in the 19th century.

Most production the United States happens in South Dakota, Kansas, Texas, Colorado, and Oklahoma. Sorghum is also a big crop in Australia, China, and South America.

How to Use Sorghum

Sorghum can be eaten and prepared like any other grain, though it does have some nuances other cereals don't possess. For one, sorghum can be popped like popcorn and eaten as a healthy snack or as a topping on a dessert, salad, or in a bowl of granola. It's more like wheat than most grains, but doesn't have any gluten so works well as a substitute when baking or cooking gluten-free foods.

You can also soak and cook it to make a porridge, grain side dish, or as a stuffing for peppers. It's also good stirred into a soup or stew, thickening the broth and adding even more heft to this cold-weather dish. Overall, cooked sorghum pairs well with mushrooms, dark green vegetables, eggplant, tomatoes, red meat, roasted chicken, roasted carrots, and an array of herbs.

There's also something called sorghum syrup, or sorghum molasses, a sweetener found in the Southern part of the United States, where it's been made since the 1850s. It's created by milling the stalks of the plant in order to press out the liquid, which is boiled to create viscosity; this also gives it a brown colour similar to maple syrup.

What Does Sorghum Taste Like?

The flavour of sorghum is mild with a trace of nutty sweetness to it, and a bit of an earthy undertone. There's also a nuance of fresh-churned earth that gives a bit of richness to the grain. Its texture is firm like a wheat berry, and cooked sorghum spheres can "pop" in the mouth when eating.

Sorghum Recipes

While sorghum is a unique ancient grain, it can be substituted for or instead of millet or wheat berry. This ingredient is a great addition to any hearty meal, especially when it needs to be gluten free. Try it as a side dish, in a casserole, soup or stew. Sorghum flour is also worth seeking out as an element in gluten-free baking.

Where to Buy Sorghum

The majority of sorghum found in the United States is used as animal feed, but that doesn't mean it can't be sourced for home cooking. Bob's Red Mill is a larger provider and shoppers can find it at most specialty grocers. Pick up sorghum in bulk from most shops that sport bins of loose grains. Finding sorghum syrup proves a bit more challenging, though if shopping in the South or online it's readily available.

Storage

Keep all dried sorghum grains in an airtight, sealed jar, bag or other container. It can last a long time this way as long as there is no moisture introduced. Popped sorghum won't last too long; about two weeks in a closed container. Other cooked sorghum will also last about two weeks in a sealed vessel as long as it's placed in the fridge. Sorghum does not have to be refrigerated after cooking if it's eaten that day.

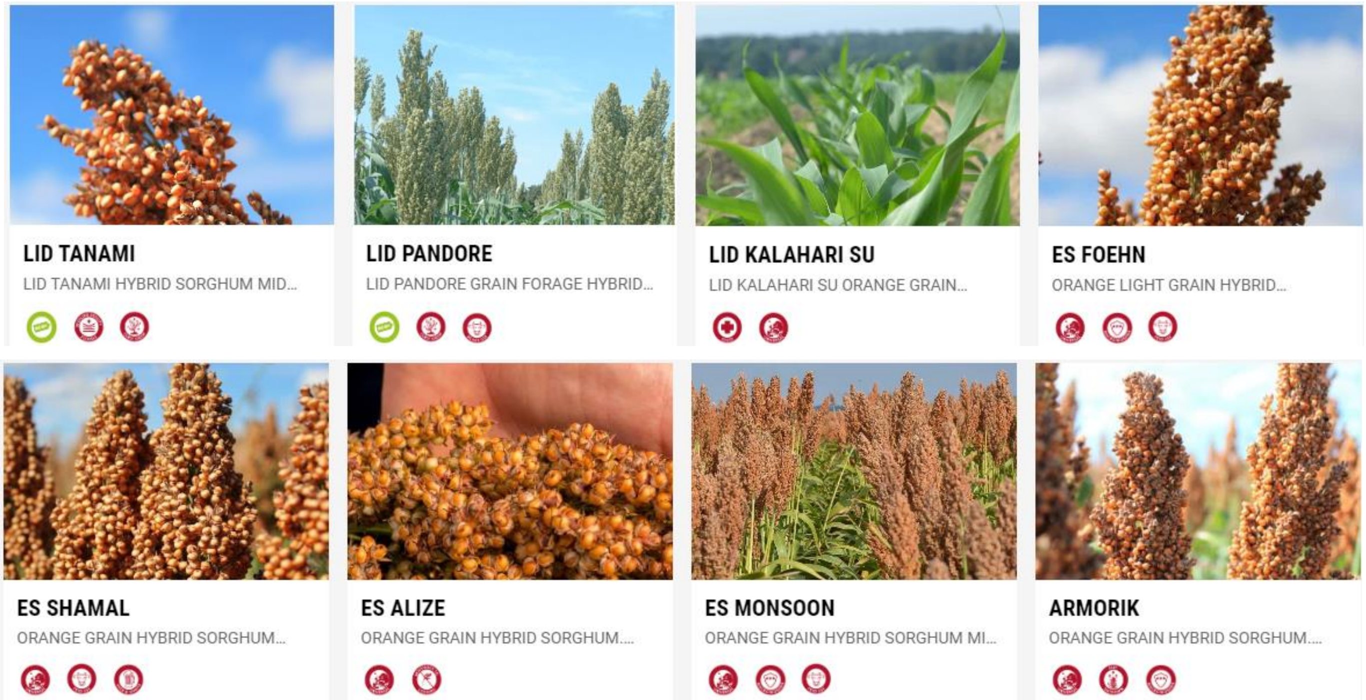
Varieties

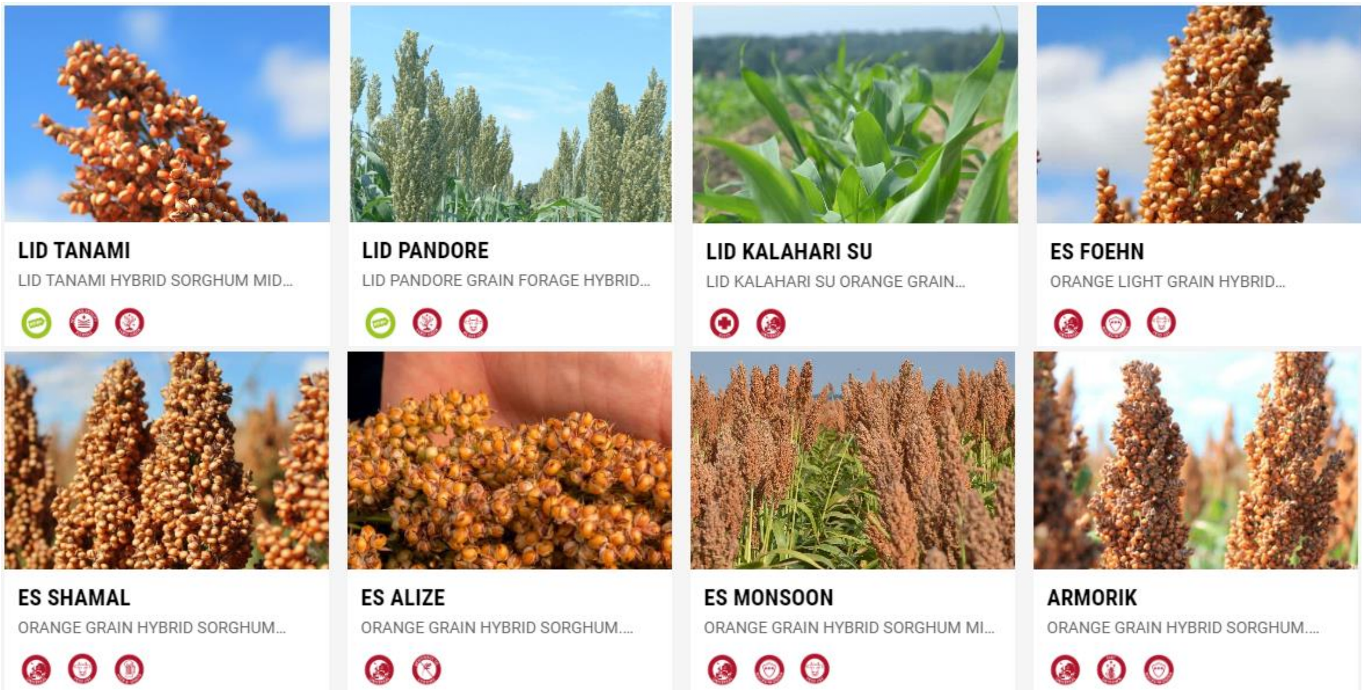
With so many types of sorghum that get grown all over the world, it's hard to pinpoint which grain is on the plate. They all look similar, round with a reddish-brown hue and papery outer shell. In general, there are **four types of sorghum: forage, biomass, sweet sorghum, and grain sorghum. Grain is what most consumers are eating. Sweet sorghum is used to make syrup, whiskey and rum. The other two kinds of sorghum are mostly for animal feed and biofuel.**

SORGHUM

Lidea has the first sorghum research programme in Europe. The varietal results demonstrate the quality of the sorghum genetics adapted to Europe, which is why Lidea genetics represent more than 20% of seeds sown throughout Europe. Our aim is to offer farmers and processors high potential varieties, adapted to all climate conditions and market segments.

https://lidea-seeds.com/crops/sorghum





BMR GOLD X

FORAGE STERILE BMR HYBRID...

ALBANUS

WHITE GRAIN HYBRID SORGHUM EARL...

STYX

FORAGE STERILE BIOMASS HYBRID...

ARSKY

ORANGE GRAIN HYBRID SORGHUM...

ES WILLY

ORANGE GRAIN HYBRID SORGHUM...

KALATUR

WHITE PEARLY GRAIN HYBRID...

PONANT

ORANGE LIGHT BROWN GRAIN HYBRID...

ES HARMATTAN

FORAGE GRAIN HYBRID MONOCUTTIN...

ARCANE

ORANGE GRAIN HYBRID SORGHUM...

ES BOREAS

ORANGE GRAIN HYBRID SORGHUM MI...

ARABESK

WINTER GRAIN HYBRID SORGHUM....

ES MOUSSON

WHITE GRAIN HYBRID SORGHUM EARL...

LID GIBSON

ORANGE GRAIN HYBRID SORGHUM MI...

ES ATHENA

FORAGE STERILE HYBRID...

ES HYPERION

FORAGE STERILE HYBRID...

LID SINAÏ

WHITE GRAIN HYBRID SORGHUM VER...

ARALDO

WHITE PEARLY GRAIN HYBRID...

ARIGATO

FORAGE BMR GRAIN HYBRID...

LID ZEALANDIA SU

WHITE CREAM GRAIN NICOSULFURON...

EMERAUDE

FORAGE GRAIN HYBRID. MONOCUTTIN...

ARMELIA
ORANGE GRAIN HYBRID SORGHUM MI...

LID MARGO
ORANGE GRAIN HYBRID SORGHUM...

RUTILE
GRAIN FORAGE HYBRID MONOCUTTIN...

ARIANE
ORANGE LIGHT BROWN GRAIN HYBRID...

JASPE
FORAGE GRAIN HYBRID MONOCUTTIN...

SAPHIR
FORAGE GRAIN BMR HYBRID...

Sorghum is the fifth most cultivated cereal in the world. It is highly popular in Africa and increasingly in Europe where the market is booming.

A HIGHLY PROMISING CEREAL FOR ANIMAL FEED

While 60% of wheat, barley and corn in Europe is destined for animal feed, sorghum plays a complementary role: high in protein, with starch to provide energy, unsaturated fatty acids and good tolerance to mycotoxins in the field, it enhances the health and nutritional quality of feed diets. **Sorghum offers a safeguard for animal nutrition.**

In addition to its nutritional values for human consumption, sorghum is also attractive because of its low cost with lower input requirements, regardless of the intended use of the feed ration: pigs, poultry, layers, dairy cow, pet food, fish and birds.

Sorghum should not be considered as a substitute cereal, but rather a lever to improve the profitability ratios of industrial feed.

Beyond its agronomic and ecological qualities, sorghum grain is nutritionally comparable to the other cereal grains in terms of protein, energy, vitamins, minerals, and is a rich source of fibre.

SORGHUM FOR FOOD: AN ASSET FOR HEALTH

Its chemical composition makes it of particularly interest, because the dried grain contains fibre and natural antioxidants. It is gluten-free and can be used in a gluten-free diet. Due to its composition, it is highly digestible and easily assimilated. It also contains important minerals such as iron, calcium and phosphorus. Grain contains vitamins such as niacin (vitamin B6) and vitamin E which give this food high nutritional value. **Sorghum is a great energy booster.**

Sorghum comes in a variety of forms: flour, whole grain, pasta, milk, flaked, puffed sorghum, sorghum flakes, energy bars, beer and spirits, and many more.

SORGHUM FODDER: MAKING THE RIGHT CHOICE

Depending on the intended use, growing areas and sowing dates of single-cut fodder sorghum, the selection criteria and their importance vary. Factors to be taken into account include: earliness of heading and harvest; energy levels and components; susceptibility to lodging; yield potential and regularity and early vigour.

- GROUPE 1 SINGLE-CUT FODDER GRAIN SORGHUM: Medium height, rich in starch, early
- GROUPE 2 SINGLE-CUT FODDER SORGHUM: High height, low starch, later
- GROUPE 3 SINGLE-CUT FODDER SORGHUM BIOMASS : Industrial uses

Australian research discovers gene to increase size, yield of sorghum

http://www.xinhuanet.com/english/asiapacific/2021-09/28/c_1310214782.htm

Source: Xinhua| 28 Sept 2021 |Editor: huaxia

SYDNEY, Sept. 28 (Xinhua) -- Geneticists from Australia's University of Queensland (UQ) have discovered a gene that could increase the grain size and potential yield of the drought-resistant crop, sorghum, according to a research unveiled on Tuesday.

Professor David Jordan from the Queensland Alliance for Agriculture and Food Innovation (QAAFI), an organisation that seeks to find sustainable agriculture and food solutions, said their findings could bear major implications for people around the world.

"Sorghum has been an important dietary source of starch in Africa for thousands of years, but it is increasingly valued in Western diets as a low-GI, gluten-free and nutritious grain."

Grain sorghum has been widely grown in Australia since the late 1930s, and has proved itself as a crop well suited to Australia's arid conditions.

Jordan's research first began six years ago when he teamed up with Dr. Yongfu Tao from UQ, who initially mapped the sorghum genome to identify which genes were associated with grain size. Tao said new variants are now "capable of doubling grain weight."

"These traits are strongly inherited, with genes accounting for as much as 80 percent of the grain size characteristics."

Tao told Xinhua the selection of traits for large grain had minimal impact on the crop's water and nitrogen requirements, which could have major implications for creating a more efficient and environmentally friendly source of food.

"Sorghum is already a staple food for over 500 million people in the semiarid tropics of Africa and Asia, where food security remains most challenging."

"I hope our study would lead to development of higher-yielding sorghum varieties to give farmers in these regions an extra amount of sorghum grain during harvesting."

Jordan told Xinhua it has taken thousands of attempts to tease out this super sorghum, and the next step will be adapting it to different climatic conditions.

"What we're trying to do is get something that performs well across all environments, not just something that goes really well in one environment and in a dry heat would be terrible."

Centre for Crop Science (QAAFI CPS)

Queensland Alliance for Agriculture and Food Innovation, The University of Queensland
https://science.des.qld.gov.au/research/capability-directory/centre-crop-science

The Centre delivers research to target improved crops, crop protection systems, and sustainable production systems in tropical and sub-tropical environments for enhanced economic and environmental outcomes. The Centre provides innovative plant-focused research by the pursuit of excellence in plant science at molecular, whole plant, and production system levels. The centre harnesses the plant science development capabilities of QAAFI, and the Queensland Department of Agriculture and Fisheries (DAF) and our national and international partners.

Website https://qaafi.uq.edu.au/centre-for-crop-science(external link)
Organisation type

- University Research Centre
- Queensland Government – Partner

Number of research staff 20-100 research staff
Address

Queensland Bioscience Precinct, 306 Carmody Rd, The University of Queensland, St Lucia QLD 4072

Strengths and capabilities

- Plant breeding and genetics
- Plant health
- Crop physiology and modelling
- Farming systems science
- Crop improvement
- Crop nutrition/agronomy
- Ag-Nano, Anti fungal silver nanoparticles

Facilities and major equipment

- Hermitage Research Station, Warwick
- J. Bjelke Petersen Research Station, Kingaroy
- Maroochy Research Station, Nambour
- Centre of Tropical Agriculture, Mareeba
- Physical Containment Class 2 (PC2) laboratory
- Quarantine laboratory
- Cropping and animal farming facilities
- Cropping research facilities at Hermitage, Toowoomba and Gatton

Lead researcher

- Professor Ian Godwin(external link)—Pioneer in the use of GM and gene edited techniques in sorghum and author of 'Good enough to eat?: Next generation GM crops'
- Professor David Jordan(external link)—Leader of Australia's public sorghum pre-breeding program resulting in genetic in 100% of the commercial sorghum grown in Australia.
- Professor Andre Drenth(external link)—Leader in research on the biology and management of plant diseases caused by fungi in Horticulture

Achievements of the centre

- Leading the most successful public sorghum breeding program in the world with sorghum now Queensland's most important cereal crop
- Identified the antimicrobial properties of the Kakadu plum powerful enough to extend the storage the shelf-life of food, particularly prawns

Developing sweet sorghum varieties for biorefinery applications

https://research.qut.edu.au/cab/projects/developing-sweet-sorghum-varieties-for-biorefinery-applications/

Project dates: 01/01/2017 - 17/12/2021

Sweet sorghum is fast-growing, high-biomass crop that can accumulate sugars in the stalk or convert those sugars into grain. Moreover, water requirements for sweet sorghum are relatively low and it can be grown on marginal land. These attributes make sweet sorghum an ideal crop to produce feedstocks for conversion into food, feed, fibre, and fuel products in a biorefinery.

Wild and improved sweet sorghum varieties have a wide range of phenotypes (*e.g.*, height, sugar content, biomass yield), so there is ample opportunity to develop sweet sorghum varieties for specific growing environments and industrial applications.

The Project will assess the agronomic performance of 31 sweet sorghum varieties grown in South-East Queensland and identify which varieties are best suited to specific biorefinery applications. The high-yield sweet sorghum varieties were developed by Earthnote Japan based upon on almost a decade of research and development.

Chief Investigators

- Associate Professor Mark Harrison

Team

- Mr Hakan Bakir
- Darcy Patrick

Sorghum Plants

https://www.jcu.edu.au/environmental-research-complex/research/research-projects/sorgum-plants

JAMES COOK UNIVERSITY AUSTRALIA

The project "Environmentally Responsive Biocomposite Fertilisers" is part of the Innovation Partnerships funded by the Advance Queensland initiative. This project is a collaboration between The University of Queensland, the Department of Agriculture and Fisheries, Manildra Group and JCU. It aims to deliver a targeted next generation fertiliser for Queensland's expanding agrotechnology sector, as a commercial product for local manufacturers. These environmentally responsive fertilisers are novel formulations based on urea, tailored biopolymers and functional additives, and a step towards high-yielding, high-efficiency agriculture.

At the ERC in JCU we grew sorghum plants to test the new developed fertilisers in a tropical environment. We simulated leaching events, collected water samples and analysed nutrients losses in the water, nutrient content of the plants at harvest and final biomass.

Higher protein, yielding sorghum on horizon

https://www.graincentral.com/cropping/higher-protein-yielding-sorghum-on-horizon/

Emma Alsop, 3 June 2022

University of Queensland researchers trialled these new high protein and yielding sorghums at Gatton and Cecil Plains, Queensland, Australia. Photo: UQ

UNIVERSITY of Queensland (UQ) researchers believe they are one step closer to reducing the Australian intensive animal industry's reliance on imported soybean, following successful trials using higher protein and yielding sorghum lines.

UQ Queensland Alliance for Agriculture and Food Innovation Centre for Crop Science director **Ian Godwin** gave an update on the four-year project during a Grains Research and Development Corporation webinar this week.

Professor Godwin said the research used gene-editing technology to produce sorghum lines which would benefit both growers and intensive animal industry, which uses most of Australian sorghum.

"The aim was three-fold; it was to get bigger grain, it was to get more protein and it was to get more digestible protein," Professor Godwin said.

Professor Ian Godwin

He said the "tight starch-protein matrix" in sorghum had been a long-term problem for researchers, with this structure causing limitations in the digestibility of the starch in the grain.

He said due to this matrix any increases in the protein content usually resulted in less starch being absorbed by the animal and reduced growth outcomes.

"More protein in itself was not likely to make it more attractive to end users, but if we can make more protein and make that protein more digestible, then that's what we are aiming for."

Professor Godwin said researchers focused on three gene families associated with grain protein, size and digestibility and, in the summer of 2018-19, grew their first field trials at Cecil Plains and Gatton, west of Brisbane.

He said several lines gave exciting results with increased grain size and seed number as well as higher protein content.

"We increased grain size without having any effect on seed number.

"We also found that we were getting large seeds, and that larger seed did not have the predicted effect of reducing the protein content, because of the genes that we had manipulated."

He said the best lines produced the trifecta of larger grains, more seeds, and a higher level of more digestible proteins.

"We got up to 16 per cent protein content which compared to the industry average of 10 per cent is fantastic and these things were actually more digestible."

Broiler feeding trials

In October, researchers selected the best varieties to undertake a broiler feeding trial in Sydney with 320 day-old chicks.

He said researchers compared their lines with commercially available varieties, with the feed mixes set to have the same level of nutrients.

He said the traditional sorghums required a higher level of soybean meal and soy oil to reach the targeted protein levels.

Professor Godwin said this trial tested whether the increased protein sorghums would be digested similarly to the commercial sorghum fortified with higher levels of soy.

“The answer was pretty pleasing to us because…there was no significant difference in growth and in fact, in some of our lines, the feed conversion ratios were as good as or better than the commercial sorghums.

“We know it is not about the higher protein alone, it is about the quality.

“If you do have higher protein with higher digestibility, it leads to really good feed conversion ratios and you are saving in the amount of soybean meal you are putting into that diet.”

Poultry industry savings

Professor Godwin said reducing the amount of soybean meal required would result in significant cost savings for the poultry industry.

“At current prices our better sorghums reduce the cost of feed by about AU$88-$100 per tonne because you are using significantly less soybean meal.

“So, that transfers to being worth somewhere between AU$0.25 and 40 cents per chicken in feed costs.”

He said these numbers become more significant when considering that Australians eat one million chickens per day, and it takes about one tonne of feed to produce 250 chickens all the way through to maturity.

“So with 15pc versus 10pc protein, the whole industry, if they adopted higher protein cereals, would save close to AU$500,000 per day because of less imported soy.”

Capturing benefits for growers

Professor Godwin said the grains and intensive animal industries would have to collaborate to ensure growers could reap some of the benefits of this new sorghum.

He said the larger grain and more seeds would result in higher yields for growers.

“From a grain growers’ point of view, increased grain size will give higher yield, potentially less screenings, a higher demand for sorghum and hopefully a higher price.

“Another thing we need to think about is potentially this could create an increase in export demand for our sorghums and some of the biggest importers of soybean meal put it into animal feed, they are on the list.”

Professor Godwin said he believes this technology can be transferred to other feed-grains.

“These sort of changes that we made might also be transferrable to things like feed wheat and feed barley.

“So, if you can do that and replace our reliance on imported soybean meal it is of great benefit to the feed-grain industry.”

How sorghum became Queensland's top crop

https://qaafi.uq.edu.au/article/2016/10/how-sorghum-became-queenslands-top-crop

31 July 2016

The sorghum story is a strong example of what is possible when there is significant targeted investment in breeding and agronomic research, and a long-term commitment.

Sorghum

When casting around for grains industry success stories, it could be difficult to top the story of sorghum.

Productivity gains in Australian sorghum are the highest in the world, and industry growth is also among the highest, globally, for any cereal crop. In 2015, for the first time, sorghum overtook wheat to become Queensland's most important cereal crop, with a farm gate value of AU$432 million.

The Queensland Government initiated the sorghum-breeding program back in 1958 at the Hermitage Research Station near Warwick, and the program began delivering to Australian grain growers through the private seed industry in the mid-1960s.

The GRDC began funding the program in 1993 and in 2010 QAAFI took over the program leadership. Over this period it has evolved to become the most successful public sorghum-breeding program in the world in terms of lines licensed to industry, uptake in commercial varieties and benefits delivered to grain growers.

With a focus on improved yield and climate resilience, commercial licensing of new sorghum lines started in 1989. Since then more than 2,400 lines have been licensed, with more than 100 sorghum lines licensed to commercial seed companies in the past year alone.

To put these figures in context, there is more use of the genetic material coming out of the sorghum-breeding program than any other public pre-breeding program in the world.

Germplasm licensed by the program is used directly as hybrid parents and also indirectly, by crossing licensed lines to commercial material to produce new parents within a company's breeding program.

All Australian hybrid sorghum varieties have genetics from the program, including traits such as midge resistance and staygreen traits (a feature of modern hybrids, which can be traced to program germplasm).

About 90 per cent – or 16 of 18 commercial varieties – are now generating royalties to the core breeding program partners.

One of the challenges for Australia is the small size of the seed market and the potential for companies to introduce parent lines from international programs and not to breed parents under local conditions. This was common from the 1970 to the early 1990s, but from the late-1990s onwards all commercial hybrids contain parents bred in Australia.

The system now encourages companies to continue breeding locally and most hybrids comprise genetics from pre-breeding and from company proprietary genetics, meaning Australian growers get the best of both public and private systems.

More important from the grower's perspective, however, is that Australian sorghum has shown productivity gains in the order of three to four per cent per year over the past 20 years, due to the breeding and agronomic improvements that have been achieved. Sorghum now holds the status as one of Queensland's most valuable agricultural industries.

One of the growers who has seen firsthand the benefit of the research investment is grower Glenn Milne from Dalby, Queensland. Glenn's family has been hosting breeding trials on his 600-hectare property on Queensland's Darling Downs since the early 1980s, and he lists midge resistance, standability (reduced lodging) and staygreen as the most important traits the program has delivered. Australia is currently the only country in the world with midge-resistant sorghum as standard.

"Midge resistance has been the biggest benefit," he says. "Many people say it's cheap to spray but the combination of the midge-resistance traits and spray gives you a really robust defence."

"Stay-green also helps in tough conditions, and provides better resistance to Fusarium," he says.

"There is less lodging among varieties that have the stay-green trait."

Glenn says climate resilience has improved over the years, which he believes is a result of enhanced genetics and an improved understanding of sorghum agronomy.

"We get better seedset under tough conditions," Glenn says, "and that is also due to better agronomy. With the introduction of zero-till and knowing how much water the soil can hold, we now understand the right conditions for the plant, so the combination of the breeding and agronomy has pushed productivity up."

Professor Graeme Hammer, director of the Centre for Plant Science at QAAFI, echoes the grower's sentiments about the focus on both strands of crop science.

"QAAFI's strategic research interest in field crop improvement spans genetic improvement as well as agronomic systems," Professor Hammer says.

"Our big-picture focus is around optimising interactions of genetics and management to get the best out of our variable cropping environment."

In 2013, the outstanding cumulative results demonstrated by the sorghum improvement program were recognised internationally when the Bill & Melinda Gates Foundation awarded the program US$4.6 million (A$6.4 million) to improve breeding programs in Africa, and to map the genes controlling two drought-resistance traits in sorghum.

In 2016, the foundation awarded the team a further US$3.8 million (A$5.3 million) to assess plant-breeding programs in developing countries and identify the best avenues to improve them.

Bill & Melinda Gates Foundation program officer Dr Jeff Ehlers said the foundation chose UQ because of its worldwide reputation for excellence in plant breeding, particularly in **tropical crops such as sorghum**: "Very few organisations have the range of technical expertise and history of success in delivery of improved varieties to farmers as UQ and its partner the Queensland Department of Agriculture and Fisheries," he said.

For geneticist and plant breeder Professor David Jordan, QAAFI's sorghum team leader, the grants are a testament to the value of long-term investment into high-quality research.

"Australian sorghum's productivity gains demonstrate the advantages of simultaneously improving both management practices and genetics in an integrated way. It is a long-term investment by both public and private-sector researchers, and if done well, it also generates large returns and lays the foundation for future improvements," Professor Jordan says.

This project is jointly supported by the Department of Agriculture and Fisheries and UQ, and the GRDC.

Origin and History

https://sorghumtrust.co.za/origin-and-history/

The cultivated sorghums in South Africa are of the specie bicolor and are known as Sorghum bicolor (L.) Moench. Linnaeus described a group of sorghums under the name Holcus in 1753 and in 1794 Moench differentiated between the general Sorghum and Holcus. Until recently **Sorghum bicolor featured prominently in its wild grass form in Africa** and was established as a crop on this continent in due course.

On account of the variety of ecological habitats in the **north-eastern part of Africa**, the greatest variety of the wild and cultivated sorghums are found there. Diggings in Sudan, at Kadero, 18 kilometres north-north-east of Khartoum and roughly 6 kilometres east of the Nile, point to sorghum which was cultivated there as long ago as the second half of the fourth millennium B.C.

It is presumed that sorghum was introduced into the East in approximately 700 B.C. on account of the trade route between East Africa and India (via Arabia). Shipping trade also took place from India all along the coast of Asia, with the result that sorghum also found its way to China. Sorghum originally reached the USA as a result of the slave trade from West Africa, but later (1874 – 1908) also from North Africa, India and South Africa.

The word "sorghum" was derived from "sorgo", the Italian name for the plant.

Hy-Gain for smallholders

https://hy-gain.org/UQ-team

Professor Anna Koltunow

Hy-Gain Project Leader

Professor Anna Koltunow is the Project Leader for Hy-Gain and a Professorial Research Fellow in QAAFI at The University of Queensland. She has research interests in plant seed and fruit development and is an internationally recognised expert in an asexual form of seed formation in plants called apomixis. She has been involved in collaborative research projects on seed and fruit development with various laboratories in the United States and Europe and has worked with the horticultural industry to develop seedless fruit. Her research on apomixis is being applied to a range of crops where it should significantly economise hybrid seed production.

View profile

Angie Strelow

Hy-Gain Project Manager

Angie Strelow is the Hy-Gain Project Manager and is responsible for operational and financial aspects of the project. She has over fifteen years experience providing operational and administrative coordination for a variety of projects. Angie has been with The University of Queensland for over 10 years working across a range of areas including with QAAFI since 2018.

Professor David Jordan

Deputy Project Leader

Professor David Jordan is the Deputy Project Leader of Hy-Gain and is a Professorial Research Fellow in QAAFI at The University of Queensland. He is a sorghum breeder and geneticist with more than 20 years experience working in both the public and private sector. For the last decade he has led the public sorghum pre-breeding program in Australia which is a partnership between The University of Queensland (UQ), The Queensland Department of Agriculture and Fisheries (DAF) and the Grains Research and Development Corporation (GRDC). This is a long running and successful research effort with a reputation for integrating across disciplines and linking research efforts from the strategic to the applied. Breeding lines from this program are widely used commercially in Australia and internationally with 100% of the commercial sorghum grown in Australia having genetics from the program. At the same time the research group continues to produce research papers at the forefront of sorghum research.

View profile Research page

Associate Professor Emma Mace

Principal Investigator

Associate Professor Emma Mace holds a senior research leadership role at both QAAFI within The University of Queensland and The Queensland Government Department of Agriculture and Fisheries. Her main research focus is on the development and use of innovative genomics tools to support plant breeding programs, with a focus on grains and in particular sorghum. She has led the development of a number of critical data resources for both applied and fundamental research in sorghum genetics and genomics that are widely used by sorghum researchers nationally and internationally.

View profile Research page

Associate Professor Brett Ferguson

Principal Investigator

Associate Professor Brett Ferguson currently leads the Integrative Legume Research Group (ILRG) in the School of Agriculture and Food Sciences (SAFS) and is an Affiliate in QAAFI at The University of Queensland. He has worked with legumes for over 20 years and his research focuses on gene and signal discovery in legumes, with an emphasis on understanding molecular signalling interactions that orchestrate plant development. His work uses modern biotechnology approaches, such as genetic transformation and genome editing (e.g. CRISPR), to functionally characterise genes and networks of interest.

View profile Research page

Professor Ian Godwin

Principal Investigator

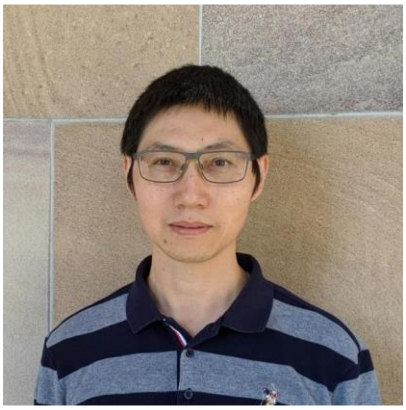
Professor Ian Godwin is the Director of the Centre for Crop Science at QAAFI in The University of Queensland. He has over 30 years experience in plant biotechnology research. Ian leads research in the use of biotechnological tools for crop improvement, with emphasis on the sustainable production of grain crops. Major focus is on the improvement of crops for food, feed and bio-industrial end-uses. He has pioneered the use of GM and gene edited techniques in sorghum. Research projects include international collaborations with a focus on food security and plant genetic resource conservation with collaborators in Germany, Denmark, the United States, China, Ethiopia and Pacific Island countries.

View profile

Dr Barbara George-Jaeggli

Senior Research Fellow

Dr Barbara George-Jaeggli is a senior researcher with the Queensland Alliance for Agriculture and Food Innovation and Agri-Science Queensland (DAF). She is a sorghum crop physiologist and mainly studies complex traits and how they contribute to cereal yield improvements. She has recently led the development of data and image analysis pipelines using proximal and remote-sensing to screen such traits in large field trials and enable the discovery of their underlying genes and genetic regions.

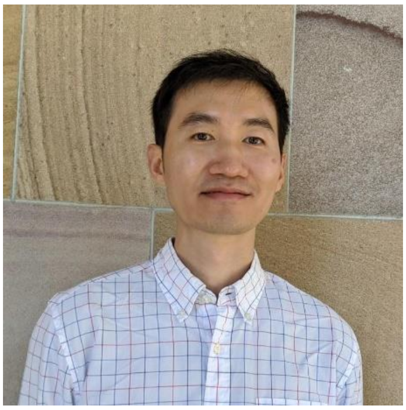


Dr Guoquan Liu

Research Fellow

Dr Guoquan Liu has more than ten years experience in sorghum tissue culture, genetic transformation, and genome editing. He developed a world-class highly efficient sorghum transformation system in 2012. In recent years, he has focused on improving sorghum grain yield and grain quality, capturing heterosis, and renewable energy through biotechnologies including synthetic biology.

View profile



Dr Huanan Su

Research Fellow

Dr Huanan Su was a member of the Integrative Legume Research group with The University of Queensland since 2015. He holds a PhD from Citrus Research Institute, Southwest University/Chinese Academy of Agriculture Science, China. Dr Huanan Su mainly focuses on the discovery and functional characterisation of novel genes and signals that manipulate legume development, with developing new molecular biology tools for genome editing and legume transformation.

View profile

Dr Lance Maphosa

Hy-Gain Research/Lab Manager

Dr Lance Maphosa has over 10 years of research experience primarily focused on agronomy, functional genomics and different omics technologies including phenomics in different cereal, oilseeds and legume crops. He has worked extensively in the private and public sector, on both GM and non-GM glasshouse and field experiments. He joined the Hy-Gain team in 2023 and his role involves lab management, stewardship and interactions with key project stakeholders.

Dr Owen Powell

Postdoctoral Fellow (Quantitative Geneticist/Bioinformatician)

Dr Owen Powell is an early career researcher at QAAFI within The University of Queensland where he is developing a unified framework to predict genotype by environment by management (GxExM) interactions for cereal crops. The unified prediction framework integrates classical quantitative genetic models with physiological crop growth models to allow the interrogation of gene-to-phenotype (G2P) relationships relevant for plant breeding. Prior to joining QAAFI, Owen developed stochastic simulations of whole breeding programs to optimize the deployment of genomic selection and increase genetic gain in hybrid crops and low-to-middle income livestock production systems.

Alan Cruickshank

Senior Plant Breeder, Department of Agriculture and Fisheries

Alan Cruickshank has over 30 years experience working as a plant breeder helping growers by improving important crops, particularly sorghum and peanuts. After working with the peanut industry to improve yield, shelf-life and disease resistance, Alan now works to study and use the great diversity of sorghum and cowpea to address current and emerging world challenges.

Colleen Hunt

Senior Biometrician, Department of Agriculture and Fisheries

Colleen has more than 20 years experience as a biometrician working on Australian plant breeding programs. Since 2005 she has been a senior biometrician in the Department of Agriculture and Fisheries primarily responsible for the analysis of all experiments conducted by the DAF/QAAFI sorghum pre-breeding program. Recently she has been focusing her research on developing statistical methods for genomic prediction, genotype by environment interactions and hybrid dominance.

David Rodgers

Scientific IT Manager

David Rodgers has over 20 years experience in Software development, data management, systems administration and IT support in both the public and private sectors. The majority of this time has been spent working for DAF and QAAFI Crop Sciences supporting cereal grains breeding programs. His main focus has been developing and supporting bespoke database and electronic data capture applications for plant breeding programs. For the last 4 years he has been heavily involved in deploying these software tools in Africa to modernise the Ethiopian plant breeding programs through a Bill and Melinda Gates foundation project.

Dr Sofie Pearson

Postdoctoral Research Fellow

Dr Sofie Pearson is a Postdoctoral Research Fellow with QAAFI at The University of Queensland. She holds a PhD from Massey University, New Zealand. Her background is in plant genetics and is passionate about improving breeding programmes through statistical genetics and identifying candidate genes underpinning phenotypic variation. The primary focus of Sofie's current research is understanding the genetic control of heterosis in sorghum and cowpea.

Angela McHardy

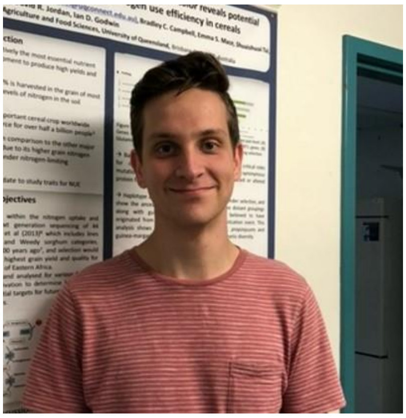
Senior Systems Programmer

Angela McHardy has over 15 years experience working in a number of positions in the public and private sectors in both Australia and New Zealand. She has extensive experience working with clients in a range of industries, including telecommunications, state government, and higher education to manage data as well as identify and develop software and web solutions. Angela is currently developing and maintaining software solutions to support the Hy-Gain project.

Sean Reynolds Massey-Reed

Research Technician

Sean Reynolds Massey-Reed is an electronic engineer working in the high throughput phenotyping with Hy-Gain. He works on the collection and processing of data from multiple sensing platforms, both in field and after harvest, to measure traits in sorghum and cowpea as well as assisting the collection of measurements for comparison. Sean also assists in maintenance and commissioning of equipment to support others in their roles. Originally, Sean joined QAAFI within The University of Queensland in 2018 as part of the ARC Centre of Excellence for Translational Photosynthesis.



Nicholas Lester

Research Assistant

Nicholas Lester has a BSc(Hons) in plant science from UQ. His previous research has focussed on CRISPR-edited sorghum floral architecture mutants, and he has an interest in reproductive developmental biology.

Jasmin Deo

Research Assistant

Jasmin Deo is a Research Assistant, focused on developing high-yielding, hybrid sorghum and cowpea seed for smallholder farmers in sub-Saharan Africa. She has a Master of Molecular Biology degree from the University of Queensland. Her Master's thesis investigated the impact of PIN genes in CRISPR-edited sorghum lines. Prior to joining UQ, she has worked for ten years as a Research Assistant at Sugar Research Australia on various projects including genetic transformation of sugarcane, tissue culture, commercial production of sugarcane varieties, nitrogen nutrition and genetic control and genomic selection for important traits in sugarcane.

Cassie Martinez

Administration Officer

Cassie Martinez offers research support to the Sorghum team located in Warwick at the Hermitage Research Facility. Her role includes domestic and international procurement, financial reporting, logistics, travel coordination, IT support and website design, primarily for the Bill & Melinda Gates Foundation MERCI project. Cassie has 25 years of experience in IT and joined The University of Queensland in 2015.

The Queensland Alliance for Agriculture and Food Innovation (QAAFI) is a research institute of The University of Queensland (UQ), supported by the Queensland Government.

One of the consequences for the crop growing in water-deficit conditions during grain filling is lodging. Lodging is the permanent displacement of plant stems from the erect position (Pinthus 1974). Three types of lodging have been reported in sorghum: stem, root, and panicle (weak neck) lodging (Esechie et al.) 18 Apr 2020

New pre-breeding co-investment to tackle sorghum lodging

https://www.pacificseeds.com.au/new-pre-breeding-co-investment-to-tackle-sorghum-lodging/

19 January 2022

A new AU$11.6 million, five-and-a-half-year joint investment is aiming to address lodging in sorghum – an issue that is consistently rated as the most significant concern facing Australian sorghum growers and costing on average AU$12 million worth in yield loss annually.

This strategic investment aims to de-couple the relationship between height, yield and lodging to increase the water-limited yield potential of sorghum, reducing grain-fill yield loss by 25 per cent. The knowledge and techniques developed will allow breeders to chase yield harder without greater lodging risk.

The investment comprises in-kind and cash investment between Grains Research and Development Corporation (GRDC), global commercial partner Advanta Seeds and trusted long-term partners University of Queensland (UQ) and the Queensland Department of Agriculture and Fisheries (DAF).

UQ researcher Professor David Jordan will lead the project with grain grower investment through GRDC, and UQ and DAFQ's world-leading expertise in sorghum research combining with Advanta's industry expertise and global scale.

Professor David Jordan inspects sorghum near Warwick, Southern Queensland

Ultimately, this pre-breeding research seeks to provide commercial sorghum breeders with the tools and germplasm to rapidly deploy pre-breeding outputs to growers, fast-tracking the path to market.

GRDC Business Partnering Manager, Brett Ford said the research partnership follows extensive engagement with growers, advisers, researchers, and industry about what they see as a key priority for investment.

"Lodging was clearly that issue that mattered most, to improve yields and yield stability," Dr Ford said.

"This co-investment is the sweet spot for effective research and development, with an outstanding combination of resources in grain research and commercialisation. Each partner has 'skin in the game', contributing expertise and financial support to the investment.

"GRDC's aim as strategic investor is to support research unique to the Australian grain industry. This collaboration will improve the accuracy and speed of sorghum pre-breeding, supporting faster commercialisation of innovation right here in Australia – and levy payers are set to benefit."

Minister for Agricultural Industry Development, Fisheries and Rural Communities Mark Furner said the co-investment was another way the State Government could support sorghum growers, and agriculture in Queensland.

“We have a long history of working closely with GRDC and UQ and we welcome the opportunity to work with commercial partner Advanta Seeds, tapping into this global expertise,” Minister Furner said. “Sorghum is an important crop for the state and we’re looking forward to addressing this considerable constraint on yields through this pioneering pre-breeding program.”

Professor David Jordan said the UQ team looked forward to working with the partners to continue to lead the way on global sorghum research and development.

“In this project we are bringing together Australia’s leading sorghum research expertise with the capacity of global industry innovator, Advanta Seeds,” Professor Jordan said.

“As part of this project, we will investigate and introduce methodology that will establish consistent, robust and replicable methods that induce lodging, testing stem composition and structure – which has never been done anywhere in the world.

“We’ll assess diverse sorghum populations to identify the key genes and genetic locations associated with reduced propensity, to lodge and draw on this knowledge, so that we can create advanced genomic tools that enable breeders to develop high yielding hybrids quickly and efficiently to tackle the issue.

“We have had a longstanding track record of delivering significant value for sorghum growers over many decades, and this five-year investment will ensure this work will continue.

“While there are no guarantees in research, it’s exciting to think what we can achieve together.”

Advanta Seeds Australia Managing Director Barry Croker said Advanta Seeds was focused on continual improvements to crop performance and grower profitability.

“The business is a significant player in the global sorghum market and at a local, Australian level we have a long, proud history of developing locally adapted, leading sorghum hybrids under the Pacific Seeds brand.” Mr Croker said.

“This investment demonstrates our further commitment to Australia’s sorghum industry and ensuring it continues to prosper long into the future.”

While Advanta Seeds has a 12-month embargo on releasing results as part of the partnership, all traits will be publicly released (unless all discoveries come exclusively from Advanta germplasm).

Sorghum is the fifth-largest grain globally in terms of volume. As a nation, Australia produced roughly 20% of volumes produced by the USA (the largest producer), making us a significant but medium size player on the global stage.

Dr Ford said the joint research project would put Australia at the centre of global sorghum pre-breeding research and would allow commercial breeders to rapidly deploy pre-breeding outputs.

“The collaboration creates a multi-win situation and Australia’s sorghum growers should benefit most directly and tangibly from the agreement,” he said.

Opinion: Australia's number one summer grain needs a champion

https://qaafi.uq.edu.au/blog/2019/08/opinion-australias-number-one-summer-grain-needs-champion

31 July 2019

Professor Ian Godwin

Earlier this month I was fortunate to join fellow scientists, industry folks, grain growers and the future stars of agriculture (the students) at the Australian Summer Grains conference on the Gold Coast. Wonderful presentations, a bit of Cicero, and many stories about doing it tough in the heat and lack of rain which seems to be our new normal. Except if you're from Brazil apparently.

We had to endure what was truly an eye opening presentation from Victor Campanelli who runs a "small" agricultural enterprise in Southern Brazil. His intention was clear – to show us what you can do with technology and rain. Rain? Like 2,000mm average (low murmur around the conference hall), and the poor fellow is run absolutely ragged by getting three crops a year in his rotation (rising muttering), turning off 80,000 head of lot fed cattle (audible gasp/oath) per annum, plus a little feed business on the side to value add the excess produce. The video of the row of planters following the harvesters brought a tear to many eyes around the room. But it nailed the reality that this is the modern global landscape, and the competition seems to be a lot better organised than we are at times.

Prof Ian Godwin in UQ Glasshouse checking on a sorghum crop.

Hence industry associations. At the conference it was apparent that many commodities have organised themselves, and with much success, were there to champion their crop, inform and assist newcomers, and develop new paths to market. The Australian Mungbean Association, Soy Australia, Maize Association Australia and the Australian Sunflower Association all had considerable presences. Chatting to them and checking out their active websites, it is also obvious that they are instrumental in getting involved post farm-gate. Topics like traceability, food safety and hygiene, market requirements and mycotoxins are key website topics.

Professor Ian Godwin

Conspicuous in its absence was a Sorghum Association. Strange when the on-farm value of sorghum production dwarfs the other summer grains. In some years sorghum is Queensland's number one grain, summer or winter. Googling away, all I could find was OzSorghum, which is a showcase that brings together the sorghum research community. Our little sorghum research community is the envy of those overseas, which is why we get regular invitations to meet and speak at their industry conferences in the US, China and Europe. Yet our wonderful research community has the potential to be a lot more effective if we had the opportunity to coordinate with an industry association.

What happens to sorghum when it leaves the farm? Do we know or even care? How much is eaten by humans in Australia? When we export to China we assume it is for Chinese liquor, the nearly deadly Baijiu (personal opinion which ~1 billion don't share). Maybe more goes into Chinese chickens and ducks? Why do feedlots on the Darling Downs import barley from the West rather than use local sorghum? Is it just that we are ashamed of sorghum? We ignore sorghum quality and where it goes at our peril. Maybe the time has come for Australia's number one summer grain to have an active Association to champion the Cinderella of Australian grains.

Professor Ian Godwin is the Director of the Centre for Crop Science at QAAFI at The University of Queensland. He is the author of [Good Enough to Eat? Next Generation GM Crops.]

Queensland

https://www.agriculture.gov.au/abares/research-topics/agricultural-outlook/australian-crop-report/queensland

Australian Crop Report: June 2023 edition

6 June 2023

Winter crop production is forecast to reach 2.2 million tonnes in 2023–24. This is down 35% from 2022–23, but 8% above the 10-year average. This result is driven by a higher area planted to winter crops which is expected to offset slightly below average yield prospects. Favourable crop prices and strong farm financial positions, accrued through record farm cash incomes over the last three years, are supporting the strong incentive to plant a crop this season. However, the increased likelihood of a drier than normal winter and spring due to the possible onsets of both El Niño and positive Indian Ocean Dipole are curtailing potential crop yields.

Area planted to winter crops is forecast to be 1.4 million hectares, 17% above the 10-year average and largely unchanged compared to last year. Following a very dry summer in most cropping regions, average to above average rainfall during March improved soil moisture levels and helped to achieve an early autumn break in most of the Southern Downs. Average April rainfall and widespread falls in excess of 25 millimetres in the middle of May helped to further realise strong planting intentions in the Darling Downs, especially for growers who missed out on planting summer crops due to localised flooding and excessive wet conditions in the spring of 2022. However, below average rainfall across much of the Western Downs and Central Queensland growing regions this planting season is expected to curtail planting intentions, resulting in significant levels of available land being left fallow over winter in these areas.

A less favourable start to the winter cropping season in some cropping regions compared to the past three seasons is expected to largely affect the area planted to wheat. Additionally, winter rainfall is likely to be below average in most cropping regions in Queensland, according to the Bureau of Meteorology's latest three month rainfall outlook (issued 25 May 2023). Area planted to barley and chickpeas are forecast to increase as growers look to mitigate risks of this unfavourable rainfall outlook, by looking to plant more resilient crops. Returns from barley and chickpeas have also improved relative to wheat, making them more attractive in the mix of plantings.

Winter crop yields are forecast to fall 35% compared to 2022–23 to around 1.61 tonnes per hectare but remain just 2% below the 10-year average. Yields are forecast to be around average for most of the Darling Downs but below average in the Western Downs and most of Central Queensland. Average to above average soil moisture levels across much of southern Queensland at the beginning of winter are expected to buffer yield prospects against the below average rainfall outlook. However, yield prospects in other cropping regions will be highly reliant on adequate and timely rainfall to realise current yield expectations.

Winter crop forecasts, Queensland, 2023–24

Crop	Area '000 ha	Yield t/ha	Production Kt	Area change %	Prod. Change %
Wheat	920	1.65	1520	–6	–42
Barley	150	2.07	310	10	–23
Chickpeas	250	1.26	315	25	8

Note: Yields are based on area planted. Area based on planted crop that is harvested, fed off or failed. Percent changes are relative to 2022–23.
Source: ABARES

Summer crop production is estimated to be the second highest on record at 2.5 million tonnes in 2022–23, largely unchanged from the previous year. **Early planted sorghum crops have performed above expectations, with strong yields and good grain quality, supported by the high soil moisture levels early in the season.** Crops have been able to tap into the full soil moisture profile through flowering and grain fill, due to strong root development. However, a lack of summer rainfall led to poor root development in late planted sorghum crops which were unable to utilise the full soil moisture profile, reducing yield potentials.

The area planted to irrigated cotton increased across southern Queensland, with warm summer temperatures supporting yield potentials and quality profiles. Late plantings to dryland cotton in central Queensland were curtailed by dry summer conditions and below average yields are expected for those late planting crops.

Summer crop estimates, Queensland, 2022–23

Crop	Area '000 ha	Yield t/ha	Production Kt	Area change %	Prod. Change %
Grain sorghum	480	3.52	1,690	12	–2
Cotton lint	251	2.04	512	17	21
Cottonseed	251	2.46	616	17	21

Note: Yields are based on area planted, except cotton which is based on area harvested. Area based on planted crop that is harvested, fed off or failed. Percent changes are relative to 2021–22.
Source: ABARES

Queensland researchers bring sorghum gene genie out of the box

https://statements.qld.gov.au/statements/92883
Published Friday, 06 August, 2021

Minister for Agricultural Industry Development and Fisheries and Minister for Rural Communities
The Honourable Mark Furner (Queensland)

Queensland scientists have developed the world’s first pan-genome for sorghum in a breakthrough for crop improvement and gene discovery.

Minister for Agricultural Industry Development and Fisheries Mark Furner said the discovery unlocks the genomic treasures to breed improved varieties of the ancient cereal grain.

“This is exciting news for Queensland where sorghum is a staple crop used mostly in the intensive livestock sector and worth more than AU$250 million this year,” Mr Furner said.

“A pan-genome describes all genetic variation within a species and this enables researchers to find previously missing genetic information.”

“A team of scientists led by Dr Emma Mace identified novel genes from wild relatives of cultivated sorghum that could help to increase crop adaptation to environmental and disease stresses.

“Other genes were also identified for productivity and nutritional traits such as grain colour, grain weight and seed dormancy.

“Until now our knowledge of the sorghum genome has lagged behind other major crops. Armed with the pan-genome data, researchers can now tap into variation at specific genes to breed improved sorghum varieties.”

Mr Furner said the Palaszczuk Government supported a wide range of agricultural research through partnerships with industry, universities and through its research locations across Queensland.

“Agriculture is an important part of Queensland’s Economic Recovery Plan, and supporting research like this will help to maintain Queensland farmers as world leaders,” he said.

Mr Furner congratulated the scientists from the Department of Agriculture and Fisheries, Queensland Alliance for Agriculture and Food Innovation at the University of Queensland, the Chinese Academy of Sciences and BGI Genomics who jointly announced their discovery in the prestigious journal *Nature Plants*.

The Global Diversity Trust and the Australian Research Council co-funded the project which aimed to improve productivity in sorghum.

Other key research outcomes included:

- Gene numbers in different sorghum varieties vary much more than thought;
- Total gene number per individual varied from approximately 31,000 to 37,500 genes;
- Wild relatives contained the largest proportion of unique genes; and
- Genomic studies are limited if based on a single individual’s genome.

The new data is already being used in breeding efforts to improve the yield and resilience of crop varieties in Australia in the face of mounting challenges to production, including climate change and increased water scarcity.

Sorghum is a drought-tolerant staple crop for half a billion people in Africa and Asia, an important source of animal feed throughout the world and a biofuel feedstock of growing importance.

Queensland Researchers Discover Genes for Sorghum Grain Size

https://www.isaaa.org/kc/cropbiotechupdate/article/default.asp?ID=19041

30 September 2021

Dr. Yongfu Tao shows grain size variations in sorghum. Photo Source: Megan Pope

Researchers at The University of Queensland are optimistic the value and versatility of sorghum, one of the world's top crops, will be improved following the discovery of genes that could increase the grain size of the crop.

Queensland Alliance for Agriculture and Food Innovation (QAAFI) Research Fellow Dr. Yongfu Tao initially mapped the sorghum genome to identify genes associated with grain size, narrowing the search with existing genetic information for rice and maize. Dr. Tao said that they have identified new variants that are capable of doubling grain weight and that these traits are strongly inherited, with genes accounting for as much as 80 percent of the grain size characteristics.

Dr. Tao said 125 regions in the sorghum genome had now been identified where variation in the DNA sequence was associated with grain size and response to environmental conditions. Their analyses included wild relatives of domesticated sorghum and Australian native sorghum.

Queensland scientists in world first sorghum discovery

https://www.agforceqld.org.au/knowledgebase/article/AGF-01415/
9 August 2021

Queensland scientists have made a world first genetic discovery that will lead to stronger sorghum crops.

Until now our knowledge of the sorghum genome has lagged behind that of other major crops, but this latest breakthrough unlocks the genomic treasures to breed improved varieties of the ancient cereal grain.

Armed with the pan-genome data, researchers can now tap into variation at specific genes to breed improved sorghum varieties.

Sorghum is a staple crop used mostly in the intensive livestock sector and worth more than AU$250 million this year (Queensland).

The new data is already being used in breeding efforts to improve the yield and resilience of crop varieties in Australia in the face of mounting challenges to production, including climate change and increased water scarcity.

Minister for Agricultural Industry Development and Fisheries and Minister for Rural Communities Mark Furner congratulated the scientists from the Department of Agriculture and Fisheries, Queensland Alliance for Agriculture and Food Innovation at the University of Queensland, and the Chinese Academy of Sciences and BGI Genomics, who jointly announced their discovery in the prestigious journal *Nature Plants*.

AgForce applauds this exciting development for our industry.

Queensland Univ researchers optimistic on grain size discovery of sorghum

https://agrospectrumindia.com/2021/10/04/queensland-univ-researchers-optimistic-on-grain-size-discovery-of-sorghum.html

4 October 2021

Image credit: www.uq.edu.au

Research activities will help sorghum breeders to expand the crop's potential

Researchers at The University of Queensland are optimistic the value and versatility of one of the world's top crops will be improved following the discovery of genes that could increase the grain size of sorghum.

The use of the drought-resilient summer crop has been constrained by the small size of sorghum grains, but Professor David Jordan from the Queensland Alliance for Agriculture and Food Innovation said that could be about to change.

Sorghum is popular among Australian growers, particularly in Queensland and New South Wales, and the research will help breeders to expand the crop's potential. The project began six years ago, involving UQ and the Queensland Department of Agriculture and Fisheries.

QAAFI Research Fellow Dr Yongfu Tao initially mapped the sorghum genome to help identify which genes were associated with grain size, narrowing the search with existing genetic information for rice and maize.

Dr Tao said 125 regions in the sorghum genome had now been identified where variation in the DNA sequence was associated with grain size and response to environmental conditions. The analyses included wild relatives of domesticated sorghum and Australian native sorghum.

The project also delivered additional information and tools to help plant breeders improve sorghum cultivars. The research is published in The Plant Journal. The research was funded by the Australian Research Council, with additional support from the Queensland Department of Agriculture and Fisheries, the Grains Research and Development Corporation and UQ.

Researchers Discover Genes to Increase Size of Sorghum Grains

https://www.republicworld.com/world-news/australia/researchers-discover-genes-to-increase-size-of-sorghum-grains.html

28 September 2021

Researchers from The University of Queensland, Australia, have suggested that the grain size of Sorghum will increase following the discovery of genes.

Australia Apoorva Kaul

Image: Pixabay/Representative

Researchers from The University of Queensland, Australia, have suggested that the grain size of sorghum will increase following the discovery of genes. As per the study, the drought-resistant summer crop, Sorghum, was affected by the small size of sorghum grains. But, now researchers have suggested that they have found the way through which the size of sorghum grains can be increased.

Researchers discover genes to increase the size of Sorghum grain

The research conducted by University of Queensland Researchers has been published in The Plant Journal. Sorghum is widely grown in Australia, particularly in Queensland and New South Wales. As per the researchers, the new research will help the growers to increase the 'potential' of sorghum crops. The researchers mapped the sorghum genome to identify the genes that were related to the grain size. Queensland Alliance for Agriculture and Food Innovation (QAAFI) Research Fellow Dr Yong Tao in the press release informed that they have identified new variants that can double the grain weight. Tao further explained, "These traits are strongly inherited, with genes accounting for as much as 80% of the grain size characteristics."

The researchers have found about 125 regions in the sorghum genome where variation in the DNA sequence was related to grain size and its response to environmental conditions. The researchers showed that genetic diversity was present in the sorghum gene pool for grain size. Dr Yong Tao in the press release explained, "This allows us to identify the genetic control of grain size with minimal change to environmental resources, such as water or nitrogen."

Professor David Jordan from Queensland Alliance for Agriculture and Food Innovation (QAAFI) stated that following the discovery of genes, it will increase the grain size. David Jordan in the press release stated that the Sorghum is Australia's third-largest grain crop. Furthermore, he informed that the Sorghum grain is used to feed animals and is increasingly used in cereals and food for human consumption. "Sorghum has been an important dietary source of starch in Africa for thousands of years, but it is increasingly valued in Western diets as a low-GI, gluten-free and nutritious grain," Jordan added.

Researchers find a genetic solution to ensure sorghum stands firm

https://www.nzherald.co.nz/the-country/news/researchers-find-a-genetic-solution-to-ensure-sorghum-stands-firm/647R6XNP5MNYCYIH2FYPWPY5CU/

The Country 4 Apr, 2021

Professor David Jordan views sorghum crop at the Gatton Research Facility. Photo / Supplied

After decades of study, University of Queensland researchers have identified a genetic solution to the problem of sorghum lodging and falling down.

Lodging was when the stems of plants carrying high grain yields were weakened by loss of water, Professor David Jordan from UQ's Queensland Alliance for Agriculture and Food Innovation explained.

The problem affects 10% of sorghum crops each year.

"Losing a bumper grain crop because plants fall over is heartbreaking for growers and undermines efforts to increase production to improve food security," Jordan said.

Working with the Department of Agriculture and Fisheries at the Hermitage Research Facility in Warwick, Jordan found that lodging occurred whenever water scarcity halted photosynthesis.

"This forces the plants to rely on carbohydrates stored in the stems," he said.

"The metabolic shift ultimately weakens the stems, culminating in their death, while pathogens can invade and further weaken stems, causing them to break."

Doctoral student Xuemin Wang analysed data from 14 seasons and found that the most severe lodging – greater than 20% – occurred in 2005, 2006 and 2017.

He found the differences in air pressure recorded on the Southern Oscillation Index explained 29% of the season variation in lodging frequency.

"Our data also found that despite substantial breeding efforts and turnover of commercial cultivars, the level of resistance to lodging does not appear to have improved," Jordan said.

The research team found that traits used to drive up yields also introduced a susceptibility to lodging.

An example was plant height, which was essential to achieving higher yields, but also raised the risk of lodging-inducing stem failure.

Sorghum

https://qaafi.uq.edu.au/sorghum

Leader in sorghum research wins Award

17 June 2021

Working with the Bill & Melinda Gates Foundation

8 May 2018

Resilience, reliability improves sorghum returns for growers

18 July 2017

Beyond MR Buster: Trials show upside to sorghum yields

24 April 2017

As global food demand rises, climate change is hitting our staple crops

20 March 2017

Study adds move value to sorghum for human food markets

14 February 2017

UQ and QAAFI deliver return on investment

14 February 2017

How sorghum became Queensland's top crop

31 July 2016

Systems agronomy for maize and sorghum in the Northern Region

Sorghum ahead: recent research towards better growing, marketing, decision making / edited by Peter Vance ... [et al.]

https://catalogue.nla.gov.au/catalog/605245

Bib ID: 605245

Format: Book

Description: Brisbane : Dept. of Primary Industries, 1992 v, 17 p. : ill., 1 map ; 30 cm.

ISBN: 0724239804
Series: Conference and workshop series (Queensland. Department of Primary Industries) QC92001.

Notes: "From the review papers presented at the 2nd Australian Sorghum Conference, Gatton, Queensland 1992'.

Subjects:

- Sorghum -- Congresses
- Sorghum -- Research -- Congresses

Other authors/contributors:

- Vance, P. N
- Queensland. Department of Primary Industries
- Australian Sorghum Conference 1992 : Grafton College)

Sorghum mutants breed crop innovation for food security

https://www.myscience.org/news/2022/sorghum_mutants_breed_crop_innovation_for_food_security-2022-UQ

12 April 2022

Life Sciences | Agronomy/Food Science

L-R Robert Henry, Patrick Mason - at Gatton library of sorghum mutants. Image: The University of Queensland

A crop of half a million genetically diverse sorghum plants growing at The University of Queensland's Gatton campus will help future-proof cereal production in a changing climate.

UQ's Professor Robert Henry said the crop would reinvent the way producers use mutagenesis, a conventional plant breeding technique that mimicked nature.

"This crop will help breeders more quickly find genetic traits of interest as essentially it is a 'here's what we prepared earlier' library of traits," Professor Henry said.

"Usually when mutagenesis is used, a gene of interest is found, a genetic variation induced, and the new trait is then bred over several generations.

"What this project is doing is generating and propagating half a million Australian-grown genetically diverse sorghum lines in advance and using high-throughput DNA screening tools to create a searchable library of genetic traits."

The collaborative research effort is led by Denmark's Carlsberg Research Laboratory, through the Semper Ardens 'Crops for the future – Tackling the challenges of changing climates' project.

Carlsberg Research Laboratory Vice President, Professor Birgitte Skadhauge, said unprecedented global challenges prove the need for sustainable ways to feed a growing population.

"There is a great need for the world to have better and more climate-tolerant crops, particularly in areas with marginal agriculture," Professor Skadhauge said.

"A significant knowledge of plant genetics is essential for the sustainable production of crops bred for traits like increased drought tolerance and improved disease resistance."

Once harvested in early 2022, seed will be taken from each individual sorghum plant and split between researchers in Australia and Denmark.

The Danish team will extract DNA from the seeds, analyse it and create a database.

Professor Henry said the crop was around 500 times larger than previous studies, significantly increasing the possibility of finding desired variants.

"When this is up and running, breeders will be able to search the database for a desired trait,' he said.

"For example, when we decide we want to find one of the DNA sequence variants that might be associated with disease resistance, we will contact Denmark.

"They'll do the screening and tell us what packet of seed is likely to have the genetic variant of the gene we are looking for.

"We'll then grow that and see if it provides the disease resistance we were hoping for."

He said the work was concentrated on sorghum but one day the idea could be used in other cereals.

"Sorghum is the starting point because it's a crop that grows in warmer and drier environments than other cereals," Professor Henry said.

"**Sorghum can be used in animal feed, human food, in brewing, and in biofuel**."

"An easily accessible library of genetic variation in such a flexible crop will help facilitate innovative uses of sorghum."

Queensland researchers discover gene that could 'supersize' sorghum grain

https://www.facebook.com/watch/?extid=NS-UNK-UNK-UNK-AN_GK0T-GK1C&mibextid=2Rb1fB&v=182829880657488

Sorghum potential: huge

https://www.northqueenslandregister.com.au/story/3586171/sorghum-potential-huge/

18 December 18 2015

Sweet sorghum has a wide potential cropping area, including tropical and sub-tropical Queensland, the Northern Territory, northern Western Australia and in temperate regions of New South Wales, Victoria and Western Australia.

A NEW Australian-based research study into sweet sorghum has shown the huge potential of the crop across a wide cropping area including tropical and sub-tropical Queensland.

Sorghum research heats up

https://www.nature.com/articles/d42473-018-00314-7

Combining genomics, phenomics and modelling, Australian researchers are developing more temperature-tolerant varieties of a staple crop

Produced by

THE UNIVERSITY OF QUEENSLAND AUSTRALIA

natureresearch CUSTOM MEDIA

Half a billion of the world's poorest people rely on the cereal sorghum to feed themselves and their stock. It's a crop exquisitely adapted to heat and drought, which explains its popularity in hot, dry environments in Asia and sub-Saharan Africa.

But even sorghum has its limits. In a changing climate, farmers are already finding that extreme heat events are having a negative impact on the productivity of sorghum crops. If temperatures increase at projected rates over coming decades, the consequences could be dire.

At The University of Queensland (UQ), a unique approach weaving together genomic, phenotypic and physiological research is quickly homing in on the genetic architecture of heat tolerance in sorghum. The work aims to provide farmers with varieties of sorghum able to withstand even higher temperatures and secure the productivity of this vital crop into the future.

Professor Graeme Hammer, Director of the Centre for Crop Science in the Queensland Alliance for Agriculture and Food Innovation (QAAFI) © CoreText

"The risks for sorghum farmers are becoming more and more severe with climate change," explains Professor Graeme Hammer of UQ's Queensland Alliance for Agriculture and Food Innovation (QAAFI), a research institute supported by the Queensland Government. "We need to get ahead of the problem and deliver tolerant material to the agricultural sector."

As one of the few research-intensive universities worldwide located in a subtropical environment, UQ is a global leader in agriculture and food science research for subtropical and tropical production systems. QAAFI supports this leadership through extensive industry linkages, globally recognised expertise and research infrastructure across a broad range of inter-connected disciplines, to deliver impact across the tropical and subtropical agriculture and food supply chains.

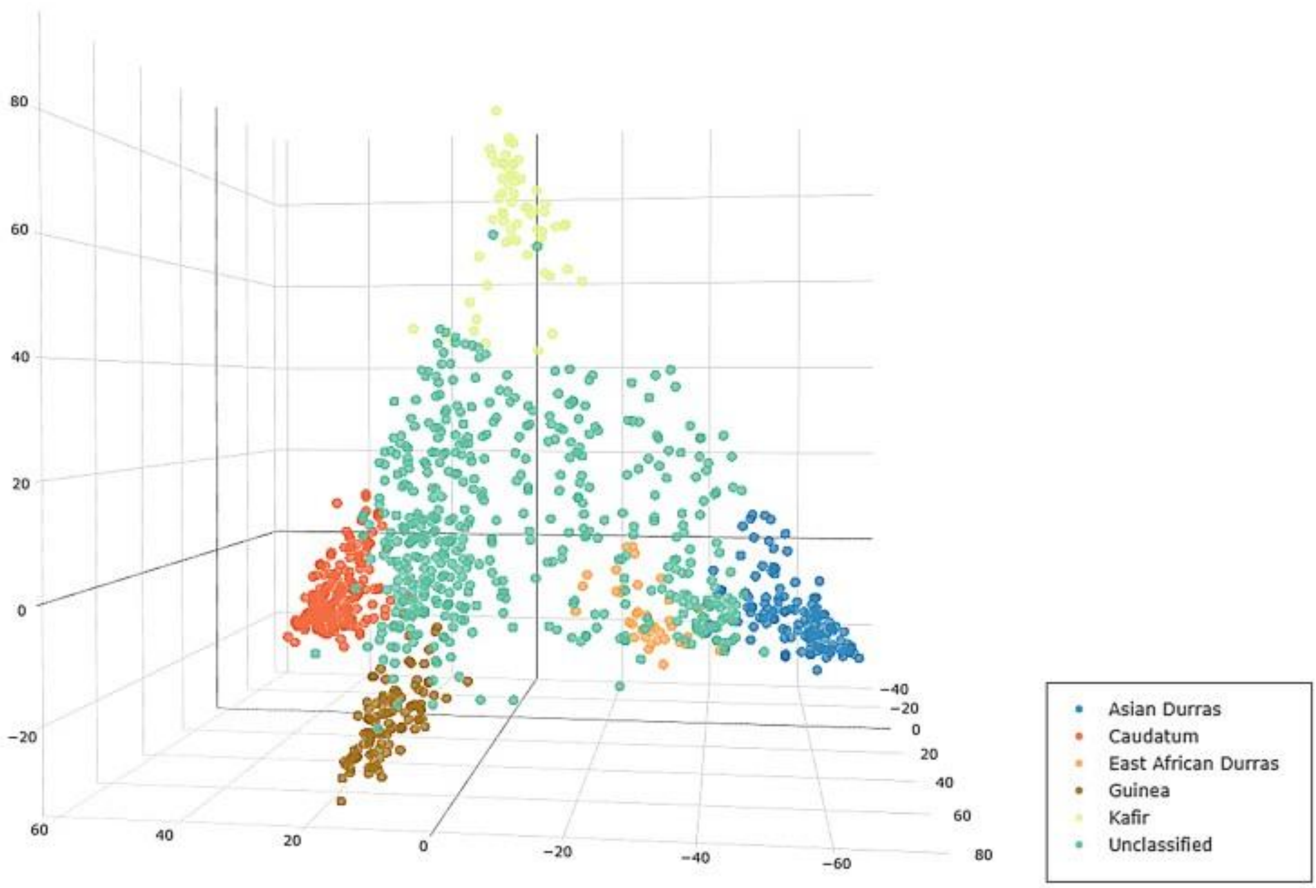
The group's approach to the heat-tolerance question began with remarkable sorghum populations at the Queensland Government's Hermitage Research Facility, south west of Brisbane. Here, material representing the diversity of the world's wild and cultivated sorghum varieties is developed and maintained under the careful eye of Professor David Jordan from UQ.

© University of Queensland

Hammer, Jordan and their colleagues used this resource to kick off a phenotypic investigation of how different sorghum varieties handle heat. Essentially, large numbers of plants were exposed to high temperatures during a key stage in development, and researchers observed which varieties were able to set fertile seeds.

Subsequent analysis showed that variation in membrane stability and its effect on pollen fertility seemed to be the differentiating factors. The next steps were to understand the genetic architecture that results in this change, and put this into the context of environmental modelling. The outcome is of such value to the agriculture sector that the Australian government has recently awarded the group a prestigious industry-linked project to do just that.

The sorghum heat sensitivity project exemplifies the integrated approach being applied in Queensland, says Hammer. “We refer to this as the GxExM paradigm, which stands for genetics x environment x management. This is an area where crop and climate modelling can connect with the adaptive elements of genetics and agronomy.”



Genetic diversity captured by the global sorghum collection maintained at the Hermitage Research Facility, with *Sorghum bicolor* racial groups highlighted Adrian Hathorn © University of Queensland

This approach has drawn attention from funders such as the Bill & Melinda Gates Foundation, who have been funding Jordan and Hammer since 2012, first to build capacity and productivity for sorghum breeding programs in sub-Saharan Africa and other water-limited environments, and later to investigate problems common to sorghum growers in low-rainfall regions across the globe.

Indeed, Jordan, Hammer and colleagues have a long track record of bringing economic and environmental gains through sorghum breeding programmes through technological innovations. Jordan and colleagues have developed a range of integrated, cross-disciplinary tools to increase the rate of genetic gain made in the program, develop high-yielding elite germplasm and also to support the dissection of complex adaptive traits, including drought and heat adaptation. "We employ an integrated approach using linking technologies, including genomics, high throughput phenotyping, remote sensing and simulation modelling," explains Professor Jordan, "to build bridges across scales and disciplines and to support information-driven pre-breeding activities."

The genetic resources developed in Australia have been used to generate productivity increase rates for the crop that are greater than those reported by any other developed nation.

“Connecting our disciplinary strengths allows us to improve plants much more quickly than has been possible in the past,” Hammer says. “This allows the techniques and knowledge that we generate to contribute to food security for many people, including smallholder farmers in Africa."

For more information on the University of Queensland research, please visit: research.uq.edu.au

World-class research supporting QLD sorghum industry

https://www.rbmagazine.com.au/news/world-class-research-supporting-qld-sorghum-industry/

Seeds Summer cropping 22 October 2019

World-class research from Queensland's leading scientists is supporting significant growth in the state's sorghum industry and boosting exports to markets around the world.

Minister for Agricultural Industry Development and Fisheries Mark Furner said his department had been leading the way in developing new varieties of sorghum for over 60 years.

"Over the last three years we have licensed more than 120 improved genetic lines to private breeders, who then use these lines to deliver pest-resistant, high-yielding hybrids to Queensland farmers," Mr Furner said.

"We are investing in innovation so that our farmers can take on the world.

"Department of Agriculture and Fisheries scientists work with the Queensland Alliance for Agriculture and Food Innovation (QAAFI) and Grains Research and Development Corporation (GRDC) to grow sorghum varieties that are more resistant to pests and diseases, while also providing higher yields.

"Queensland growers now produce some of the highest yielding rain-fed sorghum crops anywhere in the world."

The gross value of sorghum production is estimated to reach AU$552m in 2018/19, well above the five-year average, thanks to large increases in crop plantings and stronger world prices.

Mr Furner said the scientists' work was also working closely with industry.

"Because of the work done on midge resistance by my department and QAAFI, producers have substantially reduced use of insecticides and have greater flexibility in planting dates," Mr Furner said.

"Our partnership model with private breeders is respected around the world as an effective way to link leading crop research to better farmer outcomes."

Mr Furner said the Queensland sorghum industry was well placed to take advantage of the surging global demand for the crop.

"In Australia, sorghum is primarily used for stock feed but the cereal is a staple food for millions of people around the world in countries like India and Ethiopia," he said.

"There's also room to grow in Asia, where sorghum is used to make the Chinese liquor baijiu, the most widely consumed alcoholic spirit in the world.

"That is why the Queensland Government is continuing to co-invest with GRDC and QAAFI in DAF's sorghum breeding program, so that our farmers can continue to be the best and help feed the world."

World-class sorghum germplasm

https://www.daf.qld.gov.au/business-priorities/agriculture/research/public-access/world-class-sorghum-germplasm

15 July 2020

New sorghum germplasm to enhance breeding.

We collaborate with the Grains Research and Development Corporation to develop world-class varieties of sorghum.

We have created many inbred lines that can be cross-bred to create the world's best and most resilient sorghum, with resistance to drought and sorghum midge. New and better lines are made commercially available each year.

These lines have been very successful and profitable for our commercial partners. In fact, all commercially grown sorghum in Australia, and much of that grown around the world, contains our sorghum germplasm.

Our sorghum has gained a significant reputation in the Australian and international market for the following traits:

- Moderate to high **resistance to sorghum midge**, a pest that can devastate crops during the flowering period. Resistance levels are enough to give field immunity under Australian conditions.
- High levels of **stay-green drought resistance** in most material. Stay-green reduces lodging, maintains grain size and increases yield in severe end-of-season drought conditions.
- **Enhanced digestibility** in some forage and silage parent lines using the bmr12 gene. Parent lines are also available with the waxy gene, which helps ruminants digest sorghum grain.
- **Unique genetic diversity** can be introduced into sorghum breeding programs from our diversified gene pool program. This germplasm carries new genes from landraces and wild species into adapted lines with stay-green and midge resistance.
- High levels of **resistance to common pathogens**, according to feedback from international users.

Our scientists will work with your company to identify the best germplasm to suit your needs. Germplasm can be used to make breeding crosses with sorghum lines from other breeding programs, subject to the conditions of the licence agreement.

Licensing and royalties

Germplasm is licensed thorough a non-exclusive licensing arrangement that sets out the terms and conditions for the germplasm's use. An upfront fee is charged based on the number of lines licensed.

Seed companies wishing to commercialise our sorghum germplasm, or use it for breeding, must obtain a licence from the State of Queensland through DAF.

We are looking for individuals or commercial entities interested in commercialising sorghum, with a view to obtaining a licence to cross-breed, grow and sell the sorghum.

For all research commercialisation enquiries, please contact Agri-Science Queensland's Crop and Food Science Unit via the Customer Service Centre.

Sweet Sorghum

Sweet sorghum is defined as having a stalk containing sugar-rich juice, similar to sugarcane.

From: Breeding Sorghum for Diverse End Uses, 2019

https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/sweet-sorghum#:

orghum Uses—Ethanol

C.V. Ratnavathi, ... U. Lavanya, in Sorghum Biochemistry, 2016

4.21 Grain Yield

Sweet sorghums are believed to have a poor grain yielding ability. Recent studies on sweet sorghum collected from Africa and Asia, however, revealed the wide variability among them for grain yield. Variation ranging from 16.6 to 515.4/gm^2 with a mean value of 156.6/gm^2 among 90 agronomically superior sweet sorghum stocks evaluated at ICRISAT, India, was reported by Seetharama and Prasada Rao (1988). Differences existing between grain and sweet sorghums for their sink sites (Seetharama and Prasada Rao, 1988; Lingle, 1987) do not appear to cause limitations for attaining higher grain yield in sweet sorghum. It seems the higher biomass productivity of sweet sorghum comes as an advantage for higher grain also. While high yield in grain sorghum is achieved at 35–45% harvest index, equivalent grain sorghum in high energy sorghums may be attained at 5–10% harvest index. Several sweet sorghum genotypes having fresh biomass productivity potential above 100 t/ha in 100 to 150 days in the tropics and higher latitudes have been identified (Schaffert and Gourley, 1982; Smith and Reeves, 1979; Seetharama and Prasada Rao, 1988). Discovery of high concentration of sugar in the stalk of elite high yielding grain sorghums (Choudhari, 1986) provides strong support for the possibility of combining high grain yield and stalk sugar yield. Major grain yield components like the number of grains in the panicle and 1000 grain weight (TGW) showed wide variability among several sweet sorghum stocks evaluated at the National Research Centre for Sorghum.

Engineering Fundamentals of Biotechnology

T. Tan, ... F. Shang, in Comprehensive Biotechnology (Second Edition), 2011

2.58.2.1.2 Sweet sorghum

Sweet sorghum (*Sorghum bicolor* (L.) Moench) is a C4 crop in the grass family, and is characterized by a high photosynthetic efficiency. It is a multipurpose crop, yielding food in the form of grain and fuel in the form of ethanol from its stem juice. Sweet sorghum is a high biomass and sugar yielding crop. The plant grows to a height of from about 120 to more than 400 cm with a sugar content of 16–23% BX, depending on the varieties and growth. It is often considered to be one of the most drought-resistant agricultural crops as it has the ability to remain dormant during the driest periods. In addition, like other sorghum types, sweet sorghum is well adapted to temperate climates. Because of the ability to withstand dry conditions, requirement of less fertilizer, rapid growth rate, ease of planting, and lower cost of total fermentable sugars, sweet sorghum appears to be a viable alternative to corn as a potential energy crop [13, 18].

In (the) PRC, researches have been undertaken to improve the yields of both grain and juice from sweet sorghum since 1983. A new hybrid of sweet sorghum called Tianza No.2, which has high yields of both grain and fermentable sugars (5.0 tons ha^{-1} grain yield and 16.1 BX juice sugar degree), is bred by Shenyang Agriculture University. **Table 2** shows the characteristics of different varieties of sweet sorghum planted in the north of China [13]. The 0.4 million ha of saline-based land in Shandong, Liaoning, Jilin, Heilongjiang, Inner Mongolia, and Xinjiang provinces can be used for the cultivation of sweet sorghum. If the saline-based land and the sorghum-growing land are used for cultivating sweet sorghum, then the planting areas would amount to 970 kha, producing 0.35 million tons of bioethanol. India is the second largest producer of sorghum in the world, producing ∼10–11 million tons from a total area of 12 million ha. The Natural Resources Conservation Service (NRCS) has been engaged in sweet sorghum research since 1989. The new hybrids bred at NRCS, Hyderabad, have the ability to produce extremely high stalk yields of up to 50 tons ha^{-1}, with juice Brix reading between 18% and 22% (**Table 3**) [19]. India's net cropped area is about 140 million ha, 70% of which is non-irrigated. The dry and drought-prone regions, unable to raise higher value crops such as rice, wheat, and sugarcane, can be used for growing sweet sorghum. In 2007, the country's first plant for commercial production of ethanol from sweet sorghum has gone on-stream in Nanded, Maharashtra, which operates at a capacity of 7000 tons per year.

Table 2. Characteristics of different varieties of sweet sorghum planted in the north of China (1994)

Varieties	Fresh stem yield (ton ha^{-1} yr^{-1})	Juice rate (%)	Juice sugar degree (°BX)	Grain yield (ton ha^{-1})
Rio	47.4	59.0	17.5	3.4
Keller	49.5	62.2	19.5	2.8
Wray	49.8	65.4	18.5	1.8
Tianza No.2	52.1	65.3	16.1	5.0

Table 3. Characteristics of different varieties of sweet sorghum planted in India (2003)

Varieties	Fresh stem yield (ton ha^{-1} yr^{-1})	Juice rate (%)	Juice sugar degree (°BX)	Grain yield (ton ha^{-1})
RSSV 59	48.4	50.1	17.7	2.2
NSS 219	40.5	42.3	16.6	2.1
NARISS 41	34.5	48.8	14.2	1.9
SSV 84 (C)	43.6	47.1	16.5	1.8

The major challenge for sweet sorghum as a feedstock for biorefinery is stem collection and sugar storage. Because sweet sorghum can be harvested only once a year in most areas of (the) PRC and the sugar content in the stem can be degraded very soon, sweet sorghum stem has to be collected and stored in a very short period. Therefore, collection system and storage techniques are need to be established for industrial application.

Introduction

In Sorghum Biochemistry, 2016

Sweet sorghum (*Sorghum bicolor* (L.) Moench), a C4 graminaceous crop which has sugar-rich stalks and which is a water-use-efficient crop, has a very good potential as an alternative feedstock for ethanol production. It is the only crop that provides both grain and stem that can be used for sugar, alcohol, syrup, jaggery, fodder, fuel, bedding, roofing, fencing, paper, and chewing. Sweet sorghum juices usually contain approximately 16–18% fermentable sugar, which can be directly fermented into ethanol by yeast. Technical challenges of using sweet sorghum for biofuels are a short harvest period for the highest sugar content and fast sugar degradation during storage. Evaluation of 160 sweet sorghum genotypes was done for juice extractability. Sweet sorghum juice mainly contains sucrose, glucose, and fructose. While sucrose is the predominant sugar during the whole developmental stages, it constituted only about 50% of the soluble sugar at the boot stage, glucose and fructose making the remainder. Some studies have been carried out on the genetic potential of sweet sorghum for higher green cane yield and juice extractability, whereas some studies have been purely on the shelf life of the juice and how to preserve the juice at low cost against bacterial contamination. Studies have also involved testing the potential of genotypes for superior yields of cane during the post rainy and summer seasons to make the cane available for the maximum period in a year. Fermentation studies have also been carried out using *Saccharomyces cerevisiae*, the most commonly used species of yeast in alcohol fermentation. Genotypic variation for ethanol production from sweet sorghum juice has also been studied. A pilot study was carried out for the evaluation of ethanol production from sweet sorghum stalk juice.

Industrial and Nonfood Applications

Janet Taylor, ... Donghai Wang, in Sorghum and Millets (Second Edition), 2019

2.4 Bioethanol From Sweet Sorghum

Sweet sorghum, also known as sweet-stemmed sorghum, has a sap rich in sucrose like sugar cane. It was originally developed as a natural sweetener in the form of a syrup, which is produced from sweet sorghum juice using an evaporation process. The fermentable sugars in the juice (sap) (53%–85% sucrose, 9%–33% glucose, and 6%–21% fructose) can be directly fermented into bioethanol (Serna-Saldívar et al., 2012). Apart from the juice from the sweet sorghum stem, the grain in the head contains 60%–74% starch which can be hydrolyzed and fermented into bioethanol. The bagasse, the dry fibrous lignocellulosic stem material, and the residues from the head can also be used as biomass for bioethanol production.

Fig. 13.3 shows a flowchart for utilization of sweet sorghum for bioethanol via three pathways: (1) direct fermentation of extracted sweet sorghum juice (glucose, sucrose, and fructose) into ethanol; (2) enzymatic hydrolysis of pretreated lignocellulosic sweet sorghum biomass (leaves, bagasse, and seed head residuals) into glucose and xylose and fermentation of these sugars into ethanol; (3) enzymatic hydrolysis and fermentation of grain from sweet sorghum panicle into ethanol. Since pathways (2) and (3) are similar to bioethanol conversion from sorghum biomass and sorghum grain, which have been comprehensively discussed earlier, this section will focus on the process of conversion of sweet sorghum juice into bioethanol.

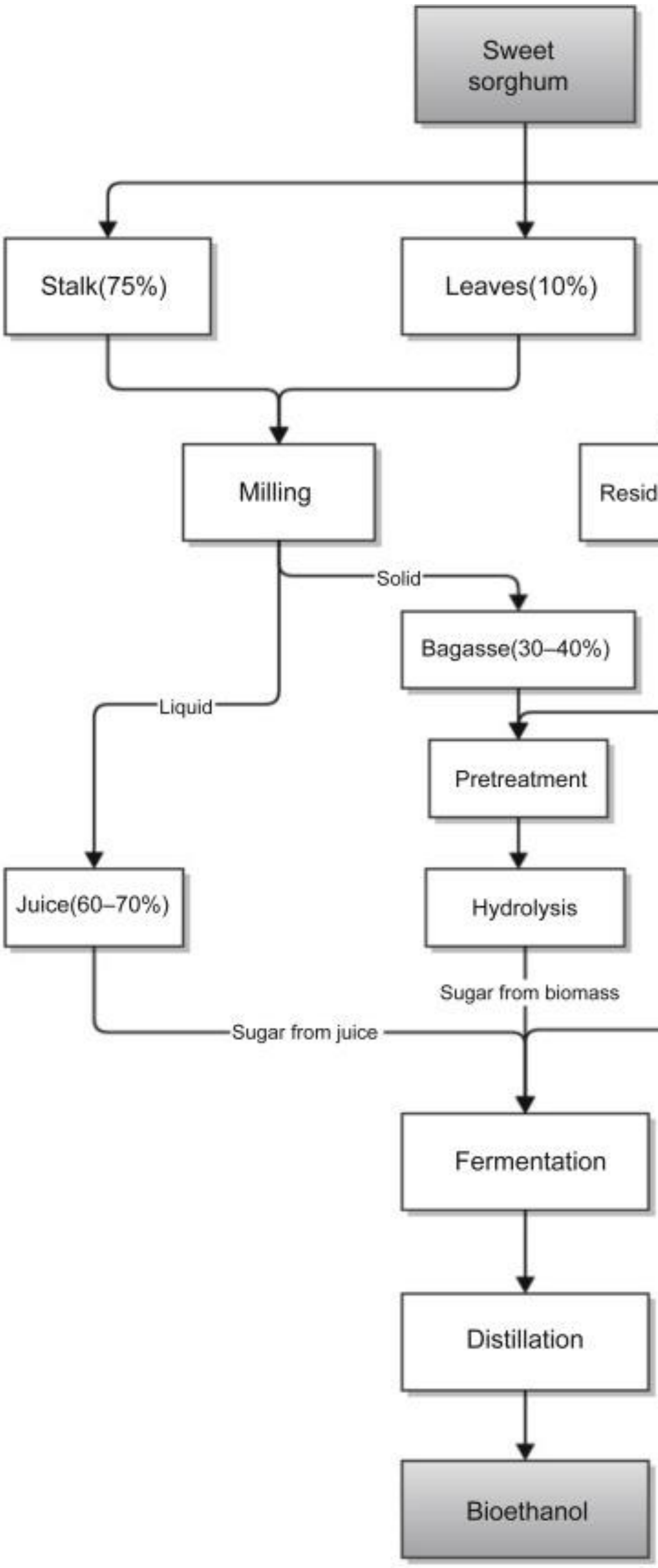


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Figure 13.3. Flowchart of utilization of sweet sorghum for bioethanol production.

Traditionally, sweet sorghum juice is extracted by crushing the harvested stalks after the panicle is removed using roller mills (with two or three rollers in tandem) or using a hydraulic press to squeeze the juice from stalks that have been chipped (Rao et al., 2013). A press efficiency (juice extraction) of 45%–55% has been reported (Caffrey et al., 2014). Sweet sorghum juice can be directly fermented to ethanol using *S. cerevisiae*. Wu et al. (2010b) studied sweet sorghum biomass yield and the fermentation efficiency. Sweet sorghum variety M81, cultivated in different locations in Kansas, USA, gave biomass yields of 18,000 to 32,000 kg/ha, with sugar and grain accounting for about 40% of the total dry mass yield. The authors reported that the fermentation efficiency ranged from 93% to 94% in laboratory flask shaking fermentation tests. Wang et al. (2011) applied a Box–Behnken response surface methodology central composite design to optimize ethanol fermentation from sweet sorghum juice using brewing instant dry yeast with fermentation parameters of temperature (25–35°C), pH (4–6), and yeast inoculation rate of 1%–5%. The optimum fermentation conditions were 27.7°C, pH 5.4, 5% inoculation, giving a 9.5% ethanol yield. Using response surface methodology, Phutela and Kaur (2014) reported an ethanol yield of 8.83% (v/v) from sweet sorghum juice with a fermentation efficiency of 87.3% using *S. cerevisiae* strain NRRL Y-2034 under optimized conditions of temperature (30°C), agitation rate (50 rpm), and yeast inoculum concentration (7.5% v/v). In addition to *S. cerevisiae*, *Mucor hiemalis* strains have been shown to be good candidates for ethanol fermentation from sweet sorghum (Goshadrou et al., 2011). Sweet sorghum juice can also be incorporated into the current dry-grind bioethanol process for improved ethanol yield and water efficiency (Appiah-Nkansah et al., 2015). These authors reported that the ethanol yield from sweet sorghum juice with the optimum grain sorghum loading was 28% higher than that from the conventional ethanol process.

Solid-state fermentation, a fermentation process with solid substrates under damp conditions, has also been studied for conversion of sweet sorghum juice to ethanol, as the process requires lower energy input and produces less wastewater. Several studies have been conducted on solid-state fermentation for ethanol production from sweet sorghum using *S. cerevisiae* (Du et al., 2014; Shen and Liu, 2008), *S. cerevisiae* strain AF37X (Yu and Tan, 2008), strain TSH1 (Li et al., 2013), and a thermotolerant yeast strain (Yu and Tan, 2008). Li et al. (2013) demonstrated the use of advanced solid-state fermentation using *S. cerevisiae* strain TSH1 on sweet sorghum stems. In their study, the stems were pulverized into particle sizes of 1–2 mm diameter and 3–50 mm length, heated to 28°C and combined with the *S. cerevisiae* TSH1 culture liquid in a continuous rotary drum fermenter and incubated for 2 weeks. The dosage rate was 1–2 mg dry cell weight/g dry sweet sorghum. Sweet sorghum, culture liquid and steam were constantly supplied to the fermenter. Sixteen tons of sweet sorghum stems yielded 1 ton of ethanol (99.5%, v/v). At a stem feed rate of 3.72 ton/h, the fermentation yielded 1.54 ton/h crude ethanol. The cost of fuel ethanol production was estimated at US$615.4 per ton (49 cent/L) on the premise that the cost of the sweet sorghum stems was US$30 per ton, which is cost competitive compared with wheat-based fuel ethanol (US$869.9 per ton), maize-based fuel ethanol (US$841.7 per ton), and cassava-based fuel ethanol (US$778.1 per ton). Du et al. (2014) isolated *S. cerevisiae* strain TSH1 from samples of soil in which sweet sorghum stalks were stored. It was cultured with crushed feedstocks (96 tons), and the ethanol fermentation process took place in a 550 m^3 industrial rotary-drum fermenter at 30°C for 21 h. The fermentation process was completed after 15 h, reaching a theoretical yield of about 88% at a 10 kg/ton/h production rate. The cost of ethanol per ton was competitive compared with other ethanol production feedstocks such as maize and cassava. Their findings indicated the strong potential of industrial-scale, solid-state fermentation of *S. cerevisiae* strain TSH1 on sweet sorghum feedstocks.

In addition to solid-state fermentation, very high gravity (VHG) fermentation is considered as an emerging fermentation method for bioethanol production because of its high ethanol yield and lower water use (Wang et al., 2007). Laopaiboon et al. (2009) studied the bioethanol fermentation efficiency from sweet sorghum juice supplemented with sucrose or sugarcane molasses as carbon sources and yeast extract and peptone or ammonium sulfate as nitrogen sources. Ethanol yield from VHG fermentation of sweet sorghum with addition of sucrose was 15% higher than that with sugarcane molasses as an additive in batch mode at 30°C, under static conditions. The data obtained were applied to develop kinetic models to demonstrate bioethanol fermentation from sweet sorghum juice using the VHG technique in the batch operation, continuous operation, and fed-batch operation modes (Thangprompan et al., 2013). An ethanol yield of 90 g/L was obtained using the continuous batch mode and 96 g/L from fed-batch production.

SYRUPS

M.A. Clarke, in Encyclopedia of Food Sciences and Nutrition (Second Edition), 2003

Sorghum Syrup

Sweet sorghum (*Sorghum bicolor*) is a giant grass, somewhat similar in appearance to sugarcane, but able to withstand cooler climates. In the Midwest and parts of the southern states of the USA, the juice of sweet sorghum is heated, clarified by skimming, and concentrated into a syrup. Sorghum juice tends to be higher in invert sugars than cane juice; it is therefore difficult to crystallize sweet sorghum sugar, and syrup is the product of choice. Sorghum syrup is produced by small plants in Tennessee, and northern Mississippi and Alabama (further information is available from the National Sweet Sorghum Producers Association, PO Box 1071, Knoxville, TN 37901-1071, USA). (*See* SORGHUM.)

The light-brown-colored syrup has a distinctive, pungent odor and flavor, in addition to its sweetness and molasses-like flavor. It is often blended with other (sugar- or starch-based) syrups, but is seldom sold industrially. Production is a cottage industry at present.

Sweet Sorghum for Biofuel Industry

A.V. Umakanth, ... V.A. Tonapi, in Breeding Sorghum for Diverse End Uses, 2019

8.2 Photoperiod- and Thermosensitivity and Genotype × Environment Interaction

Sweet sorghum is adapted to latitudes ranging from 40°N to 40°S and comes up well in drylands with annual rainfall ranging from 550 to 800 mm under a variety of soil and climatic conditions. It can be grown in areas where the temperature ranges from 15 to 45°C, but the optimum temperature for growth lies between 25 and 40°C. The day length requirement is 10–14 h. There is season specificity in sweet sorghum, which necessitates breeding of separate cultivars for different seasons. The genotype–environment interaction greatly influences the success of any breeding strategy, as the significant interaction of location (environment) with the cultivars has been demonstrated (Wortmann et al., 2010). Under Indian conditions, sweet sorghum lines grown in post–rainy season result in decreased yields compared with rainy and summer seasons because of shorter day length and lower night temperatures (Umakanth and Ashok Kumar, 2016). As the global climate is gradually changing to elevated temperatures and as sweet sorghum is bound to occupy new niches, there is a need to identify/develop sweet sorghum cultivars that are photoperiod- and thermoinsensitive, with high stalk and sugar yields and which can be grown across seasons for ensuring a year-round supply of feedstock to the industry. In addition, appropriate crop production practices that extend the feedstock availability for longer periods are required. Conversion of sorghum genotypes to adapt to long-day conditions has increased genetic diversity and greatly contributed to improved grain crop quality and productivity (Marguerat and Bahler, 2010). In view of biofuel production, characterization of sweet sorghum growing areas should be based on interactions between soil, climate, genotype, and the quantity and quality of the feedstock.

Volume 1

Neil Moss, Euie J. Havilah, in Encyclopedia of Dairy Sciences (Third Edition), 2022

Sweet Sorghum

Sweet sorghum is usually conserved as silage or grazed or green-chopped near maturity as lower quality stand-over feed that may be suitable for dry stock or older heifers but generally not for milk production. It can provide dry matter yields similar to that of maize, but is prone to lodging and more difficult to harvest. Sweet sorghum can stand over for a 6-week harvest period with stable yield and feed quality. Grain content is variable, and water-soluble carbohydrate (WSC) content is high. There is substitution between grain and WSC content. The higher WSC content allows ready fermentation of silage.

Marker-Assisted Breeding in Sorghum

R. Madhusudhana, in Breeding Sorghum for Diverse End Uses, 2019

3.2 Sweet Sorghum Traits

Sweet sorghum has shown potential as a raw material for fuel grade ethanol production because of its rapid growth rate, early maturity, greater water use efficiency, and wide adaptability (Reddy et al., 2005). Sweet sorghum, also called as sorgos, typically has low grain yields but high sugar content in the stalk. Generally, stem juice varies from 10% to 25% of sugars comprising sucrose, glucose, and fructose (Liang et al., 2010). Two approaches are followed in understanding the sugar accumulation in sorghum. One is mapping of QTL involved in sugar accumulation, while the other is the identification of genes involved through differential gene expression studies comparing sweet stalk sorghums with grain sorghums.

Ritter et al. (2008) conducted an analysis of QTL for stem sugar–related and other agronomic traits using a population derived from sweet sorghum (“R9188”) and grain sorghum (“R9403463-2-1”). QTL were identified for all sugar traits and were generally co-located to five locations (SBI-01, SBI-03, SBI-05, SBI-06, and SBI-10). For sucrose content, three major QTL were consistently detected on SBI-06, which were also co-mapped with sugar content and Brix. A major QTL was also detected on SBI-05 linked with SSR marker, mSSCIR12, where a major QTL for sugar content also co-located. Two major QTL for fructose and sucrose content were co-located on SBI-06 near Xtxp547 marker explaining 18%–24%, respectively.

Calviño et al. (2008) identified genes involved in sugar accumulation and lignocellulose synthesis by comparing genes in grain (BT × 623) and sweet (Rio) sorghum. Between them, 132 transcripts were downregulated and 63 were upregulated in sweet sorghum, “Rio.” Among the transcripts that were upregulated in “Rio,” a saposin-like type B gene displayed the highest differential expression. Several transcripts related to carbohydrate metabolism were upregulated, such as (1) hexokinase 8; (2) sorbitol dehydrogenase; (3) carbohydrate phosphorylase; and (4) NADP-malic enzyme. Transcripts that are downregulated included (1) sucrose synthase 2 and fructokinase 2, (2) α- and β-galactosidases, and (3) several others related to cell wall activities, such as cellulose synthase 1, 7, 9 and cellulose synthase catalytic subunit 12 involved in cellulose synthesis. In addition, a series of genes encoding proteins in lignin synthesis such as cinnamoyl-CoA reductase, cinnamyl alcohol dehydrogenase, 4-coumarate:coenzyme A ligase, and caffeoyl-CoA O-methyltransferase are also downregulated. Recently, Bihmidine et al. (2016) examined the expression of two additional classes of sucrose transport proteins, Tonoplast Sugar Transporters and SWEETs, for sucrose accumulation in sweet sorghum stems and confirmed the differential expression of these two genes in grain and sweet sorghum stalks.

SORGHUM | Utilization

R.D. Waniska, ... C.M. McDonough, in Encyclopedia of Grain Science, 2004

Industrial Uses

Sweet sorghums contain 20–30% sugar in the juice which is crushed from the stalks, clarified, and concentrated into an amber sorghum syrup (molasses) that is a popular product in the southern US. It has a strong flavor and is sometimes blended with cane syrup.

Sorghum grain and/or sweet sorghum biomass are used for ethanol production. Yields of 182-proof alcohol (387 l t^{-1}) from sorghum grain are comparable with maize (372 l t^{-1}). The commercial technology to ferment sweet sorghum biomass into alcohol has developed in Brazil. Sorghum grain is a good substrate for industrial and beverage alcohol where it competes with maize and other sources of starch. Several alcohol plants in the US, India, and other countries use sorghum as an adjunct for alcohol production depending upon availability and cost. In China, a distilled alcoholic beverage from “kaoliang” (sorghum) is exported. It has a unique flavour and aroma and is high in alcohol content.

Sorghum flour is used in adhesives, building board, ore refining, and metal casting as an inexpensive source of starch. The sorghum is dry-milled to remove the pericarp and sometimes converted into acid-modified dextrins. Binders that strengthen the durability of pellets for livestock feed are made from sorghum.

Sorghum is wet-milled to produce starch in Sudan and India. Sorghum starch has properties similar to maize starch. Commercial wet milling of sorghum in the USA was discontinued in the 1970s due to poor economics.

Utilization

R.D. Waniska, ... C.M. McDonough, in Reference Module in Food Science, 2016

Industrial Uses

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