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GRDC

GROUNDCOVER SUPPLEMENT

OATS

GRDC HARNESSES SCIENCE AND INNOVATION FOR OATS

By Dr Michael Groszmann and Dr Juan Juttner

■ Oats, which were historically a power feed for draught horses and oxen used for farm labour, are now the subject of growing interest for their dietary benefits for human consumption. The health benefits of oats have led to increased global scientific activity on the species, focusing on the nutritional aspects, unravelling oat genetics and improving the adaptive fit of this widely grown cereal.

The species entered European agriculture as a weed when wheat and barley were domesticated. However, it soon gained a reputation as being able to perform well as a crop in colder climates, in marginal areas and with fewer inputs. Moreover, it also had broader end-use versatility as hay, forage and grain for both stockfeed and human consumption. The high nutritional quality of oat grain is garnering more attention from dietary experts.

Oat grains have high lipid content and lysine-rich protein and soluble fibre, particularly beta-glucan. This fibre is proving beneficial in combating lifestyle diseases that are becoming more prevalent across the globe such as obesity, cardiovascular disease and type 2 diabetes.

This January–February 2023 issue of *GroundCover™ Supplement* provides a snapshot of GRDC investments underpinning oat improvement for Australian growers.

INCREASING R&D

Together with investigating new markets and developing new products with the Australian Export Grains Innovation Centre, GRDC is harnessing scientific and technological advances to place Australian oats on track to exploit these dietary imperatives.

In 2020, GRDC capitalised on many years of formative oat breeding work carried out by Dr Pamela Zwer and her team at the South Australian Research and Development Institute (SARDI) and transitioned the program to InterGrain. For oats, joining the InterGrain stable meant it could benefit from scale and technologies already being successfully applied to wheat and barley improvement.

With Murdoch University, GRDC has gained access to international research decoding the oat genome. This fundamental genetic knowledge is required to inform many aspects of oat improvement including yield, quality, disease resistance and adaptation.

Leveraging scientific skills developed in dissecting the phenology of wheat and barley, GRDC is investing in research being led by Dr Ben Trevaskis from CSIRO to unpick oats' seasonal flowering behaviour. Passing on emerging genetic tools to oat breeders, the 'oat phenology' team aims to improve oat adaptation to specific Australian environments.

Through GRDC investment, state-of-the-art approaches are being utilised to combat both Septoria and crown rust resistance. Solutions to controlling both these fungal pathogens are being sought on two fronts through decoding the fungal genomes to better understand the infection mechanisms of the pathogen while in parallel mining oat germplasm for superior forms of genetic resistance. SARDI is leading the charge in tackling Septoria, while CSIRO has attracted international expertise to battle crown rust.

Photo: Dr Sue Knights

Oats have outstanding health attributes as a dietary ingredient to combat lifestyle diseases.

Seeking to improve the performance of oats in farming systems, novel herbicide options are being evaluated for registration with GRDC support.

Marketing of oats is competitive, with product quality, pricing and customer service being crucial points of differentiation. Prominent companies are striving to develop superior quality products with bolstered health benefits. The combination of oats with several ingredients to enhance product taste and quality are enriching the value chain for oat markets.

Growers are also tapping into the health attributes of oats to obtain better returns for their crops, many capitalising on provenance to establish boutique oat businesses and selling direct to discerning customers. □

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Long game to expand Australian oat markets

The future is bright for Australian oats, but it needs to be underpinned by an industry-wide strategy

By Professor Ross Kingwell

Photo: AEGIC

Program leader Barry Cox (left) and Professor Ross Kingwell from the Australian Export Grains Innovation Centre are working to gain market insights for Australian oats.

■ Australia has a reputation for producing clean, dry, bright, sun-ripened oats and there is growing demand for them, both raw and processed.

However, oats are a minor crop in Australia, and to support the projected growth it is necessary to balance supply and demand. This requires a long-term industry development strategy.

In 2021, the Australian Export Grains Innovation Centre (AEGIC) undertook a comprehensive analysis, providing up-to-date oat market insights and key recommendations to help Australia maintain markets and capture future opportunities.

MARKETS

Oats are mostly consumed in countries where they are locally produced. In Australia, the volume of oats required for milling is continuing to grow, providing a solid foundation for growers.

According to the US Department of Agriculture, 23.3 million tonnes of oats were produced globally in 2021, but only about 10 per cent of this production was exported as raw oats or oat products.

Over the 10-year period 2012–21 Canada was the world's dominant oat exporter, selling about 1.6 million tonnes of raw oats and oat products annually, mostly to the US. Australia was the second-largest exporter over the same period, on average exporting 355,000 tonnes (about 25 per cent of the Australian oat crop), but it has more diverse markets and is the major supplier to China.

While China has growth potential, it is important for Australia to diversify market risk and continue to engage with other Asian oat markets.

Market signals indicate oat consumption is being driven by its health benefits in both traditional and emerging markets. This consumption is supported by international health authorities and governments recommending consumers replace refined grain staples with wholegrain cereals such as oats. Australia can capitalise on these developments.

STRATEGY

Oat grains have higher protein content than other grains. Oats are also rich in minerals and vitamins and are a natural laxative, being high in soluble fibre (particularly beta-glucan), and contain more antioxidants than broccoli. There is scientific evidence that oats can lower blood cholesterol, help control blood pressure, improve heart health, reduce the risk of type 2 diabetes, help control obesity and provide anti-cancer benefits.

It is these health aspects that will form a central plank for growing markets for Australian oats in many regions, particularly Asia. Sixty per cent of diabetics in the world live in Asia, while 30 per cent of the Chinese population is affected by prediabetes or diabetes. Asia already accounts for half the world's heart disease cases.

To expand oat markets, there is a need to develop interesting and affordable new products that take oats beyond a breakfast staple. Oat-based foods need to be culturally attuned and tailored to Asian palates.

Potential markets such as Indonesia already have a history of being receptive to ingredient change, illustrated by the US-supported introduction of wheat noodles in the 1960s. This substituted some rice consumption to address malnutrition issues but ensured the country was self-sufficient in rice production. Indonesia is now dealing with rising lifestyle diseases – in particular childhood obesity – and similar issues are being faced by other Asian countries. These countries can benefit from health interventions involving oats as an ingredient in Asian meals.

To further support the Australian oat industry, AEGIC is developing new oat products through understanding oat chemistry and end-product functionality.

AEGIC regularly engages with end users and Australian oat processors. In-market activities include technical exchanges, workshops and seminars where customers learn about Australian oats and the best way to process them.

To match the anticipated growth in demand, supply of oats will need to be fostered through breeding to deliver varieties attractive to growers and end users. □

GRDC Code AEG1207-001OPX

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Beyond breakfast for Aussie oats

Noodles, rice, couscous, semolina, bubble tea – oats are becoming an option for lunch, dinner and snacks

Photo: AEGIC

Barley and oats program manager Jack King (left), Dr Sabori Mitra (centre) and Dr Nabeen Dulal investigate the properties of oat noodles.

By Dr Sabori Mitra, Dr Nabeen Dulal and Jack King

KEY POINTS

- AEGIC has developed 100 per cent wholegrain oat noodles and oat 'rice' that are now being commercialised
- More recently, new oat products including bubble tea pearls, couscous and sauces and dressings have been developed
- AEGIC is informing Asian markets about the benefits of Australian oats

■ Did you know that oat porridge has been found in Neolithic bog bodies in Europe dating back 5000 years? Our Stone Age forebears from Europe obviously benefited from the nutritional value of oats.

In modern times, with the need to address nutritional challenges and with state-of-the-art science able to unravel the unique nutritional properties of the oat grain, oats are in the spotlight. Consumers around the world stand to benefit from the grain and the nutrition knowledge now available.

A team of cereal scientists from the Australian Export Grains Innovation Centre (AEGIC) is looking at novel products through which to market Australian oats into South-East Asian markets. The goal is to attract Asian consumers to oats with minimal dietary changes. But Australians also stand to gain in the move to take oats beyond simply being a breakfast staple, as we have a highly Asian-cuisine-influenced palate.

The research initially focused on products suited to the Chinese market and was supported by a dedicated GRDC project. It has since expanded to South-East Asian countries and now receives significant support from the Western Australian Government through the Department of Primary Industries and Regional Development (DPIRD), in addition to the core GRDC/DPIRD investment in AEGIC.

WA growers, in particular, stand to benefit from this work as the state has easy access to expanding export oat markets in South-East Asia.

OAT FEATURES

Most oat-based food products contain wholegrain oats, which is a major advantage as consumers benefit from the bran and germ that is not removed in processing as with other cereals.

Oats are naturally rich in beta-glucan – a soluble fibre that improves blood glucose control and insulin responses and helps decrease cholesterol (Table 1). They are high in protein and lysine, as well as being rich in minerals and vitamins and containing high levels of antioxidants such as vitamin E. More recent research shows that oats contain avenanthramides – a

unique phytonutrient that helps protect blood vessels from the damaging effects of low-density lipoprotein cholesterol.

As consumers worldwide and especially in Asia are becoming more health-conscious due to the rise in lifestyle diseases, the potential to introduce beneficial nutritional components of oats into Asian diets presents an opportunity to expand the market for Australian oats.

NOVEL PRODUCTS

AEGIC has been exploring options to use oats as a key ingredient in Asian products to enhance their nutritional value, many of them non-breakfast products – which, in turn, will promote increased daily oat consumption.

It has developed innovative ways to improve processing of oat noodles and oat rice with appealing qualities. For example, it has developed AEGIC 100 per cent wholemeal oat noodles with a standardised processing method without the use of additives. AEGIC's method uses optimum processing conditions to produce oat noodles with preserved beta-glucan, good shelf life and appealing sensory properties. These noodles can be processed into dried, frozen or ready-to-eat styles.

AEGIC has also developed 'oat rice' – a product that can be prepared and eaten like traditional rice but with the health benefits of oats. AEGIC's oat rice has twice as much dietary fibre as brown rice, fewer carbohydrates, more protein and a greater concentration of healthy unsaturated fatty acids. This innovation has improved oat rice processing yield and efficiency, allowing for the retention of beta-glucan and sufficiently deactivated rancidity-causing enzymes (increasing shelf life).

AEGIC is commercialising the intellectual property for these two products. AEGIC has also developed other innovative oat ingredients such as beta-glucan-rich fractions using innovative technology and demonstrated its application as a thickening agent (for example, in thickening sauces and gravies) and for fortification (bubble tea pearls and baked products).

Oat semolina processed from innovatively treated oat grains can be used to make various traditional food products in South Asia as well as couscous-style products commonly consumed in Middle Eastern countries

CHALLENGES

There are multiple challenges in processing oats into products and AEGIC has been innovative in overcoming these. In particular, oats lack gluten, which has viscoelastic properties, and this makes it challenging to process products such as oat noodles. Using proprietary techniques, it has been able to overcome this and produce quality noodles with satisfying mouthfeel.

The beta-glucan fraction of oats is one of the most desirable nutritional traits, so it is important to optimise processing conditions to preserve this fraction as well as other nutritional components.

NEXT STEPS

AEGIC will continue to develop innovative processing technologies for oats and new products to capitalise on expanding markets. Additionally, it is investigating the influence of Australian oat varieties on processing performance and end-product qualities of oat rice and oat noodles. Oat varieties will be sourced from different growing locations across different seasons to understand the impact of genetics and environment.

This information will enable AEGIC to better advise oat purchasers, processors and food manufacturers about varietal impacts on process and product quality and assist in targeted marketing. This work will help it identify the oat grain quality requirements for innovative oat products and this information will assist Australian oat breeders to set appropriate breeding targets.

As China is a major export market for Australian oats, to mitigate this market concentration risk, AEGIC technical experts will continue to deliver educational webinars on Australian oats and innovative oat products for South-East Asia and other potential markets. □

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Photo: AEGIC

Oat products: (clockwise from left) tuna rice, nasi goreng and whole oats.

Table 1: Comparison of cereal nutritional components.

Proximate nutritional composition (g per 100g)	Oatmeal	Wholegrain wheat	Brown rice	Pearled barley
Water	8.5	12.0	12.2	10.3
Carbohydrate	58.7	60.2	73.9	69.7
Protein	14.0	13.5	7.4	9.2
Fat	8.0	2.1	2.8	1.6
Beta-glucan (fibre)	4.4	0.8	0.1	4.2

Source: Welch, R. W. 2011. *Oats: chemistry and technology. Nutrient composition and nutritional quality of oats and comparisons with other cereals.* F.H. Webster and P.J. Wood, eds. AACC: St. Paul, MN, USA, 95–107

Oats benefit from joining InterGrain stable

When InterGrain successfully tendered for the Australian oat breeding program in 2020, it brought efficiencies of scale and the latest technologies to the endeavour

Photo: Dr Sue Knights

After decades of breeding oats for many Australian environments, Dr Pamela Zwer (left) has passed the baton to InterGrain's Dr Allan Rattey.

By Dr Sue Knights

Oat development in Australia has historically ridden on the coat-tails of wheat and barley, but the cereal has now been taken into the fold of established cereal breeder InterGrain.

The new venture is backed by a joint $5.4 million investment from GRDC and AgriFutures Australia over five years. InterGrain will continue to focus on oats for grain and hay, with an increased emphasis on the needs of developing health markets while harnessing new technologies to deliver improved genetic gain per dollar.

Dr Allan Rattey has taken the reins of the oat program within the InterGrain cereal breeding portfolio. InterGrain will build on the success and stability of the long-term, publicly funded breeding program led by the South Australian Research and Development Institute (SARDI) and capitalise on innovations for Australian growers' benefit.

"We have been very fortunate to have a seamless transition from the public national program for oats into the InterGrain stable," Dr Rattey says.

"The sharing of knowledge, together with germplasm, from the public program by Dr Pamela Zwer, Sue Hoppo and Peter McCormack from SARDI, with the formative oat development work by Dr Robyn McLean, Blakely Paynter and Georgie Troup with the WA Department of Primary Industries and Regional Development (DPIRD) has provided an excellent starting point for the InterGrain oat breeding program."

Dr Rattey has previously worked as a wheat breeder and pre-breeder and will be leveraging these years of experience together with InterGrain's resources for the oat program's advantage.

"At the same time as InterGrain ventured into oat improvement, the WA State Government established the $10.2 million Processed Oat Partnership to run for five years being led by DPIRD. Together these two initiatives stand to provide a significant leg-up for the Australian oat industry."

SCALE

Oat improvement is set to benefit from many aspects of being part of the InterGrain stable.

"Plant breeding combines many research skills, and the increased scale via testing more targeted genotypes across more environments possible at InterGrain will help drive our selection of improved varieties," Dr Rattey says.

"We've expanded the footprint of oat development for Australia by more than doubling the previous public program's number of plots and sites, taking more oat genotypes to more environments."

Each year InterGrain runs wheat, barley and oat trials at 63 sites across diverse Australian environments consisting of more than 300,000 plots. This scale helps efficiency of labour and equipment and enables the InterGrain oat program

to leverage off these greater resources in wheat and barley for a much larger oat program than previously possible.

"We are always looking for ways to improve the efficiency of our trial programs, such as using an automated seed packer that speeds up seed packing six to eight-fold."

NEW TECHNOLOGIES

InterGrain is at the forefront of developing and accessing new technologies that drive efficiencies in its wheat and barley improvement programs, and oats stand to benefit from these developments.

"We have a long-standing relationship with Agriculture Victoria research to develop genomic platforms to increase our genetic selection gains," Dr Rattey says.

"This technology has developed to the point that it costs less to genotype new lines and identify improved ones than it does in field testing. We are also using high-throughput phenomic systems that involve the use of drones mounted with various sensors to assess field-based traits such as biomass for hay and canopy temperature for variety characterisation.

"By interrogating images with appropriate, automated feature extraction algorithms, we can better match new varieties to environments using this technology and fast-forward oaten hay breeding."

InterGrain is also exploring the potential of proteomics to inform the selection of grain quality aspects to target growing health markets that will specifically inform oat quality improvement and new, healthier products.

COLLABORATION

To ensure access to new technologies and to develop further beneficial collaborations, InterGrain employs a dedicated research and business development manager, Dr Dini Ganesalingam. Her role is to develop research collaborations to enable maximum scientific impact of InterGrain's cereal breeding programs, and oat improvement will gain from these collaborations too.

These collaborative linkages access the latest research and technologies including new breeding technologies, genomic selection, biometrics, physiology and plant pathology – adding greater precision and efficiency to the oat breeding pipeline.

For example, collaborative links have been established with Professor Chengdao Li at Murdoch University, who is leading genetic research in decoding the oat genome for Australia as part of the international oat pan-genome effort (PanOat). The fully characterised oat pan-genome will provide significant breeding gains.

Knowledge about the adaptation of oats to the Australian environment is being informed by Dr Ben Trevaskis' (CSIRO) team, which will also identify better-adapted oat germplasm and genetic markers that underpin flowering time.

Significant oat disease knowledge and molecular tools will be provided for oat crown rust (*Puccinia coronata*) by collaborations with Professor Robert Park's team at the University of Sydney and Dr Melania Figueroa's team at CSIRO. For Septoria leaf blotch (*Septoria avenae*), there is a close collaboration with Dr Judith Atieno and Dr Tara Garrard at SARDI.

Further collaborations will be sourced by InterGrain to benefit oat improvement as the program progresses.

COMMERCIALISATION PIPELINE

"One key advantage that InterGrain can provide for oats is our proven commercialisation pathway," Dr Rattey says.

"With established irrigation facilities and the ability to fast-track the bulking-up of new varieties, together with state-of-the-art breeding tools, we can cut the breeding and commercial release time for a new variety to eight or nine years from 13 to 15 years."

Together with dedicated commercial staff covering regions and promoting InterGrain cereal varieties, this is a significant means to respond to growers' needs for new varieties. These staff can, in turn, report on new oat trait requirements of growers to the breeders.

Growers can access the latest independent performance data on oat varieties adapted to their environment via GRDC's National Variety Trials (NVT) program, with which InterGrain has a close working relationship.

"Working with NVT, we ensure that aspects of agronomy, such as sowing dates for oats, are relevant for growers in different regions," Dr Rattey says.

INNOVATION AND NEW PRODUCTS

"InterGrain is always seeking novel technology to release market-leading varieties that benefit the Australian grains industry. In partnership with Grains Innovation Australia and Nufarm, we've released to Australian growers the world-first imidazoline-tolerant varieties. These oaten hay varieties, Kingbale$^{\Phi}$ in 2021 and Archer$^{\Phi}$ in 2022, are suitable for IBS Sentry application to target more weeds in hay crops."

Photo: Dr Sue Knights

Dr Dini Ganesalingam is building key collaborative links for InterGrain's oat breeding program.

Dr Rattey says goodwill and a seamless transition from the public oat breeding program to InterGrain meant there was very little disruption to the oat release pipeline.

"Two new hay varieties – Wallaby$^{\Phi}$ and Kultarr$^{\Phi}$ – were released in 2022, with more than 60 tonnes of grain being distributed by InterGrain's marketing team in conjunction with AEXCO to targeted growers for demonstration trials and seed bulk-up by growers and seed sheds for increased 2023 planting. In addition, InterGrain is fast-tracking the release of a grain variety from material that was underway within the public program." □

GRDC Code IGP2103-OO1AWX

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grdc.com.au/news-and-media/audio/podcast/a-new-era-for-oat-breeding;
grdc.com.au/events/past-events/2022/february/grdc-grains-research-update,-perth?videoId=6300156939001

Mission to decode the oat genome

Development of an oat pan-genome heralds a new era for oat improvement for the Australian industry

By Dr Sue Knights

■ Market opportunities for Australian oats are growing as consumers learn about their health benefits. However, until recently, oats have not profited from yield and quality trait improvements that are being realised for barley and wheat through the application of new breeding technologies.

Oats have a complex evolutionary history and are thought to have been domesticated more than 3000 years ago while growing as a weed in wheat, emmer and barley fields in Anatolia, Turkey. Cultivated oat (*Avena sativa*) is a hexaploid species; it has three complete sets of chromosomes from different species. In this respect it is genetically more like wheat than barley, which is diploid (it only has one set of chromosomes).

COLLECTIVE EFFORT

The genetic variability of cultivated oats and its related species has only been explored to a limited extent. Lack of genomic information and tools could be a key limiting factor that has also hampered genetic gain of adapted oat varieties.

This is about to change with the activities of an International Oat Pan-Genome Consortium (PanOat), says Professor Chengdao Li from Murdoch University, who leads Australia's effort in PanOat.

PanOat involves scientific experts from around the world, many of whom have established reputations in decoding the genetic basis of wheat and barley. Australia has joined Canada, Germany, Finland, Denmark, Poland, Spain, Sweden, the UK and the US to develop this oat genomic resource. The PanOat initiative is being led by Dr Martin Mascher from the Leibniz Institute of Plant Genetics and Crop Plant Research in Germany.

Similar ventures have been undertaken for wheat and barley using an international consortium. Oats now stand to gain from the scientific knowledge generated in these initiatives through improved efficiencies and reduced cost of the technology.

GRDC investment in partnership with the Western Crop Genetics Alliance (joint venture between Murdoch University and the Department of Primary Industries and Regional Development, Western Australia), with some recent support from the WA Processed Oat Partnership, has secured Australia's early and ongoing involvement in PanOat and ensured inclusion of Australian oat varieties in the pan-genome initiative.

Photo: Evan Collis

With an impressive track record in developing genomic tools for barley improvement, Professor Chengdao Li now has his sights set on what can be achieved for oats.

"THE PAN-GENOME REPRESENTS THE ENTIRE SET OF GENES WITHIN A SPECIES, CONSISTING OF A CORE GENOME – CONTAINING SEQUENCES SHARED BETWEEN ALL INDIVIDUALS OF THE SPECIES – AND THE 'SPECIALISED' GENOME FOR ENVIRONMENTAL ADAPTATION."

– PROFESSOR CHENGDAO LI

"The pan-genome represents the entire set of genes within a species, consisting of a core genome – containing sequences shared between all individuals of the species – and the 'specialised' genome for environmental adaptation," Professor Li says.

"Assembling a pan-genome is a vital resource for plant breeders as it captures the extent of variation within a species beyond what traditional genotype sequencing can achieve. The 'specialised genome' in the pan-genome work is critical as this repertoire of genes can code for many agronomically important traits.

"The work will generate a blueprint of oat genetic diversity, which will enable breeders to accelerate the rate of genetic gain for the crop.

"Essentially, breeders will be able to go prospecting for new traits and introduce new genetic diversity in breeding programs using the pan-genome information.

"The goals of PanOat include characterising core gene sets and identifying lineage-specific genes of commercial varieties in each country.

"PanOat will also catalogue structural variation in wild and domesticated oats and accumulate comparative sequence information for use in agronomic and quality trait mapping."

Through the oat pan-genome project, an efficient and cost-effective framework will be developed that can be used to map new genome sequences, enabling new oat genomes to be assembled. This will mean that a researcher can generate useful genome sequences of specific accessions of interest for only a few thousand dollars.

Gene discovery, genome analysis and the development and application of genomics-based tools to support oat breeding will be dramatically enhanced through this resource.

EVOLUTIONARY INSIGHTS

"Ultimately, PanOat hopes to undertake evolutionary genomic analyses to understand the origin and evolution of oats," Professor Li says.

Wheat and barley have a long history of co-evolution with humans as they became crops, and growers progressively selected better-performing varieties. Oats' domestication rode on the coat-tails of these cereals as it initially was a weed among the cereals.

Professor Li says the ability to 'mine' the pan-genome for oats is a way to determine what has been gained or lost within the oat genome during the course of domestication of the species for agricultural purposes.

"We will be able to ascertain how much diversity may have been lost and identify genetic traits that could be useful to recombine into commercial varieties, such as flowering time, heat tolerance, disease resistance and even quality attributes such as beta-glucan.

"The PanOat initiative will provide fundamental genetic-based information to determine whether oats can be developed as a gluten-free food for people with coeliac disease."

The venture has sequenced 30 oat genomes from oat genetic resources across the world. PanOat has discovered that there are more genetic structural changes in the oat genomes than wheat, which has important implications for breeders when wanting to introgress new genes of interest. "These translocations also make oats agile in adapting to different environments."

PANOAT AND AUSTRALIAN OATS

As part of the international consortium, four oat genomes nominated by Australia will be sequenced and assembled that cover the diversity of Australian oat varieties.

The oat variety Bannister(ф) is representative of WA germplasm and is a long-time benchmark variety for its yield and adaptation, while Bilby(ф) is representative of South Australian germplasm and favoured for its grain quality.

A third line nominated by Australia is a Spanish variety, FM13, which contributes to international diversity. This line is adapted to Mediterranean conditions and is therefore of relevance to Australia.

Williams(ф) is the fourth variety nominated. It is a founder line of Australian oats and is favoured for its disease resistance profile.

Australian oat varieties have a very narrow genetic background, with most germplasm being drawn from cooler northern regions of Europe and North America. The Australian grains industry would benefit from expansion

Photo: Dr Sue Knights

Dr Pamela Zwer, retired national oat breeder, with her South Australian-bred Bilby(ф), a line favoured for its grain quality and nominated for sequencing in the PanOat genome mapping initiative.

of the pan-genome with a focus on increased knowledge of genetic variation from germplasm adapted to warmer Mediterranean-like environments, such as Spain. To address this, GRDC has recently embarked on expanding the oat pan-genome efforts towards inclusion of additional accessions from environments more similar to Australian growing conditions.

"Development of the pan-genome, with unique Australian oat genetics incorporated, will help accelerate and extend the outputs of other GRDC investments in oats. These include the InterGrain breeding program, optimising oat phenology for Australia and capturing novel sources of resistance to the main oat diseases – Septoria leaf blotch and oat crown rust," Professor Li says.

"Additionally, GRDC and WA's Processed Oat Partnership investment in PanOat will leverage current and future outputs from the recently established OzOats diversity panel developed by CSIRO with support by GRDC. This initiative will provide a bridge between phenotypic outputs and information of genetic variation provided via the pan-genome." □

GRDC Code UMU2003-002RTX

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Photo: Dr Sue Knights

The University of Adelaide's Dr Scott Boden is part of a multidisciplinary team unravelling the flowering behaviour of oats in Australian environments.

Oat life cycle optimisation

The basis of oats' seasonal flowering behaviour is being unpicked using emerging genetic tools to improve its adaptation to Australian environments

By Dr Ben Trevaskis, Dr Scott Boden and Dr Felicity Harris

■ Ensuring plant development is matched to optimum seasonal conditions is a key means to maximise crop performance. This is achieved through adjusting the timing of life cycle events of plants, known as phenology – a fundamental goal of cereal breeders.

As oats have a number of different end products – fodder, hay and grain – harvested at different times of the plant's life cycle, optimising the development pattern for different varieties is challenging (Figure 1).

Genes that underlie this variation have been identified in wheat and barley, including those that modify the extents to which vernalisation (prolonged winter cold) or long daylengths are required to trigger flowering. Plant breeders have been using this knowledge for centuries to select for improved adaptation; however, modern scientific developments are now making this process more precise.

For example, gene-based models are being developed to predict when specific varieties will flower at different sites or sowing dates, which can inform crop management decisions.

Although it is known that oat is a vernalisation-responsive long-day plant that flowers after winter as days lengthen in spring, less is known about genetic control of oat development. An improved knowledge of the genes that regulate oat phenology has potential to drive rapid gains in breeding and to contribute to production of new crop management tools.

To this end, GRDC has invested with a team led by CSIRO in a project aiming to understand the genetic variation that influences the phenology of oats in Australian and international breeding programs.

Bringing together multidisciplinary skills, the team has experience in crop data science (CSIRO), agronomy (NSW Department of Primary Industries and Charles Sturt University) and molecular

genetics (University of Adelaide). All members have worked extensively in aspects of wheat and barley phenology.

The team combines data-driven methods to understand crop biology, including the application of genomics and phenomics, together with the development of new analytical approaches and field and glasshouse observations to unravel plant adaptive responses. Of particular importance is resolving gene-environment interactions to understand and predict the flowering behaviour of oats at a range of locations.

STOCKTAKE

Starting in July 2020, the team began by compiling a pedigree database of Australian oats' breeding history by tracing the parentage of modern varieties. This pedigree database includes more than 1000 oats and extends back to the earliest modern varieties, circa 1892.

Using an overview of global breeding pedigrees, the team selected a panel of approximately 300 oat accessions to form a 'core population' for genetic analyses – the 'OzOat population'.

This population includes Australian varieties as well as diverse international oats. The accessions have been chosen to capture genetic diversity but also a high degree of gene shuffling (recombination), which enables genetic analyses.

The OzOat panel has been grown in controlled glasshouse experiments to record when different accessions flower under different daylengths and to provide pure seeds for further genetic analysis. Preliminary phenology data demonstrated that the population captures a wide range of diversity in oat flowering behaviour.

A subset of about 80 lines has now been grown in field conditions at Wagga Wagga (NSW) to validate observations of flowering behaviour made in controlled conditions. The trial was sown at two dates (7 May and 2 June 2021) and the timing of different developmental stages – such as panicle emergence, anthesis and plant maturity – were recorded, as well as some other traits, such as plant height, panicle architecture and yield components.

Data has confirmed that the OzOat panel captures a wide range of flowering behaviours and is more diverse than modern Australian oats. This provides a good starting point to breed new Australian oats with flowering behaviours suited to emerging farming-system needs, such as earlier sowing. This was further evaluated with another field season in 2022.

GENETIC INTERROGATION

Oats are a member of the *Avena* genus that is part of the same subfamily of grasses as wheat and barley. This close evolutionary relationship, combined with the similar flowering physiology of wheat, barley and oats, suggests there are good prospects to transfer knowledge from wheat and barley to oats. This could be the case for genes that code for both vernalisation and photoperiod responses.

To understand the genetic basis of plant development, in parallel to the phenology studies, the OzOat population has been genotyped using a genotyping-by-sequencing protocol optimised for oats. Essentially, this allows the team to read differences in the oat genetic code across the entire genome.

Using statistical methods and machine learning, the team will link variation in flowering behaviour that may be driven by vernalisation or photoperiod responses to specific changes in the genetic code. This knowledge could then be used by oat breeders to select lines that have desirable flowering behaviours using DNA diagnostic technologies (for example, molecular marker platforms) that will accelerate the plant breeding process.

YIELD COMPONENTS

Not only do phenology genes play a central role in adaptation, but also they are likely to influence developmental traits that underlie grain yield, as is the case for other temperate cereals. It is, therefore, a logical step with this adaptation work to start to dissect the genetic driver of yield components for oats.

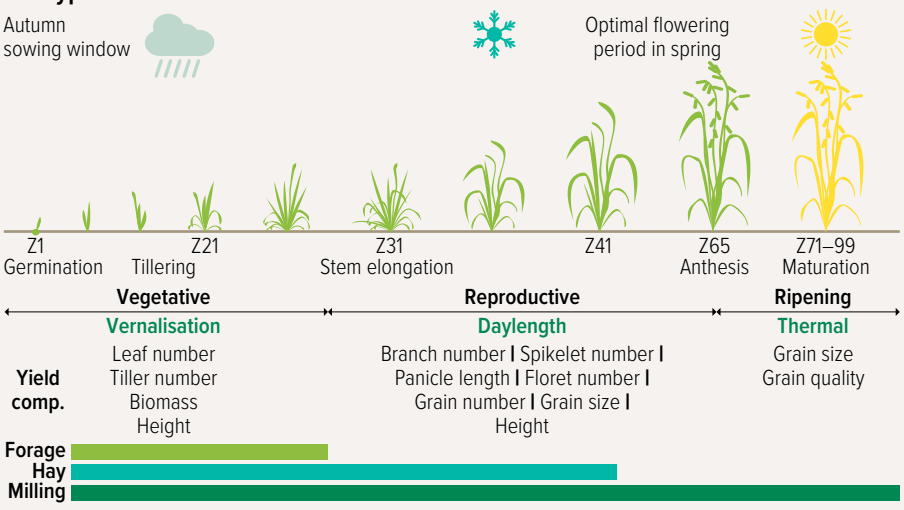
The grain-producing flowers of oats are arranged on an inflorescence known as a panicle. Spikelets develop on elongated branches that radiate from nodes on the main stem and on secondary branches. This contrasts with the compound inflorescences of wheat and barley, where spikelets are attached directly to the main inflorescence stem. Panicle length and the number of branch nodes produced on each panicle can vary, both with genotype and environment (Figure 1).

Historically, oat yield improvements have been slow in comparison with other crops, due partly to proportionally fewer investments owing to the volume of oats produced. However, once the genetic basis of the adaptive traits for oats are understood and this knowledge is combined with the latest genomic technologies, the team will be able to make large gains by manipulating oat development to increase the components of yield. □

GRDC Code CSP2007-002RTX

More information: Dr Ben Trevaskis, ben.trevaskis@csiro.au; frontiersin.org/articles/10.3389/fpls.2022.955623/full

Figure 1: Schematic representation of the oat life cycle, including phase durations (vegetative, reproductive and ripening) and their impact on yield in a typical Australian context.



Source: Modified from Trevaskis B et al. (2022) Advancing understanding of oat phenology for crop adaptation. *Front. Plant Sci.* 13:955623. doi: 10.3389/fpls.2022.955623

Three-pronged strategy to beat oat leaf blotch

Understanding the virulence of Septoria leaf blotch fungus is helping to better inform breeding for resistance in Australian oat varieties

By Dr Tara Garrard and Dr Judith Atieno

An infection of Septoria leaf blotch of oats can significantly decrease grain yield and downgrade oaten hay quality, particularly in high-rainfall zones.

The disease is caused by the fungus *Parastagonospora avenae* f. sp. *avenaria*. Commonly managed by rotations or stubble burning, foliar fungicides can also be applied for in-season control, but the most cost-effective way to manage the disease is the development of resistant oat varieties.

Since 2012, Australian oat breeding germplasm has been evaluated every year for reaction to Septoria inoculum at a nursery in Manjimup, Western Australia. Despite this sustained screening effort, only moderate resistance has been identified and current Australian oat varieties are predominantly susceptible.

In 2020, GRDC commenced a partnership with the South Australian Research and Development Institute (SARDI) using a three-pronged strategy to better understand the disease virulence and diversity of the fungus, to identify potential new sources of resistance in international germplasm sets and to develop molecular markers to fast-track breeding efforts.

This is the first research to look at improving Septoria leaf blotch resistance in oats by seeking to understand the genetic drivers of the pathogen's virulence and the host's resistance and involves combining skills in plant pathology and molecular genetics.

SARDI researchers collaborated with Dr Manisha Shankar, plant pathologist with Department of Primary Industries and Regional Development WA, to enable assessment of the Manjimup nursery during the 2020-21 COVID-19 border closures.

ASSESSING VIRULENCE OF THE PATHOGEN

Assessing the observable traits of a fungus is known as 'phenotypic pathotyping' and provides researchers with a method to gauge the variability of the pathogen and understand the fungus's ability to cause disease.

In this project, a total of 37 Septoria leaf blotch isolates were pathotyped from diseased oat leaves collected in 2020 and 2021 throughout WA and SA.

The pathotyping was conducted at SARDI on a differential set of 24 adult Australian oat varieties and breeding lines to capture virulence at the advanced crop growth stage. A high degree of diversity was observed in both the virulence and aggressiveness of the fungal isolates, likely due to active sexual reproduction of the Septoria leaf blotch pathogen in Australia.

The virulence and aggressiveness traits of isolates from the pathotyping dataset were used to select appropriate isolates for screening oat germplasm under controlled environment conditions for sources of resistance.

SOURCES OF RESISTANCE

The diversity in Septoria leaf blotch isolates complicates breeding for durable resistance in oats. To date, limited research has been undertaken to seek sources of resistance to Septoria leaf

Photo: Dr Judith Atieno, SARDI

Dr Judith Atieno (left) and Dr Tara Garrard inspecting the Septoria leaf blotch nursery at Manjimup, Western Australia.

blotch from international oat germplasm. This project addresses this gap by screening diverse US, Canadian and Scandinavian oat germplasm collections.

Using these diverse sources of germplasm, SARDI researchers undertook screening in controlled environment growth rooms with isolates selected from pathotyping. The lines were also screened in the field at the Manjimup nursery with naturally occurring isolates. Using a combination of screening methods ensured that the lines were exposed to multiple pathotypes and enabled comparison between response to SA and WA isolates.

Genetic variation for Septoria leaf blotch resistance in the international oat germplasm was observed in the field nursery, with 102 lines found to be more resistant than the moderately resistant check variety, Koorabup$^{\Phi}$. Australian oat varieties Tammar$^{\Phi}$, Tungoo$^{\Phi}$ and Glider also exhibited moderate levels of Septoria leaf blotch resistance.

DEVELOPMENT OF BREEDING TOOLS

Genotyping of 376 oat lines was conducted to detect small genetic differences that could influence the host disease reaction. Genotyping is the process of determining the genetic make-up (genotype) using DNA sequences. These DNA sequences are compared to identify unique (polymorphic) markers. In total around 29,000 polymorphic DNA-based markers were identified and mapped to the latest version of the oat reference genome.

Relatedness of the different lines was investigated using DNA marker analysis. The majority of Australian varieties and advanced lines were found to be closely related and were distinct from the global germplasm. This suggests that the international germplasm has the potential to provide new resistance genes that will support genetic gain in the breeding of Septoria leaf blotch-resistant oats for the Australian environment.

The use of many minor genes for resistance, commonly known as adult plant resistance, is expected to be necessary to create resistance in oats to Septoria leaf blotch that will be more durable for the Australian industry. The three-pronged approach undertaken by SARDI researchers will be the key to deliver multiple sources of resistance to Septoria leaf blotch to the breeding program.

FURTHER WORK

Further research will:

- obtain whole genome sequences of SARDI's collection of Septoria leaf blotch isolates to understand the factors driving the pathogen's virulence;
- develop and validate genetic markers for Septoria leaf blotch resistance in oats and provide these markers to oat breeders for selection of resistance; and
- incorporate resistance genes into Australian adapted oat varieties. □

GRDC Code UOA2007-001RTX

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THIS IS THE FIRST RESEARCH TO LOOK AT IMPROVING SEPTORIA LEAF BLOTCH IN OATS BY SEEKING TO UNDERSTAND THE GENETIC DRIVERS OF THE PATHOGEN'S VIRULENCE AND THE HOST'S RESISTANCE AND INVOLVES COMBINING SKILLS IN PLANT PATHOLOGY AND MOLECULAR GENETICS.

Photo: Dr Tara Garrard, SARDI

Septoria leaf blotch infection on oats.

Photo: Jamus Stonor, SARDI

Dr Judith Atieno (left), Mrs Entesar Abood and Dr Tara Garrard inspecting Septoria leaf blotch fungal cultures at the cereal pathology laboratory at SARDI.

Photo: Dr Sue Knights

GRDC ups ante in race to manage oat crown rust

Watched over by Professor Melania Figueroa's previous rust team from the US and new team in Australia, Eva Henningsen presented her paper 'A chromosome level genome reference for oat crown rust' at the 11th International Oat Conference in Perth.

By Dr Sue Knights

KEY POINTS

- Oat crown rust populations evolve rapidly, necessitating durable plant genetic resistance for sustained management
- New technologies, resources and collaborations are being applied to develop management solutions for oat crown rust

■ Plant genetic resistance is the key to managing diseases caused by fungal pathogens, but it is often an ongoing race between plant breeders and evolving pathogens. For oat crown rust, the race is a particularly challenging one and can be likened to a steeplechase – full of obstacles.

Oat crown rust, caused by *Puccinia coronata* f. sp. *avenae*, is a significant leaf disease of oats worldwide. It not only causes reductions in grain yield and quality, but also reduces the yield and quality of fodder and hay.

Although fungicides can be used to control the pathogen, there is a risk of the pathogen developing insensitivity to these chemicals, as well as additional management requirements, particularly for fodder and hay due to withholding periods. Control through varieties with durable genetic resistance is the most economical and environmentally friendly method.

GRDC has long-standing investments with the University of Sydney rust team, managed by Professor Robert Park. Park and his team have not only provided valuable industry support through their oat crown rust surveillance service, but also applied significant effort to identifying possible sources of genetic resistance towards developing crown rust-resistant oat cultivars.

However, oat crown rust is a very complex, variable and adaptable fungus that has been quite successful in breaking down many resistance sources in oat varieties. To improve our ability to combat oat crown rust and develop effective resistant oat varieties,

we need new innovative approaches.

In 2022, GRDC upped the ante against oat crown rust by enlisting new expertise and technologies to improve ways of achieving effective oat genetic resistance. This includes getting to know more about the fungus itself by decoding its genetic make-up.

KNOW THE FOE

Professor Melania Figueroa's work is at the forefront of understanding the molecular basis of plant-microbe interactions and developing durable resistance in crops. In 2018 her team at the University of Minnesota in the US published the first genome assembly – a sequence that reflects DNA content – for oat crown rust, which set a milestone in rust research and fungal biology.

In 2019 Professor Figueroa relocated to Australia to join CSIRO and worked towards positioning the team to battle oat crown rust, which is also a significant problem in Australia. Professor Figueroa's graduate masters student Eva Henningsen also relocated from the US and to date she continues her postgraduate studies at the Australian National University and CSIRO addressing the oat crown rust problem with an Australian view.

In 2022 Professor Figueroa's team released the complete DNA make-up of the entire chromosome set of the pathogen – with no gaps.

"Rusts are amazing organisms; their two nuclei can be genetically very different. We first noticed this for oat crown rust, and since it has been noticed in other rusts as well. This is partly why rusts evolve so quickly," Professor Figueroa says.

The high degree of fungal variability is likely also due to the existence of an ancillary host for the fungus – wild oats, which are an extensive fungal reservoir that enables a large number of mutations to occur.

The provision of a high-quality genome reference for the oat crown rust fungus is essential to thoroughly investigate the virulence evolution and diversity of the fungus in Australia and around the world.

With co-investment from CSIRO, Professor Figueroa successfully tendered for a GRDC investment call to provide genetic resources to the industry and control oat crown rust.

Photo: CSIRO

New technologies and resources are becoming available in the race to develop durable genetic resistance to oat crown rust.

OAT DEFENCE

Breeding for resistance to oat crown rust began in the 1950s and has been based mainly on all-stage resistance (ASR), often referred to as seeding or major gene resistance. Although providing complete immunity, ASR genes are generally short-lived and overcome by the rapidly evolving fungus in only a few years. Alternatively, adult plant resistance (APR), or minor gene resistance, does not confer complete immunity, but is often far more durable than ASR. Combining ASR and APR could create very efficient, long-lived, broad-spectrum resistance.

New technology is increasing the rate at which researchers can identify valuable ASR and APR genes, with efforts to be bolstered by the complete sequencing of 30 diverse oat genomes by the International Oat Pan-genome Project (PanOat).

NEW TECHNOLOGIES AND APPROACHES

At present the only way to profile rust pathotypes is greenhouse virulence tests using oat varieties or 'differentials' with different resistance genes and challenging them with rust samples sent in by growers. However, genomic tools are beginning to provide information on the pathogen that could lead to faster diagnostics and also inform genetic improvement of oats.

Professor Figueroa points out that "Genetic sequencing used to be expensive, but as the technologies have advanced these costs are reducing and it is time for oats to capitalise on these developments".

"On the pathogen side, we were able to take a data-intensive approach to genomic sequencing and develop an artificial intelligence model to help predict virulence of the pathogen on oats with a high accuracy for North America," says Professor Figueroa. Now her team is exploring the expansion of this model to help Australia.

"Implementation of next-generation sequencing and high-throughput pipelines also provide an opportunity to take a deeper look into the causes of disease at a molecular level. This work will help reduce and refine the number of differentials required for field surveillance of the pathogen."

In parallel, the CSIRO team is using novel sequencing platforms to genotype oats with sources of disease resistance and identify markers for key resistance genes with a focus on delivering durable genetic control for Australian conditions.

"We are looking for gene combinations that can help us manage the disease in the field and applying lessons we learned from other cereals like wheat."

Resistance genes, together with access to new genomic breeding technologies being implemented by InterGrain for oats, will remove obstacles and accelerate developing oat varieties more resistant to oat crown rust. Professor Figueroa encourages growers to inspect crops and nearby weeds for rust diseases, and if oat crown rust is suspected then send freshly collected samples in paper to: Melania Figueroa, CSIRO, GPO Box 1700, Canberra, ACT 2601. □

GRDC Code CSP2204-007RTX

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Could oats be used to manage Fusarium crown rot?

Photo: NSW DPI

The 2021 Goonumbla Fusarium crown rot trial where nine oat varieties were assessed.

By Peter Matthews

KEY POINTS

- In a year with above-average rainfall and mild temperatures during grain fill, oats showed reduced yield loss from Fusarium crown rot compared with wheat and barley
- This one-year study has shown little variation in Fusarium crown rot tolerance across nine oat varieties

Over the past decades, Fusarium crown rot (FCR) has become one of the most important diseases of cereal crops across Australia.

Predominantly caused by *Fusarium pseudograminearum* – although *F. culmorum* can also be important in higher-rainfall areas in the southern region – FCR is a stubble-borne disease.

Its prevalence has increased with the widespread adoption of stubble retention cropping practices and increasing cereal frequency in cropping systems. However, little is known about the role oats could play harbouring the fungal inoculum in cropping systems.

Through the Grains Agronomy and Pathology Partnership (GAPP) co-investment project, supported by the NSW Department of Primary Industries and GRDC, trials were undertaken to test whether oats have the potential to manage FCR in NSW cropping systems.

Three questions were addressed:

1. **Are oats more tolerant to FCR than wheat or barley?**
2. **Do oat varieties vary in tolerance?**
3. **Is persistence of stubble-borne inoculum following crop harvest shorter with oats, providing a paddock management benefit?**

Further research is required, but it appears that the findings of this preliminary one-year study indicate that oats could provide some benefit in reducing in-crop yield loss from FCR compared with other cereals. However, oats might not necessarily reduce paddock inoculum levels or, therefore, FCR risk within NSW farming systems.

ABOUT THE EXPERIMENTS

Trial sites were established at Goonumbla and Gilgandra in 2021. The experimental treatments covered cereal species comparison (oats versus wheat versus barley) with plus and minus FCR inoculation in split plots (two grams per metre of row in inoculated plots, a mixture of five *Fusarium pseudograminearum* isolates).

There were nine oat varieties differing in plant architecture and phenology (quick-slow season types), together with three wheat and three barley varieties matching phenology groups from quick through to slow (Table 1).

Table 1: Cereal varieties used in the experiments, listed from quick to slow season.

Oat varieties: Durack(D); Mitika(D); Kowari(D); Yallara(D); Bilby(D); Bannister(D); Williams(D); Koala(D); and Yarran (winter type)
Wheat varieties: Vixen(D); Sunmaster(D); and Beckom(D)
Barley varieties: La Trobe(D); Laperouse(D); and RGT Planet(D)

Source: NSW DPI

Photo: NSW DPI

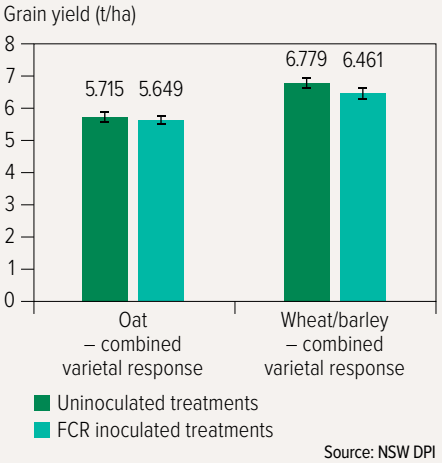
Williams$^{\phi}$ oat stubble showing the typical pink fungal growth in stems infected with Fusarium crown rot from the Goonumbla site in 2021.

The season was characterised by above-average rainfall and mild spring conditions, with Gilgandra recording rainfall based on long-term Bureau of Meteorology (BoM) records in the 95th percentile and Parkes (closest BoM weather station to the Goonumbla site) in the 85th percentile.

Through the critical flowering and grain-filling period of September, October and November, Gilgandra received 70, 3 and 370 per cent respectively above the long-term monthly rainfall averages, with Parkes 64, −28 and 201 per cent respectively. At both sites the trials were not moisture-stressed during this critical period, with good soil moisture reserves and timely in-crop rainfall.

With the good seasonal conditions, above-average yields were achieved at both sites, with an average site yield at Goonumbla of 6.08 tonnes per hectare and at Gilgandra 6.06t/ha. These good seasonal conditions severely restricted FCR expression and, therefore, the ability to draw robust conclusions from a single year of experimentation.

Figure 1: Grain yield of oats compared to grouped wheat/barley varieties (l.s.d. (P<0.05)–0.1513) at Gilgandra in 2021.



Source: NSW DPI

Stubble-borne inoculum levels at harvest and following a summer fallow period between oats, wheat and barley plants showed little difference at either the Goonumbla or Gilgandra sites when inoculated at sowing with FCR. However, there were differences for tolerance to FCR of oats versus wheat and barley at the Gilgandra site, with FCR reducing grain yield of the wheat/barley inoculated treatments by 4.7 per cent (Figure 1). This provides some evidence that oats could have improved tolerance (that is, reduced grain yield loss) to FCR compared with bread wheat and barley.

FCR did not significantly affect grain quality, with only minor variety effects seen for seed size at Goonumbla and screening levels at Gilgandra. This is expected given the good rainfall at the end of the season, which limited the usual negative effect of FCR infection on water flow through the plant stems.

OAT FCR VARIETAL DIFFERENCES

Of the nine oat varieties tested in 2021, no differences were seen between varieties for plant infection at the two sites. This will limit a grower's ability to select an oat variety with improved tolerance to FCR, as they can when choosing bread wheats and barley varieties.

There could be an opportunity for early generation screening for FCR in the national oat breeding program, or screening overseas germplasm for FCR tolerance, as the disease becomes a bigger issue in southern farming systems with the continued adoption of conservation cropping practices.

FURTHER RESEARCH

Research in a low-to-average rainfall season that favours FCR expression is needed to confirm the difference between yield loss in wheat and barley compared with oats, as indicated in this single-year study with above-average rainfall. If improved tolerance to FCR infection in oats (reduced yield loss) can be confirmed, it could offer growers a crop choice for paddocks where FCR levels are above risk levels for wheat or barley, providing another lower-risk cash crop in their rotation.

However, growers would need to be aware that while the production of oats in this situation might increase profitability in that individual season, it appears to increase or maintain stubble-borne FCR inoculum loads for subsequent winter cereal crops within the farming system. □

GRDC Code DPI2108-015BLX

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How do dual-purpose oats fit in the HRZ?

By Dr Natalie Moore, Rick Graham and Fiona Scott

Photo: Peter Formann, NSW DPI

Dual-purpose winter crop experiments are determining the fit of these species in high-rainfall environments. This site at NSW DPI Tamworth in 2020 included grazed and ungrazed treatment combinations of five crop types, with 26 varieties sown at three dates. Photo taken 2 September 2020.

Oats were part of a suite of dual-purpose cereal varieties investigated for their fit in the non-traditional, high-rainfall grain region of north-eastern New South Wales.

Included in the NSW Department of Primary Industries and GRDC Grains Agronomy and Pathology Partnership investment operating from 2019 to 2022, trials evaluated oats, wheat, barley, triticale and canola varieties for their potential to produce grain following grazing. The species were evaluated at Tamworth and Glenn Innes, with an additional site for canola at Tamworth.

Based on 2020–22 pricing, gross margin analysis showed that for many of the grain/graze and hay treatment combinations, baling the crop for hay at growth stage 65 (GS65) was more profitable than taking the crop through to grain harvest. However, these seasons were wetter than average at the trial locations.

For oats, the greatest flexibility for grain recovery after grazing at GS30 at both trial sites was demonstrated by the varieties Eurabbie, Mannus(ϕ) and Nile.

DUAL-PURPOSE OAT PERFORMANCE

Treatments at both locations were sown at three times, ranging from 13 March to 30 April at Tamworth and 5 March to 18 May at Glen Innes in 2020 and 2021.

Simulated grazing was applied at growth stage 30 (GS30). Shoot biomass, feed value, maturity, grain yield and quality data were analysed to identify the best-performing and most-profitable treatment combinations in 2020 and 2021. Feed values of all treatments were high, suiting most ruminant diets.

Yield performances of the five highest-yielding ungrazed and grazed oat varieties are shown in tables 1 and 2 for the two locations. Varieties Mannus(ϕ), Yiddah and Eurabbie were higher in grain production after grazing at GS30 and comparable or higher in production of dry matter at GS30, suggesting that they could be considered as higher-yielding alternatives to the long-term industry standard Nile in both environments.

For grain-only production, the oat variety SF Dynasty(ϕ) produced some of the highest grain yields in the ungrazed treatments at both sites and was also the fastest-maturing variety. However, it did not recover well after grazing. Due to wet conditions at harvest in both seasons, oat grain quality was lower than expected.

At the Glen Innes site in 2021, varieties Nile and SF Dynasty(ϕ) showed the least storm damage and highest retention of grain compared with the other oat varieties in the experiment and were the only two varieties that were harvested for grain.

For several treatment combinations, grazing at GS30 improved grain recovery compared with the ungrazed treatment, including Eurabbie oats. This is likely due to the positive effect of grazing in reducing lodging, particularly in wet or high-growth-potential seasons.

A critical decision point for growers is at GS65, where the crop can be grazed again or 'locked up' for grain recovery.

Experiment data for both seasons and sites were used for economic analysis conducted by Fiona Scott and Dr Kanchan Joshi from the NSW DPI Agricultural Economics and Biometrics unit.

Gross margins per hectare were generated for all species and treatments and should be interpreted in the context of the relative grain, hay and livestock prices used at the time of calculation, which were oats, triticale, feed wheat and feed barley $242/tonne, canola $601/t, with a 1.5 per cent price discount for each percentage point below 42 per cent oil.

On-farm wheat prices used included $277/t for Prime Hard/H1, $266/t for Australian Hard/H2, $262/t for ASW and $258/t for APW. Cereal hay was priced at $230/t and canola hay at $210/t.

Cattle (for grazing cereals) prices were sourced from the Meat & Livestock Australia Eastern States National Livestock Reporting Service historic data for 2020 and 2021. Cattle were assumed to be purchased at 300 kilograms/head liveweight at $4.29/kg. Sale prices used were $4.67/kg liveweight for 330 to 400kg/head, $4.01 for 400 to 500kg/head and $3.99 for 500 to 600kg/head.

Lambs were assumed to be used for grazing canola and a low-risk grazing operation was assumed, since the canola planting occurred relatively late in the season, limiting the time available for grazing. It was assumed that larger, high-quality lambs would be purchased and grazed for additional weight gain.

An example of the comparative gross margins for Tamworth shows that the top

Table 1: Grain yield (t/ha) and sowing date (SD) of the five highest-yielding ungrazed oat treatment combinations at the Tamworth and Glen Innes sites for two seasons (varieties that produced the same yield from the same sowing date are grouped).

Tamworth						Glen Innes					
2020			2021			2020			2021[1]		
Variety	Yield	SD	Variety	Yield	SD	Variety	Yield	SD	Variety	Yield	SD
Eurabbie	4.11	23/4	Eurabbie	6.29	30/4	SF Dynasty(Φ)	2.25	24/4	SF Dynasty(Φ), Mannus(Φ) and Yiddah	2.96	21/4
Eurabbie	3.61	2/4	Eurabbie	5.51	8/4	Eurabbie	1.54	24/4			
Eurabbie	2.92	13/3	SF Dynasty(Φ)	5.12	30/4	Bimbil	1.38	24/4	Nile, Eurabbie and Bimbil	2.35	21/4
Mannus(Φ)	2.78	23/4	Nile	4.32	30/4	Eurabbie	1.28	24/3			
SF Dynasty(Φ)	2.56	13/3	Mannus(Φ)	4.27	30/4	Nile	1.25	24/4	SF Dynasty(Φ), Mannus(Φ) and Yiddah	2.22	18/5

[1] Due to weather/bird damage in 2021, only the varieties Nile and SF Dynasty(Φ) were taken to grain harvest at Glen Innes.

Source: NSW DPI

Table 2: Grain yield (t/ha) and sowing date (SD) of the five highest-yielding grazed oat treatment combinations at the Tamworth and Glen Innes sites for two seasons (varieties that produced the same yield from the same sowing date are grouped).

Tamworth						Glen Innes					
2020			2021			2020			2021[1]		
Variety	Yield	SD	Variety	Yield	SD	Variety	Yield	SD	Variety	Yield	SD
Eurabbie	4.25	2/4	Eurabbie	5.31	8/4	Nile	2.87	24/4	SF Dynasty(Φ), Mannus(Φ) and Yiddah	2.66	21/4
Eurabbie	3.86	23/4	Eurabbie	4.41	21/3	Eurabbie	2.85	24/4			
Mannus(Φ)	3.82	2/4	SF Dynasty(Φ)	4.35	30/4	SF Dynasty(Φ)	2.58	24/4	Nile, Eurabbie and Bimbil	2.52	21/4
Yiddah	3.51	2/4	Eurabbie	4.20	30/4	Eurabbie	2.02	8/4			
Nile	3.36	2/4	Mannus(Φ)	4.10	30/4	Bimbil	1.66	24/4	SF Dynasty(Φ), Mannus(Φ) and Yiddah	2.13	18/5

[1] Due to weather/bird damage in 2021, only the varieties Nile and SF Dynasty(Φ) were taken to grain harvest at Glen Innes.

Source: NSW DPI

Table 3: Top five most-profitable gross margins per hectare for Tamworth, 2020 and 2021.

Tamworth 2020 Wheat	13/3 Grazing + hay GM/ha	2/4 Grazing + grain GM/ha	2/4 Grazing + hay GM/ha
Einstein			$2879
RGT Accroc	$3046		
RGT Calabro	$2731	$2768	$2762
Tamworth 2021 Oats	**21/3 Grazing + hay GM/ha**	**8/4 Grazing + grain GM/ha**	**8/4 Grazing + hay GM/ha**
SF Dynasty(Φ)		$2500	$2504
Eurabbie	$2420	$2696	
Nile			$2409

Source: NSW DPI

five most-profitable options were grazing and grain or hay options for all wheat in 2020 and all oats in 2021 (Table 3). The first times of sowing for grazing and hay and second times of sowing for both grazing and grain and grazing and hay were most profitable for both years.

For maximum grain-only production from the dual-purpose varieties in both environments, highest grain production was achieved at later sowing dates. However, this might not suit growers who need early grazing opportunities as biomass production generally declined as sowing dates got later. A balance must be struck in choice of variety and sowing date.

It is therefore recommended – where practical – to stagger or split sowing dates to spread the risk of damage from adverse weather and to increase opportunities for both grazing at GS30 and grain (or hay) recovery depending on seasonal conditions and prices.

Encouraging growers to adopt these system changes to increase grain production will require ongoing agronomic support, particularly in the higher-rainfall regions of north-eastern NSW and where livestock grazing systems dominate. □

GRDC Code DPI2003-016BLX

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Sowing windows reviewed for NVT oat trials

Photo: Dr Sue Knights

NVT manager (west) Isabelle Rogers manages the largest geographic area for GRDC's National Variety Trials, which includes 30 oat sites.

Grower and industry relevance of performance data is ensured by GRDC's National Variety Trials program seeking input into its processes

By Dr Sue Knights

■ To help growers select new superior grain varieties for their environment, GRDC established the National Variety Trials (NVT) in 2005 – providing a one-stop shop for accurate, consistent, independent and timely information on variety performance.

NVT manager (west) Isabelle Rogers has the largest area to manage – in Western Australia – which includes a number of oat trial sites.

"GRDC's NVT program is the largest independent, coordinated trial program in the world, with a primary purpose to provide growers with independent performance rankings on varieties suitable for their region. It also benefits breeders by providing detailed comparative data on commercial and advance breeder cultivars from breeding programs operating in Australia," Mrs Rogers says.

"The NVT covers 10 grain species and each year we manage more than 650 trial sites over 300 locations across Australia. In 2022 this included 30 oat trials. Commercially relevant milling and dual-purpose varieties are included, as well as the most-advanced lines from plant breeding programs and seed companies."

All sites are overseen by GRDC NVT staff and managed by regional service providers according to established protocols, which ensure consistency across sowing, harvest and trial management. Data collected from trials undergoes rigorous statistical analysis and quality assurance tests before publication.

Thirty NVT trial locations for oats in 2022 were spread across Australia on a range of soil types and in different rainfall zones. These locations are regularly reviewed in a process that involves extensive consultation with stakeholder groups including NVT advisory committees (NACs), GRDC regional grower panellists, NVT participating breeders, NVT service providers, statisticians, industry experts and market production intelligence. A similar process is followed for most facets of NVT, including deciding on sowing windows for the trials.

Sowing windows are set to represent standard local practice and trial managers generally aim to sow at the same time as the grower for the paddock used or within days to avoid complications of emerging crops and subsequent chemical drift issues.

"Grower practice is always evolving, so we aim to reflect that in our trials and are constantly reviewing decisions like sowing times," Mrs Rogers says.

"We look for changes to growers' practice that occur consistently and that will be present long term. As a result, our main season trials are now sown considerably earlier than they would have been 15 years ago."

For oats, NVT worked closely with InterGrain's oat breeder to understand agronomic preferences, especially around germination windows, which were subsequently adjusted forward by another one to two weeks (region specific) for 2022 following ratification by the NACs and other industry participants.

InterGrain oat breeder Dr Allan Rattey says the germination windows are the agreed time period that NVT should be sown within, and act as the guide in determining which germplasm is suitable in which trials. This means that sowing dates for NVT have adjusted to better reflect grower practice across the country. □

More information: Isabelle Rogers, 0427 419 509, isabelle.rogers@grdc.com.au

RESOURCES

To inform milling and dual-purpose oat variety selection, the following resources are available from the NVT website (nvt.grdc.com.au):

- **Harvest Reports;**
- **trial results;**
- **Long Term Yield Reporter;**
- **Sowing Guides; and**
- **disease ratings.**

Information on hay and forage oat varieties can be obtained from the relevant state Sowing Guides on the GRDC website and on the NVT website.

Collaborations key for oat weed management tools

By Dr Sue Knights

■ Oat production in Australia has been constrained partly due to the lack of weed management tools. This is because oats have been considered a minor crop by many of the chemical registrants due to the relatively small area of production, making the registration of crop protection chemicals for pest, disease and weed control more challenging.

However, through several industry collaborations, this is changing and began with the registration of Nufarm TriflurX®, a Group 3 mode of action pre-emergent herbicide for use with oats, in early 2022.

"Grass weed control and lack of chemical options in oat crops compared to the other major cereals have been significant and ongoing issues for oat growers," says GRDC manager for chemical regulation Gordon Cumming.

The registration of Nufarm TriflurX® was achieved through the collaborative efforts of GRDC, the Western Australian Department of Primary Industries and Regional Development, ConsultAg and the Grain Industry Association of WA.

THREE YEARS OF COLLABORATION

"The registration of Nufarm TriflurX® for oats followed three years of cross-agency collaborative work that covered field trials involving both crop safety and residue studies to generate the required data for the Australian Pesticides and Veterinary Medicines Authority (APVMA) registration submission," Mr Cumming says.

AgriFutures Australia, supported by AGVET Access Grant Program funding through the federal Department of Agriculture, Fisheries and Forestry, undertook the crop safety studies for oaten hay production, while GRDC invested in the required grain residue studies that included hay and forage samples.

Field trials and data generation are only one part of the process. The label is owned by the chemical registrant, and they are required to prepare and make the submission to the APVMA. Nufarm provided the regulatory expertise to compile the submission based on its TriflurX® label, which is now the only product to carry this registration for oats.

GRDC is now starting the process with another pre-emergent herbicide for oat growers, prosulfocarb, a Group 15 herbicide.

"Annual ryegrass is a particular target for this different mode of action herbicide. Its proven ability to develop resistance to herbicides means we must continually change up the means with which we control this weed species. We need additional tools in the toolbox for oats," Mr Cumming says.

"Generating the required data to support the registration of prosulfocarb for oats will take a similar time to the TriflurX® registration and, if successful, is likely to be available for growers in 2025."

HERBICIDE-TOLERANT OATS

Oats have a reputation for vigorous early growth that can suppress weeds and also a long history in being used to clean up problem weeds by making hay. But as farming systems change, new tools are required.

The development of imidazoline-tolerant crop varieties has provided significant farming systems advantages – both by the application of imidazoline herbicides to control a broad spectrum of grass and broadleaf weeds, including weeds that are closely related to the crop itself, and the use of imidazoline-tolerant crops where there may be imidazoline soil residue concerns from previous crops.

Oats have now been equipped with imidazoline tolerance with the registration of the world's first tolerant oat, Kingbale(ϕ), in early 2021. It was the culmination of three years of research and development between Australian companies Nufarm, InterGrain and Grains Innovation Australia (GIA). The plant breeding work was undertaken by Dr Michael Materne from GIA.

Together with GIA and Nufarm, InterGrain released a second imidazoline-tolerant oaten hay variety, Archer(ϕ), in August 2022. Nufarm Sentry® herbicide is registered for pre-planting incorporation by seeding for hay and seed production in Kingbale(ϕ) and Archer(ϕ). □

GRDC Codes EAS2205-005SAX, EAS2205-006SAX

More information: Gordon Cumming, gordon.cumming@grdc.com.au

Photo: GRDC

GRDC manager for chemical regulation Gordon Cumming has been overseeing registrations of new herbicides for use in oats in collaboration with other agencies.

Australia reaps rewards as international oat conference host

International conferences held in Australia provide ready access to valuable knowledge and consolidate collaborations

By Dr Sue Knights

With a theme of 'health', the 11th International Oat Conference (OAT2022) was finally convened in Perth in early October 2022, after a two-year delay caused by COVID-19.

Ashley Wiese, a member of the conference organising committee and a Western Australian oat grower, said international conferences provided unique opportunities to share knowledge among industry experts.

On reflection, Mr Wiese said, the two-year delay was a huge benefit for the global oat community and Australia. "The delay meant that scientists had made further progress in their areas of research for oats to share with the global community, and also gave Australia's new national oat breeding venture at InterGrain time to get established," he said.

"The conference was a valuable opportunity for Australia to boost its oat reputation on a global scale and it increased our chances of establishing and consolidating valuable partnerships."

OAT2022 drew experts from across the oat value chain, including from Europe, the US, the UK, Asia and even Iceland. Being hosted in Australia enabled more than 160 Australian delegates to attend.

Mr Wiese was encouraged to see the amount of oat research occurring around the world and to connect with the tight and collaborative global oat research network.

ADDRESSING CHALLENGES

OAT2022 covered an extensive range of oat-related topics – from health trends in oats, global markets, quality, products and innovation to genomics, bioinformatics, breeding, agronomy, crop protection and stress tolerance.

"My takeaway from the conference was that the forecast growth of oat trade is strong, driven greatly by oat milk and the snack food market. But the incentives globally for a grower to produce oats are challenging when compared to a grower's other options," Mr Wiese said.

"Oats are a small crop globally and have lacked research funding compared to other cereal crops. They also have an outdated pricing model based around their historical use as a feed grain rather than a health food.

"The boost in investment by GRDC and AgriFutures in the National Oat Breeding program investment with InterGrain has never been so important. We need to produce new varieties that are profitable for growers while bringing all the health benefits that our markets are demanding."

GRDC was a gold sponsor of the conference, together with platinum sponsors Uncle Tobys, Quaker Oats, CBH Group, Unigrain, Blue Lake Milling, Morning Foods, Seamild and others.

To maximise inclusion of the international oat community, the OAT2022 organiser, Grain Industry Association of Western Australia, ran the conference as a hybrid event, offering both in-person and virtual presenter opportunities and attendance.

A pre-conference tour visited a dedicated field trial at York to inspect locally adapted oat lines. Supported by the WA Department of Primary Industries and Regional Development, the site contained trials that compared their performance to international germplasm and historical oat lines together with agronomy and physiology experiments. Additionally, attendees also had the opportunity to visit local oaten hay exporter Gilmac.

Capitalising on the pool of oat experts being brought together, four post-conference workshops were convened. These focused on oat quality, functionality and innovation, oat breeding technologies, oat crown rust and an international oat rust workers' meeting. The workshops were an opportunity for OAT2022 attendees to share ideas, generate new collaborative opportunities and advance key research fields. ☐

Alannah MacTiernan, Minister for Regional Development, Agriculture and Food and the Hydrogen Industry in Western Australia, opens the 11th International Oat Conference in Perth.

Photo: David Broadway

GRDC Code GIA1910-001AWX 9177693

More information: OAT2022 Conference proceedings are available to attendees via the Event App. For further information on the conference, visit internationaloat.com or visit the GIWA Facebook page for photos of the event.

'Global oat development gains momentum', *GroundCover*™ January-February #162, page 14

‘Dad’s oats’ – a value-added business driven by ideals

Over 160 years, the Cain family has tapped into consumer values, transitioning from fuelling hungry gold miners with oats to online marketing directly to health-conscious oat connoisseurs

By Dr Sue Knights

Photo: Andy Rogers, Weekly Times

The fourth and fifth generations of the Cain farming dynasty (from left) Ruth, Matt, Alicia, Maurice and Pete continue the family tradition of growing oats for progressively more sophisticated markets.

With a unique heritage and skill set, the Cain family has established a value-added oats business targeted to modern needs.

Five generations of the Cain family have produced crops on their 800-hectare property situated in the 500-millimetre rainfall region of Natte Yallock in the foothills of the Victorian Pyrenees, about 100 kilometres north-west of Ballarat.

“Our forefathers first planted onions, wheat and oats in 1861, dug by spade and planted by hand to feed the growing goldfields population,” says Peter Cain, who – together with his sister Alicia, brother Matt, and their parents and partners – are involved in the business.

Their value-added business is called Dad’s Oats.

“It is a tribute to family farming, to our dad and mum – Maurice and Ruth – and to the generations who have tirelessly worked the land before us,” Alicia says.

APPLYING A UNIQUE SKILL SET

The Cain siblings are an entrepreneurial and educated team, having all studied at the University of Melbourne. Matt studied agricultural science and has been a practising agronomist for more than 16 years. He now runs the farming operations with his wife Kate, including growing the oats used for Dad’s Oats.

Pete studied commerce and agricultural science and has worked in private equity, technology companies and now runs a few businesses – including Farmtell, which provides weather, water and security products to the agricultural industry – and a small farm near Ballarat.

Alicia studied commerce and property and construction and is a qualified commercial property valuer.

“My brother Pete and I started Dad’s Oats as a part-time business around seven years ago. Dad had been growing high-quality oats for many years and, with Matt now taking the helm, we were excited about the opportunity to work together to build a business connected to the farm that had potential for growth and was fun,” Alicia says.

“The oats had always been sold as a bulk commodity, and yet we knew they were good quality and felt that if we could take a small batch direct to the customer, these quality traits would be appreciated and we could get better returns. I love having a product to market that I know is high-quality, locally grown and healthy, as these are all really important values to me.”

KNOW YOUR MARKET

Alicia and Pete gauged the market signals directly by attending farmers’ markets in Melbourne with their Dad’s Oats products.

“This was an excellent way to have one-on-one interactions with our customers and gather feedback on what they thought of the product, the common questions they had and what they were looking for. On the back of this, we launched our Steel-Cut Oats, given so many people were requesting them,” Alicia says.

“From the markets as a starting point, we then expanded through a number of small gourmet and speciality produce stores and now also sell through our online store.”

Dad’s Oats’ customer mix is predominantly health-conscious people who value high-quality products with known provenance.

“Many of our customers like to consider themselves as oat connoisseurs and they appreciate Dad’s Oats’ taste and texture compared to general supermarket oats. Our subscription product has been quite successful as people love the convenience of having the oats delivered regularly to their door.”

To meet the needs of growing numbers of health-conscious consumers, the Cains now grow Kowari(t) oats, which have high beta-glucan levels proven to reduce cholesterol levels, as well as demonstrated robust agronomic performance. □

More information: dadsoats.com

Useful NVT tools

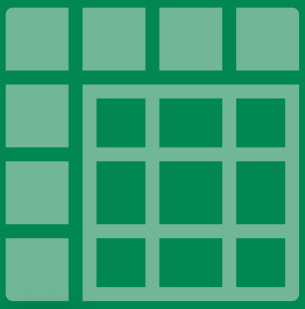
GRDC NATIONAL VARIETY TRIALS™

Visit the NVT website @ nvt.grdc.com.au

- Harvest Reports
- Sowing Guides

Trial results

Long Term Yield Reporter



NVT Disease Ratings

To receive email notifications the moment results for your local NVT trials are available, sign up to the NVT Trial Notification Service

SCAN QR CODE

To receive the latest NVT publications (Harvest Reports and Sowing Guides), subscribe to NVT communications

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