CROP SCIENCE SOCIETY
OF SA INCORPORATED

C/- Waite Campus
PMB No 1, Glen Osmond, South Australia 5064
ABN 68 746 893 290

NEWSLETTER

Welcome to the March issue of the Crop Science Society of SA newsletter

In this month's newsletter we explore:

- SARDI research for the South Australian Grain Industry
- Growing safflower – Factsheet
- The Leaf Protein Co. presentation at CSSSA's February meeting by Rob Blum & Fern Ho.
- Novel agronomy strategies for reducing the yield decline from delayed emergence

We hope you are keeping well. Please contact us if you have any requests for content or information.

Many thanks
Craig Davis
President, Crop Science Society of South Australia

SARDI research for the South Australian Grain Industry

Summary of talk given to CSS by Peter Appleford, Executive Director SARDI

The South Australian State Government has developed to Growth State Initiative. Growth State aims to achieve an average 3% per annum increase in Gross State Product. As a key economic generator food, wine and agribusiness has been identified as one of the nine key growth sectors over the next 10 years. The Food, Wine and Agribusiness Sector Plan, developed under the Growth State is aimed at reaching revenue of $23 billion by 2030 to the South Australian economy.

The priority areas for growth under the Food, Wine and Agribusiness Sector Plan are:

- Productivity
    - local processing capacity
    - AgTech adoption
    - Research and Development
    - Add value through the supply chain
- People/skills
    - Improve business capacity and capability
    - Support workforce growth
    - Promote career opportunities
- Infrastructure
    - Improve digital connectivity
    - Strengthen supply chain and transport networks
    - Improve regional infrastructure
- Market
    - Develop markets opportunities/new products
    - Improve market access through biosecurity, integrity, traceability and food safety
    - Promote state products
- Sustainability
    - Increase access to natural resources
    - Encourage reuse/recycling
    - Manage biosecurity threats and pest animals
    - Minimise impacts and costs of production and processing techniques
- Operating environment
    - Collaboration and co-investment
    - Smarter regulation
    - Minimise business costs and administrative burdens

There is strong alignment between the Food, Wine and Agribusiness Sector Plan and the pillars of the SA Grain Industry Blueprint:

- Market opportunities
- Capturing value
- Biosecurity and market access
- Innovation
- Building industry capacity and skills
- Infrastructure.

The South Australian Research and Development Institute (SARDI) as the government primary industries research and development RD&E provider then determines how they can best support a 3% per annum increase in Gross State Product – aligning activity with the sector plan and the blueprint.

SARDI has research sites across South Australia and the ones most relevant to crop sciences are located at:

- Waite (Plant Research Centre - Crops, Biosecurity)
- Roseworthy (Livestock and Farming Systems)
- Struan, Kybybolite, and Turretfield Research Centres (Livestock, Pastures and Crops)
- Minnipa Agricultural Centre (Field Crops, Low Rainfall Farming Systems)
- Port Lincoln (Aquatics, Field Crops and Farming Systems)
- Clare Regional Centre (Pulses, Field Crops and Farming Systems)

Across these sties SARDI holds high level broad acre crop sciences expertise in

- Agronomy - cereals, pulses, soil science, climate risk analysis, crop physiology
- Crop Improvement - molecular genetics, value-added oats and pulses, vetch breeding
- Plant Health/Biosecurity - diagnostic services (inc. PredictaB), insect pest management, disease management, nitrogen fixation

Performing key activities in:

- Developing and supporting management strategies to:
    - increase productivity
    - increase resilience-drought, heat and frost, soil constraints
    - manage risk -climate risk, pest and disease risk
- Identifying novel genetics, tools and methodology to increase genetic gain and yield
- Identifying new plant traits and agronomic practices which provide increased protein levels
- Developing & delivering diagnostic tests for pests and pathogens to growers and researchers
- Undertaking pest and disease surveillance to monitor new and existing pests and pathogens
- Evaluating new technologies to improve efficiency (sensing, data tools)

SARDI is presently working towards delivering or establishing a number of new initiatives, including:

Oat Centre of Excellence – delivering RD&E in genetics and physiology, agronomy and breeding, nutritional sciences and processing technologies/product development to provide added value through the supply chain for the oat sector.

Pulse Proteins – investigating use of dry-fractionation of pulse grain to provide protein-rich products for food and feed. This will be linked to providing management options for growers to enable delivery of pulse grain to the required specifications for pulse protein markets. It is aimed to develop new opportunities for food and feed manufacturers to utilise high-protein ingredients for new product development and value adding to existing products.

Plant Based Foods - Expanding the Waite to include capability in plant-based food R&D infrastructure to support plant ingredient development. SARDI will work with the ingredient manufacturing industry to develop viable plant-based food ingredients through advanced and specific processing technologies and market assessment. It will also work with food manufacturing industry to develop prototype plant-based food products such as healthy low fat/allergy alternatives, high fibre food products, ready to eat products, food service products, children's snack products and longer shelf life products for export.

SA Drought Resilience & Adoption Hub – establishing a network for primary producers, researchers, funding partners, farming systems groups, agribusinesses, government agencies, landscape boards & industry representative groups to work together to enhance adoption of drought resilient practices

AG Tech Demonstration Sites – this project aims to develop a two-way marketplace for technology developers and industry to enhance the adoption of AgTech in South Australia by demonstrating and validating AgTech linked to farming decisions and operational activities, and supporting enhanced interactions between start-ups and farmers. It also aims to identify key farm decisions and processes that can be supported by AgTech and demonstrate available AgTech products to increase the productivity and profitability using world's best practice technologies and management, document and communicate the improvements in physical and financial performance, and demonstrate the use and value of new products and management options in a farm system.

SARDI

SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

Government of South Australia
Department of Primary Industries and Regions

Growing safflower - Factsheet

Following significant enquiry on the agronomy of safflower production after our February presentation with David Hudson of GO Resources on GM SHO Safflower, please see below a PIRSA article covering much of the key basic knowledge required for South Australian producers.

Introduction

Safflower is a winter-spring growing, annual oilseed cash crop which belongs to the same family as sunflower and thistles (Asteraceae family).

Safflower is a minor crop in SA grown principally in the South East and mid North on heavier soils with good water holding capacity. Area sown fluctuates depending on season and grain price. It has a relatively low gross margin, but is grown for its rotational and management benefits.

Seed from the safflower crop is crushed for its high grade oil, which is used in industry and is a premium grade edible oil. Safflower meal is a valuable source of protein that is used as a stockfeed concentrate.

Safflower provides a disease break crop for cereals and grain legumes, and its taproot provides similar soil conditioning benefits to canola.

Safflower can be grown and harvested with the standard cereal cropping machinery. Average yields range from 0.5 to 1.3 t/ha in the mid North, and 1.0 to 2.5 t/ha in the South East.

Growth requirements

Safflower has a long growing period, approximately 20 to 23 weeks, depending on variety, locality and time of seeding. It grows very slowly in the winter months, when it is susceptible to weed competition. It's main growth period is from mid spring into summer when moisture supply is critical for seed yield and oil content.

Safflower will provide the best returns on the better wheat growing soils. It will yield best when grown on deep, fertile, well drained soils with good water-holding capacity in areas receiving more than 450 mm rainfall. Preferable soil types are neutral to alkaline loams and clay/loams.

It will not perform well on heavy, structureless soils, or shallow soils overlying limestone or compact clay, both of which impede root development.

In South Australia it is an ideal crop to sow where seeding of winter crops has been delayed due to waterlogging or a late start to the season. The gross margin of safflower is likely to be higher than later sown cereal or grain legume crops.

The plant requires good reserves of subsoil moisture at sowing and 50 mm or more rainfall prior to flowering if yields in excess of 1.0 t/ha are to be achieved.

Early in its growth, safflower is sensitive to cold and dry conditions, and susceptible to waterlogging. Its deep taproot enables it to better withstand dry conditions during budding, flowering and grainfill.

Time of flowering is determined by daylength. Sown late, plants run up to flower with few branches, while early sown crops have more time to branch prior to flowering.

Nitrogen and phosphorus requirements are similar to those for growing a wheat crop.

Place of safflower in the rotation

Safflower is mostly sown following a long-term pasture as it is an ideal crop to commence a cropping rotation. Its disease resistance enables excellent cereal root disease control.

Safflower is spring sown on paddocks that become too waterlogged over the winter months to allow survival of winter sown crops, and also in paddocks where herbicide resistant weeds are a problem.

The later sowing allows more time for weed control by cultivation and knockdown herbicides during winter reducing reliance on in-crop herbicides, which is a major advantage on paddocks with herbicide resistant ryegrass and wild oats.

Good weed control over the winter months prior to sowing will conserve moisture for the crop into the summer months, which is required because of linola's late maturity.

If grown after a succession of crops, nitrogen fertiliser requirements are going to be greater than if sown as the first crop following pasture. Germinating volunteer safflower is easily controlled by cultivation prior to sowing the next crop.

Safflower depletes subsoil moisture more than other winter crops which can reduce yields of following crops.

Varieties

Gila the first safflower variety released, was replaced in 1987 by two varieties with improved disease resistance. Gila is susceptible to alternaria leaf blight and phytophthora root rot, both of which will seriously reduce yield.

Sirothora is recommended for irrigated production. It has resistance to phytophthora, which is more likely to infect irrigated crops. It is susceptible to alternaria.

Sironaria is recommended for all dryland plantings. It is resistant to alternaria, and moderately resistance to root rot.

In the absence of disease, both of these varieties will yield equal to Gila, but when disease is present, the yield of Fila drops away significantly. All three varieties are similar in maturity and seed quality, although Sirothora and Sironaria will yield 0.5 to 1.5% less oil.

Seed

Seed of safflower is mostly white and shaped like small sunflower seeds. There are between 22,000 and 26,000 seeds per kilogram. The seed is covered with a thick hull, which gives a high fibre content. Average analysis of the seed is 38% hull, 34% oil, 22% protein and 6% moisture.

Sowing rate

Safflower should be sown at 15 to 20 kg/ha in medium rainfall districts and at 20 to 25 kg/ha where annual rainfall exceeds 500 mm. At the low seeding rates aim for a plant density of 20 to 30 plants per square metre, and 30 to 40 plants/m2 with the higher seeding rates.

Lower seeding rates should be used when sown early. Early sown safflower crops have the ability to branch and produce many seed heads, while late sown crops tend to run up to a single stem.

Seeding rates which are too low produce plants with thick, woody stems, which are difficult to harvest, and compete poorly with weeds.

Sowing times

In the mid North safflower can be sown from July to September, and as late as September or October in the South East.

Safflower requires long daylight hours to flower, so flowering date is relatively unaffected by sowing date. Where soils are vulnerable to winter waterlogging, sow when the soils have dried out sufficiently.

Late sowing in September and October will only produce yields in excess of one tonne per hectare on deeper soils (greater than one metre) with good moisture content that receive follow- up rains in early to mid summer for seed development.

In milder districts sowing can commence in June/July given the soil is not waterlogged, or likely to become waterlogged before spring. Given adequate nutrition and kept weed free, these crops have the highest yield potential.

Very early sowing increases the risk of frost damage to crops. Also, if the crop puts on too much vegetative growth early, this can cause problems later on during flowering and seed fill when moisture is more likely to be limiting. Crops sown early into cool soil will also be slow to emerge and early growth will be slow, putting the crop at greater risk from weed competition.

Oil content is determined by moisture availability during grain fill, and is likely to be higher with earlier sowing.

Paddock preparation

Safflower yield relies heavily on stored moisture in the subsoil. The greater the sub-soil moisture, the better the yield prospect. Paddocks should be kept weed-free in the months leading up to sowing. This is best done with knockdown herbicides, as excessive cultivation will often delay sowing due to the soil being untrafficable.

The seedbed should be firm with moisture close to the surface for even germination.

Seeding operation

Safflower can be sown with seeding machinery used for sowing cereal crops. Row spacing should not exceed 180 mm as it is a poor competitor against early weed competition.

Direct drilled crops can be successful provided weeds are controlled well, and accurate seeding depth and good seed-soil contact is achieved.

Sowing depth

Safflower should be sown shallow into moist soil to ensure even and rapid emergence. Where topsoil moisture is limiting seed can be sown to a depth of 40 mm. Where top soil moisture is adequate, seed should be sown at 15 to 20 mm. sow seed shallow on soils which surface seal, or pack down following rain.

Nutrition

Safflower has similar phosphorus, sulphur and nitrogen requirements to a wheat crop. Safflower responds to manganese and iron on black and grey soils in the South East. A foliar application of manganese and/or iron about six weeks after sowing will increase seed yields.

Nitrogen, phosphorus and sulphur removed by one tonne of grain

1 tonne of grain	Nutrient removal (kg/t)		
	N	P	S
Wheat	23	3	2
Safflower	25	4.3	4

Nitrogen

Rates of more than 20 kg/ha of nitrogen sown with the seed may adversely affect seed germination. Late sown safflower into pasture paddocks allows for greater mineralisation during the months leading up to sowing, reducing the need for further nitrogen applications. If applying extra nitrogen, it should either be drilled before sowing the crop, or topdressed prior to budding while the topsoil is still damp in early to mid spring, so it can move down the soil profile where the roots can access it.

Nitrogen application guide for safflower (kg N/ha)

Yield (t/ha)	Good pasture >80% legume last year	Poor pasture <20% legume last year	Grain legume last year	Cereal last year
1.0	0-10	10	0-10	10
1.5	0-10	30	0-10	30-40
2.0	10-20	50	20-30	40-60

Phosphorus

Safflower has similar phosphorus requirements to cereals. It removes slightly more phosphorus in the grain than does wheat. A 1.0 to 1.5 t/ha crop requires 8 to 12 kg/ha of phosphorus to maintain soil phosphorus levels.

Weed control

Effective weed control is essential for high yields, both prior to sowing for moisture conservation and in seedling crops.

Winter sown safflower can suffer severely from weed competition because of its slow crop growth during the cool winter months. Spring sown safflower is less unaffected by weeds because of its increased vigour, and the opportunity to control weeds over the winter months prior to sowing.

Grasses and most broad-leaf weeds can be readily controlled with a comparatively wide range of herbicides.

Herbicides

Pre-sowing

Trifluralin (1.4 to 2.1 L/ha) and Stomp® (2 to 3 L/ha) will control annual ryegrass, wireweed, and suppress silver grass and fat hen. Avadex BW® (2 L/ha) can be used for wild oat control.

Post-emergent

No products are registered. However, limited trial data and field experience suggests the following products can be used:

Metsulfuron (7 g/ha) can give effective control of a range of broadleaf weeds. Crop height may be shortened if applied at the very early rosette stage. Temporary yellow blotching may occur.

Chlorsulfuron (25 g/ha) can be used post-emergent. Temporary yellowing of the crop is sometimes seen.

Be aware of plantback restrictions for other crops when using both these herbicides.

Selective grass herbicides have been used safely on safflower crops for control of most annual grasses, except silver grass. Do not use 2,4-D, MCPA or dicamba on or near safflower.

The overuse of particular groups of herbicides through the rotation can lead to herbicide resistance, which has occurred in grassy weed species especially. To avoid herbicide resistance, weed management through the rotation should aim to minimise the need for herbicides, to avoid the overuse of any one group of herbicides and to use the least selective herbicide. Effective grass control in the safflower crop has the benefit of reducing the need for selective grass herbicides in the following cropping years.

Diseases

Diseases losses in safflower are reduced by growing no more than one crop in every three years in the same paddock, sowing seed from only healthy crops and by growing disease resistant varieties.

Alternaria leaf blight

Alternaria is fungal disease which thrives in warm, humid conditions, attacking leaves, stems, heads and seeds of safflower. It can be carried over on seed, causing seedling death.

It is the most damaging disease of safflower, and is most severe in seasons with wet springs from flowering onwards.

The control strategy is to grow the alterneria resistant variety Sironaria. If susceptible varieties are grown the fungicide mancozeb is useful in limiting losses caused by this disease.

Root rots

Safflower does not tolerate waterlogging. Phytophthora rootrot is favoured by wet soils and high temperatures. The disease risk is greatest in irrigated crops in South Australia, and the phytophthora resistant variety Sirothora is recommended.

Other diseases

Seedling damping-off can occur during seedling emergence, particularly in cold, wet soils containing large amounts of undecayed plant residues.

Rust can occur in the later stages of crop development, however control is rarely required.

Insects

Red-legged earth mite

Safflower seedlings can be attacked by red-legged earth mite, so careful monitoring of the emerging crop is required with appropriate quick action to control insect damage.

Rutherglen bug

They are often present during grain fill. Spray crops when several bugs per seed head are found. Maldison is most commonly used for control.

Black field crickets

Crickets damage mature heads and seeds on black cracking soils in the South East. Baiting may give useful control, but ideally crops should be harvested as soon as they are ready. It may be necessary to desiccate weeds to allow early harvest. Spraying has not given reliable control.

Pink cutworm

Cutworm may damage seedling plants by chewing through stems at ground level, leaving bare patches in crops. They hide in the soil around plants during the day, making them difficult to find. They can be controlled with synthetic pyrethroids.

Native budworm

Budworm have not been a significant pest of safflower.

Harvesting

Safflower is ready to harvest when grain moisture is below 8%. This occurs at about 4 to 6 weeks after wheat has matured. Harvest the crop as soon as it is ripe because prolonged unseasonal wet weather can cause the seed to germinate in the head.

Header settings should be adjusted so that grain is not broken or cracked as this will cause deteriation in oil quality. Drum speed should be about 500 rpm while the concave may need to be opened to allow free movement of trash and stalks. If the crop is too dry when harvesting the plants smash into small pieces, making it difficult to separate the seed and obtain a clean sample.

Safflower heads do not shatter when ripe, but should thresh easily when the moisture content is at the required level. As safflower seed is lighter than wheat, it is easily lost from uncovered bulk bins on trucks, so loads should be covered for transport.

Yields

Safflower yields vary considerably depending on moisture supply throughout their growing period. Average yields are 30 to 40% of wheat yields. In South Australia, average dryland yields vary from 0.5 to 2.5 t/ha. The test weight of safflower seed is around 52.5 kg/hl, which is similar to oats.

Marketing

Safflower seed is used for oil and meal production, and small amounts go into the birdseed trade. Its oil is a high quality edible oil with a long shelf life. It is also used in manufacturing. The meal from dehulled seed is used in pig and poultry rations, while meal from seed with the hull left on is high in fibre and only suitable for cattle and sheep.

Safflower growers should take advantage of fixed tonnage/ fixed price contracts or guaranteed minimum price contracts. In recent years prices have fluctuated from $270 to $340 per tonne. Seed delivered must conform to set standards with premiums or penalties for seed which is better or worse than these standards. Moisture content must be below 8 pc.

The standard oil content is 34 pc with a 2 pc premium or reduction for each percent oil above or below this level. Other standards are impurities (4 pc), broken seed (7 pc) and damaged seed (3 pc).

Received standards

Moisture	Oil	Impurities	Broken seed
<8%	34% 2% penalty/bonus for each 1% above or below 34%	>4% impurities seed is rejected	>7% broken seed then seed is rejected

Last update: September, 2002

Agdex: 146/10

Author: Mark Stanley and John Hannay, Senior Agronomists, Trent Potter, Senior Research Officer, SARDI.

Government of South Australia
Department of Primary Industries and Regions
RURAL SOLUTIONS SA
PIRSA
SARDI
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

Disclaimer

Use of the information in this Fact Sheet is at your own risk. The Department of Primary Industries and Resources and its employees do not warrant or make any representation regarding the use, or results of the use, of the information contained herein in terms of its suitability, correctness, accuracy, reliability, currency or otherwise. The entire risk of the implementation of the information which has been provided to you is assumed by you. All liability or responsibility to any person using the information is expressly disclaimed by the Department of Primary Industries and Resources and its employees.

The Leaf Protein Co. presentation at CSSSA's February meeting by Rob Blum & Fern Ho.

Driven by consumer demand and economic development, global protein consumption has grown 58% in the last 20 years. This phenomenon is causing both economic opportunities and environmental degradation caused by greenhouse gas emissions and the gradual destruction of native biomes in emerging economies.

Fern and Rob are two engineers who share a passion for the environment and for building a sustainable agrifood system. After extensive research, they co-founded The Leaf Protein Co, a startup that is set to unlock Earth's most abundant source of proteins: green leaves.

The Leaf Protein Co is building upon an extensive body of research in leaf protein extraction and applications, started by Pirie (UK) and Telek (US) during the Second World War. The field was further developed by McDonald (NZ) and Vincken (NL) and has become a priority research area in Europe today.

Initially, Rob's Brazilian heritage gave The Leaf Protein Co its initial focus to use a Brazilian leafy cactus known as Pereskia Aculeata. Running their own independent experiments, the founders extracted a 50% protein concentrate from mucilage-rich Pereskia. And now that the business is based in Australia, they are researching Australian native plants to produce leaf protein. To find out more about The Leaf Protein Company, please contact Fern at fern.ho@theleafprotein.com.

Novel agronomy strategies for reducing the yield decline from delayed emergence

Kenton Porker[1], Brendan Kupke[1], Melissa McCallum[1], Courtney Peirce[1], Paul Swain[1], Wayne Reid[1], Peter Hayman[1], Dane Thomas[1], Bronya Alexander[1], Andrew Ware[2]and James Hunt[3].

[1]South Australian Research and Development Institute Waite Agronomy and Climate applications; [2]Eyre Peninsula Ag Research; [3]LaTrobe University.

GRDC project code: DAS1910 – 003BLX

Keywords

- sowing time, frost, phenology, crop development, yield, defoliation, establishment.

Take home messages

- Matching crop variety development to environment should remain a key focus of crop management, such as early sowing of a slower developing winter cultivar (prior to 1 May). There are some downsides to winter wheat adoption, as there is risk of later emergence (after 1 May), hence flowering later than optimal, and reduced yields.
- It is very important to make the most of early establishment opportunities because, other than genetic improvement, there were a lack of solutions for negating yield decline from later emergence or for speeding up crop development.
- Strategies to improve earlier establishment under low soil water potentials would be transformative for lower rainfall districts.
- Applications of hormones showed little ability to speed up development or increase yield of late emerged crops.
- Barley was better suited to later emergence than wheat. There are possibilities to quantify the regional differences in the role of barley and other crops compared to wheat in the rotation and sowing time schedules needs to be revaluated accordingly.

Background

Current investment to close the yield gap has focused on earlier sowing with slower developing cultivars. In order to exploit the maximum yield, the farm's sowing program has to be finished and germination needs to occur by 15 May in many districts of South Australia (SA). The management of the early sown wheat project (ULA9175069) has demonstrated that when slow developing wheats are sown before 20 April they yield similarly to a fast developing cultivar sown in its optimal window (May 1-5). Larger and more consistent losses occur in frost prone landscapes from early sown, quick developing cultivars, and delaying sowing to avoid frost losses, trades off with yield loss due to drought and heat. At later sowing there is a significant yield penalty in both development groups due to increased heat, drought, reduced biomass and reduced tillering.

The yield penalty from later emergence in winter cultivars has not been quantified and there has been less focus on reducing the yield decline from later planting through agronomic management.

Much of the Southern Region, particularly SA, is limited in the ability to fully exploit early sowing by seasonal breaks that typically don't allow for crop establishment before 1 May in over 50% of years. The varied nature of climatic events also results in a significant percentage of seasons where the seasonal break doesn't occur until late May to early June. In these years water use efficiency is often lower and offers potential to be improved through new approaches.

The ability to reduce the yield decline from later planting through agronomic management in wheat and barley was evaluated. Management that focused on attempts to produce more biomass and mimic the morphology of early sown crops while still flowering on time using faster developing cultivars was explored. If such an approach could be successful, this paradigm shift would reduce the trade-off from missing earlier planting opportunities.

Methods

Experiments were conducted at four locations in SA, which vary in rainfall and temperature and thus seasonal yield potential (Table 1). Three germination dates were targeted, defined here as time of sowing TOS1, TOS2 and TOS3. TOS1 was in mid-April which is optimal for winter cultivars in all environments and too early for quick developing spring cultivars. TOS2 was in early to mid-May (depending on site), which is optimal for quick developing spring cultivars. TOS3 was in early June, which is considered too late for all cultivars and the focus of this experiment. Sowing dates and site locations are outlined in Table 1.

Table 1. Site locations, GPS coordinates and corresponding sowing dates.

Site location	Sowing date		
	TOS1	TOS2	TOS3
Minnipa	17/4/19	7/5/19	4/6/19
Loxton	15/4/19	10/5/19	4/6/19
Giles Corner	18/4/19	16/5/19	6/6/19
Cummins	15/4/19	14/5/19	14/6/19

Wheat and barley genotypes were selected based on developmental patterns. A winter cultivar suited to earlier sowing was selected with local adaptation to each site. For wheat this was either DS Bennett[A], Longsword[A] or Illabo[A], for barley this was Urambie[A] and Cassiopee. The quick developing spring wheat, Scepter[A] and the barley variety, Compass[A] were the controls across all sowing times.

Additional agronomic treatments applied at the latest sowing date (TOS3) aimed to maximise biomass and reduce the yield decline from later planting or missed opportunities in wheat and barley (Table 2). Agronomic interventions such as doubling plant density, doubling nitrogen (N) supply, applying growth promoting root auxins and hormones, and including quicker developing cultivars were tested.

Cultivar and species responses to sowing date

The trends for wheat and barley were similar for TOS1 and TOS2. Highest yields were achieved by early sown (TOS1) winter cultivars, yielding similar to their respective quick spring cultivars sown at their optimal time (TOS2). Winter barley was approximately 0.45t/ha higher yielding than winter wheat at both sowing times TOS1 and TOS2, suggesting winter barley might be better adapted than current winter wheat cultivars. Winter cultivar yields were optimised at the April germination date and both wheat and barley suffered a 12% yield penalty when emergence was delayed until mid-May (TOS2).

Spring barley yielded similarly to spring wheat at TOS1 and TOS2 (Figure 1 and Figure 2), however barley yielded 0.4t/ha higher at the later planting, suggesting barley is more suited to later emergence than wheat. Both quick spring wheat and barley suffered a yield penalty from early planting, and there is evidence of less yield decline in barley relative to wheat at later planting. In the quick spring wheat, there was a 13% yield penalty from early sowing compared to May sowing and 11% from delayed planting. In the quick spring barley there was a 12% yield penalty from early sowing compared to May sowing and there was no yield penalty from delayed planting unlike wheat. This is an important consideration for growers where breaks are likely to occur past 15 May.

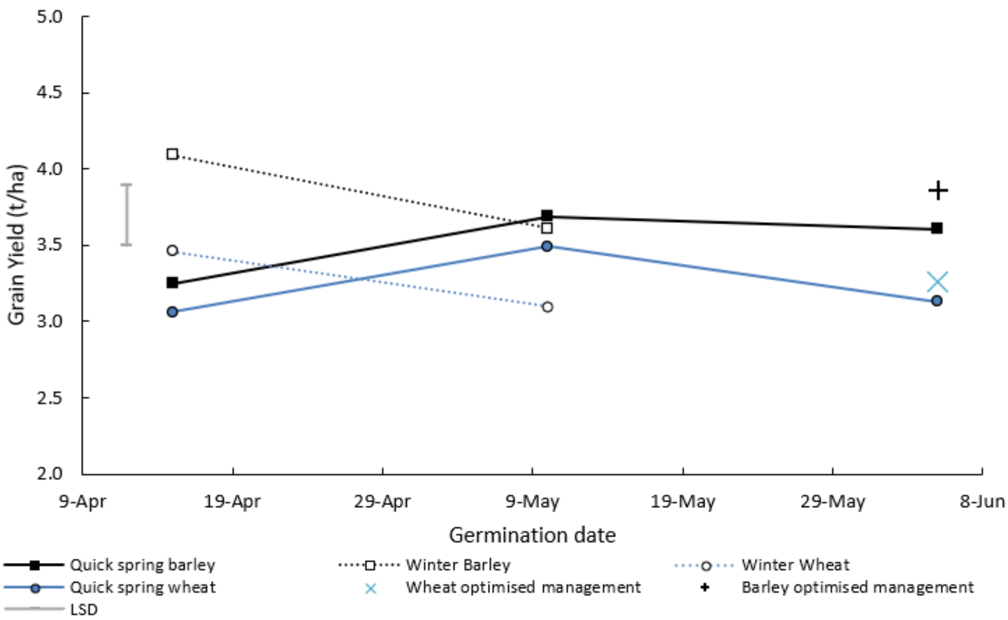

Figure 1. Grain yield responses to germination date of quick barley, quick wheat, winter wheat and barley averaged across four locations in South Australia 2019. The optimised management data points are for the late sown quick spring wheat (X) and barley (+) and represent the highest yielding treatment with different management tailored for later planting.

When the same responses are analysed in terms of total biomass production, the trends are similar to the yield responses but there are a few key differences that are insightful. The quick spring wheat was more effective at producing biomass from earlier planting dates than the quick spring barley and winter wheat achieved a similar biomass to the winter barley. Therefore, the yield differences between these treatments are most likely to be due to a poorer harvest index of wheat which was driven by its poorer frost tolerance compared to barley. Barley was effective at producing more biomass than wheat at later planting dates consistent with the yield responses. The physiological reasons for this requires more investigation. One plausible explanation is that barley has a greater ability to grow at sub-optimal temperatures associated with the vegetative phase occurring during the peak of the cold winter.

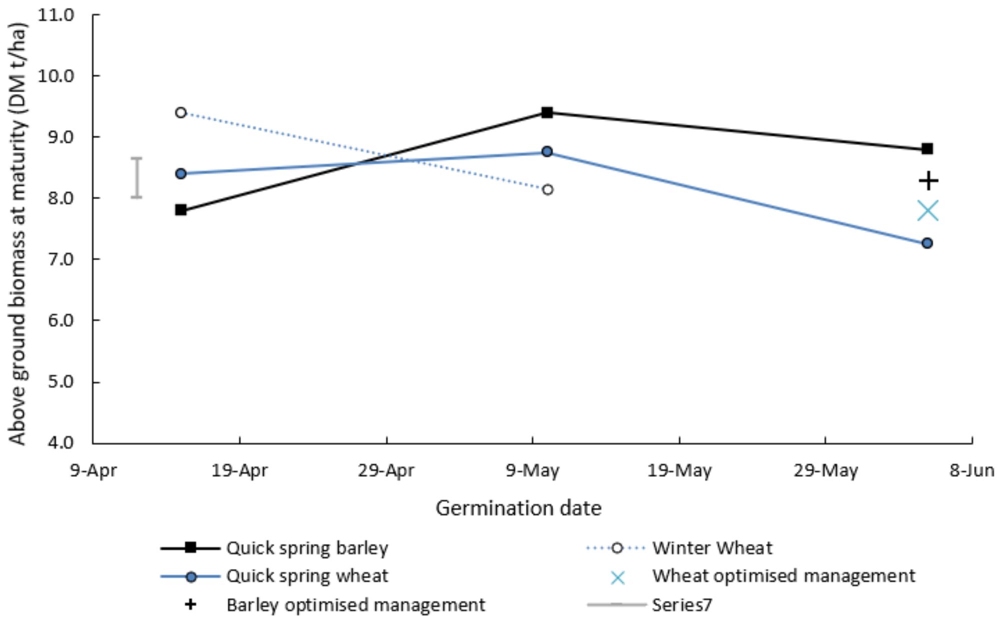

Figure 2. Total biomass responses to germination date of quick spring barley, quick spring wheat, winter wheat and barley averaged across four locations in South Australia 2019. The optimised management data points are for the late sown quick spring wheat (X) and barley (+) and represent the highest yielding treatment with different management tailored for later planting.

Management to limit the yield decline of late emerged crops

At later emergence, other agronomic interventions such as doubling plant density, doubling N supply, applying growth promoting root auxins and hormones did not reliably increase yield relative to control (Table 2, Figure 1 and Figure 2). There was also evidence of yield penalty with exogenous hormones; gibberellic acid and cytokinin. It was possible to increase biomass in wheat relative to the control, however this did not translate into increase in grain yield. Currently adapted cultivars performed the best under the same management regime from early planting.

Table 2. Grain yield, biomass, and harvest index responses to management at later emergence (TOS3) average across all sites with standard quick – mid wheat Scepter and quick barley cultivar Compass.

Cultivar/ phenology	Management	Grain Yield (t/ha)	Biomass (t/ha)	HI
Wheat				
Scepter^{A}	Control (180 seeds/m^{2})	3.1	7.3	0.46
Scepter^{A}	Double Seeding Density	3.1	7.4	0.42
Scepter^{A}	Double Seeding Density + 50 Seedbed N	3.1	7.9	0.39
Scepter^{A}	Double Seeding Density + AUXINS	3.3	7.8	0.42
Scepter^{A}	Double Seeding Density + Gibberellic acid & Cytokine	2.9	7.3	0.38
Corack^{A} (Quicker)	Double Seeding Density	3.2	7.8	0.40
Barley				
Compass^{A}	Control (150 seeds/m^{2})	3.6	8.8	0.44
Compass^{A}	Double Seeding Density	3.5	8.6	0.43
Compass^{A}	Double Seeding Density + Gibberellic acid & Cytokine	2.8	7.6	0.34
Spartacus^{A} (Quicker)	Double Seeding Density	3.8	8.3	0.46
Spartacus^{A} (Quicker)	Double Seeding Density + Gibberellic acid & Cytokine	3.2	8.1	0.38
CSIROB3 (Very Quick)	Double Seeding Density	3.1	7.0	0.39
	P value Treatment	<0.001	<0.001	<0.01
	LSD	0.35	0.51	0.02

Conclusions and recommendations

These data highlight that there may be limited scope to reduce yield penalties from later planting with the crop management techniques evaluated here. However, species choice is critical and barley was better suited to later planting than wheat. The mechanisms for this require further investigation and may be due to faster growth or maturity rates under suboptimal temperatures associated with delayed planting. The suitability of other species such as oats would also warrant investigation.

Matching crop variety development to environment remains the best focus of management. Our other experiments (discussed at the 2021 Grains Updates, Adelaide?) suggest there are a number of solutions to slow development and negate the yield penalties associated with sowing a quick spring variety prior to its optimal time (such as winter cultivars and resetting crops). However, the lack of solutions for negating the yield decline from later emergence means making the most of early establishment opportunities, and these techniques are even more important. These solutions require validation for adoption along with further research to improve establishment of crops prior to the 15 May.

Another interesting finding is that it has previously been assumed the yield penalty from winter cultivars emerging after 1 May is significantly greater than any spring cultivars emerging after that time. However, this research suggests that the new generation of winter cultivars may not suffer the same degree of yield decline as previously thought. This means growers may actually have more opportunities in many parts of SA to establish winter wheats than currently predicted in the next module of research. This research needs to be validated.

Acknowledgements

The research undertaken as part of this project is made possible by the significant contributions of growers through both trial cooperation and the support of the GRDC, the author would like to thank them for their continued support.

Contact details:

Kenton Porker

Kenton.Porker@faraustralia.com.au

[A]Varieties displaying this symbol beside them are protected under the Plant Breeders Rights Act 1994