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Project Code	
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FINAL REPORT 2019

PROJECT CODE	:	S618

PROJECT TITLE
Benchmarking yield potential of barley in higher rainfall zones

PROJECT DURATION

Project Start date	1 April 2018					
Project End date	31 March 2019					
SAGIT Funding Request	2018/19		2019/20	$	2020/21	$

PROJECT SUPERVISOR CONTACT DETAILS

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PROJECT REPORT

Executive Summary

This project evaluated for the first time a series of slower developing barley cultivars with a longer crop cycle length, greater vernalisation and/or photoperiod in the South East and Mid North higher rainfall environments (HRZ) within the context of earlier sowing (prior to April 20). We proposed lengthening the crop life cycle by earlier sowing and slower developing cultivars as a way of increasing potential yield.

The results showed promise for slower developing winter barley in the HRZ in the South East, and faster developing winter barley cultivars in the more marginal HRZ such as the Mid North of SA. However, the fast spring cultivars that growers have access to also yielded similar to winter cultivars in both experiments and demonstrates the current spring barley options are also well adapted to the SA HRZ.

While there is the added benefit of a longer grazing window in winter cultivars, the lack of yield advantage of the winter cultivars highlights the need for more germplasm development. There is also a need for more agronomic work to establish the best management practices to reduce lodging and improve biomass partitioning in these higher rainfall regions.

Project Objectives

The objective of this study was to evaluate the potential of novel slower developing barley varieties to increase profitability in the higher rainfall zones (HRZ) of SA compared to current spring barley benchmarks. This project was designed to demonstrate possible benefits of untried novel germplasm in these regions in 2018 that have potential for grazing and grain yield as a new management tool for growers.

Overall Performance

The project was a success and generated a great deal of grower interest, improved growers' understanding of yield physiology, and increased grower confidence and belief in the ability to achieve much higher yields than previously thought in the HRZ. There is now an appetite for more research in this area, particular in the higher rainfall, cooler and longer duration environments.

The project was overseen by Dr Kenton Porker who, along with SAGIT/GRDC intern Melissa Mccallum (SARDI Waite Agronomy), managed the Tarlee site.

The South East component was managed by Mr Nick Poole and Kat Fuhrman (FAR), along with SARDI agronomy staff from Struan. Kirsty Dickenson was employed on the project as a research officer, but left SARDI early in the project. The void was filled by Amanda Pearce and SARDI casual technical staff.

The collaboration with FAR worked well in the South East with GRDC now recognizing the importance of this centre with subsequent investment. The trial located with the MNHRZ group also gave access to growers in the region.

Building a relationship with European breeding companies was a great outcome from the project, however one of the largest difficulties is access to suitable germplasm for the higher rainfall environments and the pathway to market appears slow without more investment in breeding for the HRZ.

Key Performance Indicators (KPI)

KPI	*Achieved (Y/N)*	*If not achieved, please state reason.*
Experiments sown at both locations	Y	
In season measurements, and yield data complete	Y	
Annual results compiled and recommendations made for the potential of winter barley based on 2018 phenology and yield responses	Y	
SAGIT progress report completed	Y	
SAGIT Final Report	Y	

Technical Information

Material/Methods

Genotypes used in the study are outlined in table 1 and 2 and experimental sites outlined below. The genotypes reflect the biggest diversity in development tested in the HRZ zones of Australia including winter barley (requirement for vernalisation) and spring varieties from Europe. Spring cultivars do not require vernalisation and European spring (RGT Planet) typically develop slower than Australian spring cultivars (ie Rosalind).

- Mid North High Rainfall Zone (Tarlee): A higher rainfall site, that offers potential for dual purpose use of barley for grazing.
- South East High Rainfall Zone: (Located in collaboration at the FAR SA Crop Technology Centre Millicent) in an environment capable of yields >10t/ha

Management treatments - A single application of the plant growth regulator Moddus evo (200ml/ha) was applied at Z31, grazing treatments were simulated by defoliation at 5 leaf and Z30, Z30 alone and untreated to manipulate the relationship between biomass and partitioning of resources in winter relative to spring barley during the critical period for yield determination. Measures of biomass removal, onset of stem elongation, flowering time, harvest index, yield, yield components, and grain quality were conducted on every plot. Sites were managed for nitrogen, based on water limited yield potential and a full fungicide regime was applied. Supplementary irrigation of 10 mm was required at Riverton to ensure establishment.

Growing Conditions - Both experiments were established before the 20th of April. The site at Tarlee required 10mm of supplementary irrigation. Millicent established on rainfall. The two growing environments were contrasting, Millicent was characterized by cooler conditions during grainfill and more than double the winter rainfall compared to Tarlee. Tarlee had a greater number of extreme cold (frost) and heat events during the critical flowering in September (figure 1).

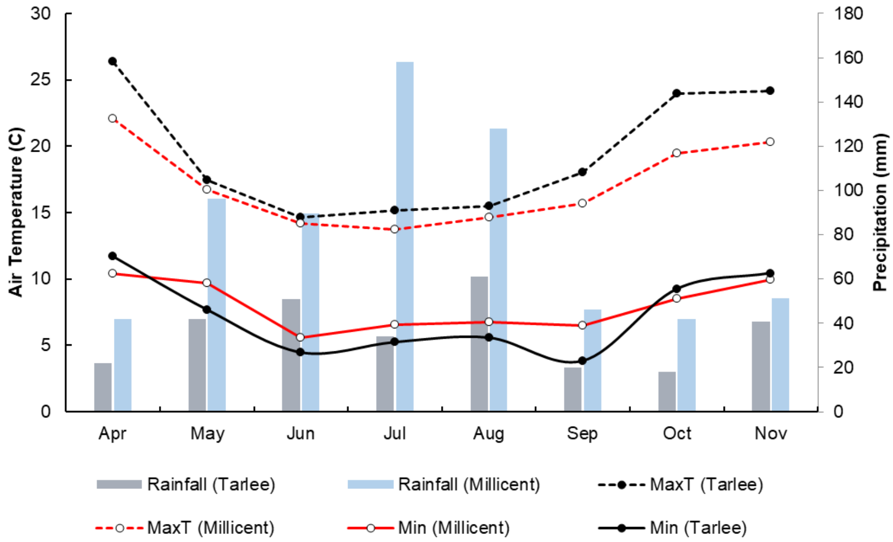

Figure 1. Sum of monthly rainfall, and mean minimum and maximum temperatures at Tarlee and Millicent in the growing season 2018.

Growth stage 30 and Grazing - Winter cultivars were slower to stem elongation compared to spring cultivars. However, the fastest winter cultivar Urambie was similar to the slowest spring cultivar Oxford. The longer vegetative period of winter cultivars allows for prolonged grazing periods and greater biomass available for feed. Greater biomass removal was observed at Millicent but not at Tarlee (Figure 2, Table 1 and Table 2).

Grain yield and flowering time - Millicent was significantly higher yielding (7.2 t/ha average) than Tarlee (4.8 t/ha average). There was not a significant relationship between flowering date and yield at Millicent, and spring cultivars yielded similar to winter cultivars. However, at Tarlee flowering date was negatively related to grain yield meaning fast developing cultivars were favoured (Figure 3). Terminal drought and a frost event in late September contributed to higher levels of sterility in later flowering treatments. The late frost at Tarlee was uncharacteristic of that environment. These experiments could be extrapolated to other environments in the HRZ and it could be hypothesized the winter cultivars are more likely to be suited to earlier sowing based on their flowering date particularly in frost prone environments, flowering up to 40 days later than the fast spring cultivars.

Genotype responses: - Despite large differences in flowering date, the highest yielding spring yielded similar to the highest yielding winter cultivar at both sites, suggesting there is potential for winter cultivars. Factors other than phenology such as lodging, and a combination of poor biomass accumulation and partitioning, are the major driver of yield differences (results not presented) at Millicent. At Millicent the highest yielding spring cultivars were RGT Planet and Rosalind yielding significantly more than current spring check Westminster. Slower winter cultivar (UK Winter) was the highest yielding winter type similar to Planet and Rosalind. The poor yield performance of Oxford is due to disease. Oxford is extremely susceptible to disease in this district and can no longer be reliably managed under high net form net blotch pressure. At Tarlee faster spring and winter cultivars were favoured. The fast winter cultivar Urambie yielded similar to the best performing spring cultivar Compass despite a month difference in flowering date (Table 1 and Table 2).

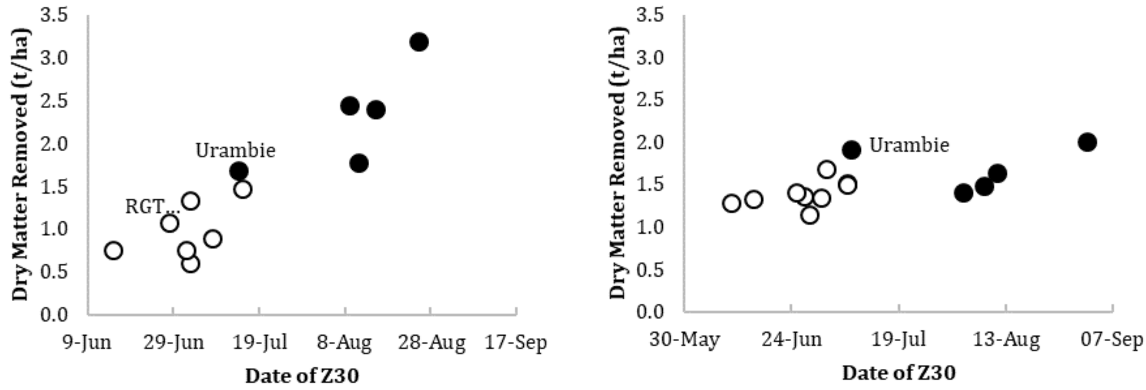

Figure 2. The relationship between growth stage 30 (onset of stem elongation) and dry matter removed (t/ha) by simulated defoliation (grazing) at (a) Millicent and (b) Tarlee. Open circles ○ = Spring cultivars, closed circles ● = Winter cultivars.

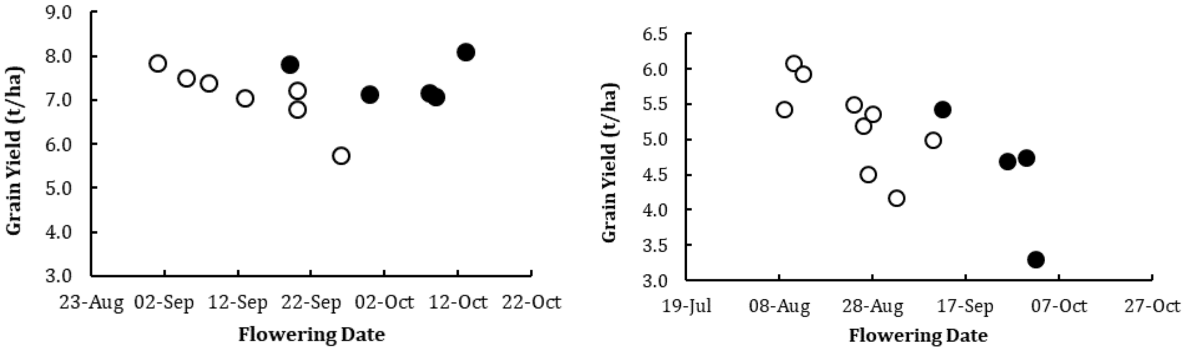

Figure 3. The relationship between flowering date and grain yield (t/ha) in the control treatments at (a) Millicent and (b) Tarlee. Open circles ○ = Spring cultivars, closed circles ● = Winter cultivars.

Management Intervention - The management intervention of grazing had the biggest effect on grain yield and there was significant variety x management interactions (Table 1 and Table 2). Grazing and plant growth regulator treatment also had an effect on canopy architecture, crop development, and lodging. The winter cultivars were more prone to lodging at Millicent (Figure 4), while lodging was not present at Tarlee.

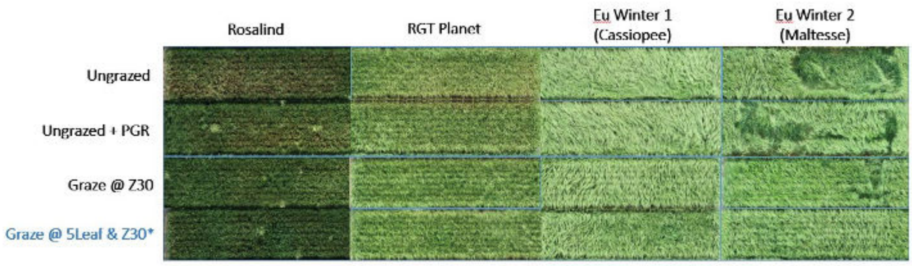

Figure 4. Example of lodging at the Millicent site in 4 different genotypes at different management levels.

Plant growth regulators: The single application of the plant growth regulator reduced the incidence of lodging but did not necessarily improve crop yield due to reductions in biomass and or harvest index (data not presented). The addition of a single application of a plant growth regulator did not have a significant influence on grain yield at Tarlee, but increased yield in some spring cultivars at Millicent. The addition of a single application of Moddus (Plant Growth Regulator) improved yield by 0.8t/h – 1.1t/ha in three European cultivars RGT Planet, Hacker, and a UK Winter line. All other cultivars did not respond.

Grazing defoliation - Grazing delayed crop development by up to 8 – 23 days in the fast spring cultivars at both sites and and by 1 – 7 days in the slow developing winter cultivars. At Millicent yield increased in Rosalind by 1.7t/ha due to the longer growing cycle but reduced yield by 1.1 t/ha at Tarlee. At Millicent yield was only reduced in the winter cultivar Urambie, however at Tarlee yield was decreased in Rosalind, Fathom, RGT Planet, Hacker, Urambie and Cassiopee. Grazing increased yield in the slowest winters Maltesse and UK winter at Tarlee. Management generally had little effect on grain quality, variety differences were the key drivers of grain quality. Spring cultivars had lower test weight, and Urambie had inferior grain size compared to European winter cultivars.

Table 1. Cultivar yield and flowering date with management intervention and without (standard control) at Millicent in the South East.

Cultivar	Standard Control Grain Yield (t.ha)		Standard Control Flower Date	Management Intervention (Grazing) Grain Yield (t/ha)	Z30 Date	Flower Date	No of days flower delayed	DM removed (t/ha)*	
Rosalind (Aus Spring)	7.8	ab	01-Sep	9.5*	15-Jun	21-Sep	20	0.8	hi
RGT Planet (Eu Spring)	7.5	abc	05-Sep	8.0	28-Jun	17-Sep	12	1.1	fg
Hacker (Eu Spring)	7.4	bc	08-Sep	7.8	2-Jul	28-Sep	20	0.8	hi
Traveler (Eu Spring)	7.1	bc	13-Sep	7.3	15-Jul	29-Sep	16	1.5	de
Fathom (Aus Spring)	6.8	bc	20-Sep	6.6	3-Jul	28-Sep	8	0.6	i
Westminster (Eu Spring Control)	7.2	bc	20-Sep	6.8	3-Jul	02-Oct	12	1.3	e
Oxford (Eu Spring)	5.7	d	26-Sep	5.6	8-Jul	07-Oct	11	0.9	gh
Urambie (Winter Control)	7.8	ab	19-Sep	6.7*	14-Jul	04-Oct	15	1.7	d
Cassiopee (Winter)	7.1	bc	30-Sep	6.7	9-Aug	07-Oct	7	2.5	b
Salamandre (Winter)	7.2	bc	08-Oct	6.6	11-Aug	10-Oct	2	1.8	cd
Maltesse (Winter)	7.1	bc	09-Oct	6.5	15-Aug	10-Oct	2	2.4	b
Uk Winter (Winter)	8.1	a	13-Oct	8.0	25-Aug	17-Oct	4	3.2	a
LSD Cultivar p = 0.05	0.5								
LSD Management p=0.05	0.2								
LSD Cultivar x Man. P=0.05	0.8								

Table 2. Cultivar yield and flowering date with management intervention and without (standard control) at Tarlee in the Mid North.

Cultivar	Standard Control Grain Yield (t/ha)		Standard Control Flower Date	Management Intervention (Double Graze) Grain Yield (t/ha)	Z30 Date	Flower Date	No of days flower delay	Total DM removed (t/ha)*	
Rosalind (Aus Spring)	5.4	abc	09-Aug	4.5*	10-Jun	01-Sep	23	1.3	e-i
Compass (fast spring)	6.1	a	11-Aug	6	15-Jun	28-Aug	17	1.3	d-h
Fathom (Aus Spring)	5.9	ab	13-Aug	4.9*	25-Jun	29-Aug	16	1.4	c-h
RGT Planet (Eu Spring)	5.5	abc	24-Aug	4.6*	27-Jun	03-Sep	9	1.4	d-h
Banks (slow spring)	5.2	cd	26-Aug	5.2	1-Jul	06-Sep	11	1.4	d-h
Traveler (Eu Spring)	4.5	ef	27-Aug	4.6	2-Jul	04-Oct	8	1.7	a-d
Hacker (Eu Spring)	5.4	bcd	28-Aug	4.5*	28-Jun	04-Sep	7	1.1	f-j
Westminster (Eu Spring Control)	4.2	f	02-Sep	4.0	7-Jul	10-Sep	8	1.5	c-e
Oxford (Eu Spring)	5.0	cde	10-Sep	5.2	7-Jul	18-Sep	8	1.5	c-e
Urambie (Winter Control)	5.4	abc	12-Sep	4.4*	8-Jul	16-Sep	4	1.9	ab
Cassiopee (Winter)	4.7	def	26-Sep	3.8*	3-Aug	29-Sep	3	1.4	c-h
Salamandre (Winter)	4.7	def	30-Sep	4.6	11-Aug	02-Oct	2	1.6	b-d
Maltesse (Winter)	3.3	g	02-Oct	4.1*	8-Aug	03-Oct	1	1.5	c-f
Uk Winter (Winter)	2.8	g	10-Oct	4.2*	1-Sep	12-Oct	2	2.0	a
LSD Cultivar p = 0.05	0.3								
LSD Management p=0.05	0.3								
LSD Cultivar x Man. P=0.05	0.7								

*Yield figures followed by different letters are considered to be statistically different (p=0.05), * indicates management intervention had a statistically significant effect on grain yield in that cultivar.*

Conclusions Reached &/or Discoveries Made

Summary:

These results show promise for slower developing winter barley in the higher rainfall district in the South East, and faster developing winter barley cultivars in the more marginal higher rainfall zones such as the Mid North of SA. However, the best performing spring cultivars also yielded similar to winter cultivars in both experiments and demonstrates that the current spring barley options are also well adapted to the SA HRZ. While there is the added benefit of a longer grazing window in winter cultivars, the lack of yield advantage of the winter cultivars highlights the need for more germplasm development. There is also need for more agronomic work to establish the best management practices to reduce lodging and improve biomass partitioning in these higher rainfall regions.

- Australian breeding efforts and recent European spring introductions such as RGT Planet have improved yield in the HRZ compared to current benchmark cultivars Oxford and Westminster, however if sowing before the 20th of April these cultivars are likely to flower too early for growers in frost prone landscapes.
- These experiments demonstrated that the winter cultivars are more likely to be suited to earlier sowing based on their flowering date, flowering up to 40 days later than the fastest spring cultivars. However, despite large differences in flowering date the highest yielding spring yielded similar to the highest yielding winter cultivar at both sites, suggesting factors other than phenology maybe driving yield responses in the HRZ.
- Slower developing winter cultivars were favoured in the South East and faster developing winter cultivars in the Mid North
- The farming system benefit of winter barley should not be overlooked as the longer vegetative phase of winter cultivars allowed for greater dry matter removal by grazing. Up to 3 times more biomass was removed by grazing in slow winter cultivars than fast spring cultivars of similar yield at Millicent, and biomass removal was similar at Tarlee between spring and winter barley.
- Grazing could reliably be used as a strategy to delay flowering time in early sown fast spring cultivars. Grazing delayed crop development by 20 days in the fast spring cultivar Rosalind at both sites and by 1 – 4 days in winter cultivars.
- Winter cultivars were more prone to lodging in the high yielding environment at Millicent and lost significant yield due to lodging and poor biomass partitioning to yield. The application of a plant growth regulator and defoliation reduced the incidence of lodging but did not necessarily improve crop yield due to reductions in biomass and or harvest index.
- The addition of a single application of a plant growth regulator did not have a significant influence on grain yield at Tarlee, but increased yield in some spring cultivars at Millicent.

This project provided insight into further raising barley yield in the HRZ and based on biomass and flowering behaviour reinforces the opportunity for winter barley. We concluded that growing winter barley in Australia is a different agronomic system and requires more evaluation under different management strategies along with targeted germplasm enhancement to improve standability and harvest index in cool, mild, high yielding environments greater than 8t/ha such as Millicent, whereas at Tarlee and in hotter high rainfall environments, faster developing cultivars with phenology patterns similar to Urambie are favoured to avoid terminal drought and heat stress.

Intellectual Property

Genotypes were used provided under MTA by the plant breeding companies. This is a high possibility that Secobra may pursue release of a winter cultivar for the high rainfall zone project.

Application / Communication of Results

This project evaluated, for the first time, a series of slower developing barley cultivars with a longer crop cycle length, greater vernalisation and/or photoperiod requirement within the context of earlier sowing (prior to April 20) in the South East and Mid North higher rainfall environments (HRZ). The key take home message from the project is:

- *Lengthening the crop life cycle by earlier sowing with slower developing cultivars is a way of increasing potential yield, however current well adapted spring cultivars are hard to beat.*
- *While winter barley shows promise we are still learning how best to manage it*

Other Findings:

- Results show promise for slower developing winter barley in the higher rainfall district in the South East, and faster developing winter barley cultivars in the more marginal higher rainfall zones such as the Mid North of SA.
- The best performing spring cultivars yielded similar to winter cultivars in both experiments and demonstrates that the current spring barley options are also well adapted to the SA HRZ.
- Australian breeding efforts and recent European spring introductions such as RGT Planet have improved yield in the HRZ compared to current benchmark cultivars Oxford and Westminster.
- Growers should be cautious if sowing current fast spring cultivars before the 20th of April as they are likely to flower too early in frost prone landscapes.
- The farming system benefit of winter barley should not be overlooked, the longer vegetative phase of winter cultivars allowed for greater dry matter removal by grazing.
- Grazing could reliably be used as a strategy to delay flowering time in early sown fast spring cultivars.
- Winter cultivars were more prone to lodging in the high yielding environment at Millicent and lost significant yield due to lodging and poor biomass partitioning to yield. The application of a plant growth regulator and defoliation reduced the incidence of lodging but did not necessarily improve crop yield due to reductions in biomass and or harvest index.

Conclusions

We concluded that growing winter barley in Australia is a different agronomic system and will require different management strategies along with targeted germplasm enhancement to improve stand ability and harvest index in cool, mild, high yielding environments greater than 8t/ha such as Millicent, whereas at Tarlee and in hotter high rainfall environments, faster developing cultivars with phenology patterns similar to Urambie are favoured to avoid terminal drought and heat stress.

Potential Industry Impact:

If winter barley can replicate the success story of winter wheat in the high rainfall zones it would be transformational. Winter wheat is routinely yielding above 12t/ha in adjacent experimental fields compared to the highest barley yields consistently failing to reach 10t/ha. While there are many challenges to increasing the yield of barley greater than 10t/ha in the HRZ, the data presented here and the success observed in wheat suggests the quest for higher yields is worth the perseverance.

Extension and Communication events:

- 8 August 2018 GRDC regional grower updates Riverton (Kenton)
- 8 August 2018 Mid North High Rainfall Zone winter walk at Giles Corner (Kenton)
- 19 September 2018 Landmark advisors group at Millicent trial (Nick Poole)
- 26 September 2018 Mid North High Rainfall Zone field day at Giles Corner (Kenton)
- 25 October 2018 SA FAR Crop Technology Centre Field Day, Millicent (Kenton)
- 14 November 2018 - Hyper Yielding Field Day FAR, Tasmania (Kenton)
- 9 September 2019 – 19h Australian Barley technical Symposium, Perth (Kenton)
- Article in Mackillop Farm Management Group annual results Booklet

Numerous tweets have been utilised to promote the project:
https://twitter.com/SAGrainTrust/status/1024436294468939776
https://twitter.com/SAGrainTrust/status/1057036678571814912
https://twitter.com/SAGrainTrust/status/1072642753597710336

Ag Communicators have conducted an interview that was prepared for publication in the Stock Journal, a highlights section was also included in the Ingrain magazine.

A peer review manuscript is in preparation incorporating results from NSW, and Tasmanian collaborators. Kenton plans to submit this to the European Journal of Agronomy and present at the 2020 European Agronomy Conference using funds from a recent award received at the Australian Agronomy Society.

Path to market:

The winter cultivars will now likely be incorporated into the new GRDC hyper yielding investments for further feasibility and genotype evaluation. This is a good outcome for growers looking for extension information following on from the project, results will be included in further communication with this investment.

Barriers to adoption will include a lack of suitable germplasm developed by breeders for the higher rainfall zones of SA due to market failure. While winter cultivars appear to have a higher yield potential, their yield is less stable and are more negatively impacted by drought than well adapted spring cultivars. This may be too risky for some growers. Other barriers include the lack of market development of longer developing cultivars for malting. Growers will likely choose established well adapted spring malting varieties such as Planet and even lower yielding options such as Westminster.

We also recognise that the major barley area of Southern Australia is located in the Low – Med Rainfall environments where slow developing varieties will not be suited.

POSSIBLE FUTURE WORK

The project was only one year of field work and the findings have been successfully used to guide further work, including future investment by GRDC in the Hyper Yielding initiative and irrigation experimentation in high yield scenarios. The lack of yield advantage of the winter cultivars highlights the need for more germplasm development. There is also need for more agronomic work to establish the best management practices to reduce lodging and improve biomass partitioning in these higher rainfall regions.

Kenton has approached GRDC about continued support for early sowing work in barley, currently there isn't any reliable information for early sowing barley in the low – high rainfall environments of SA.

In Collaboration with Secobra, faster developing winter cultivars are now available and have been passed through quarantine and are being bulked up for experimental work potentially in 2020.