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Crop Updates 2007 - Cereals

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May the productivity and profitability of 2007 make the hardship of 2006 a distant memory.

Steve Penny
CEREALS CONVENOR

Strategies for aligning producer and market imperatives in cereal breeding in Western Australia

R. Loughman, R. Lance, I. Barclay, G. Crosbie, S. Harasymow, W. Lambe, C. Li, R. McLean, C. Moore, K. Stefanova, A. Tarr and **R. Wilson**, Department of Agriculture and Food, Western Australia

KEY MESSAGES

The cereal grain supply chain is serviced by breeding entities that are required to develop varieties that have improved production and marketing characteristics in optimal combinations. Productivity and yield stability gains and grain quality advances required in marketing demand constant attention in breeding. Objectives can only be met through access and adoption of breeding related technology through utilisation of extensive regional, national and international networks for R&D. Breeding provides a key mechanism for delivery of innovation and technology through extensive R&D programs firstly to farms as new varieties then into markets as improved commodity grades and to consumers as excellent products.

BACKGROUND

Requirements for cereal varieties include a breadth of production and marketability characteristics to maximise industry returns in competitive export markets. Drivers of change in cereal breeding in WA reflect these market and production challenges and form the basis of demand for technological advances in breeding methods.

MARKET IMPERATIVES IN WHEAT AND BARLEY

Within the four premium quality wheat grades in WA (AH, APW, ASWN, ASFT) there exist an extensive array of quality parameters that reflect market requirements. These include numerous delivery standards, milling characteristics and end product performance. The difference in quality parameters between the grades requires the maintenance of three broad germplasm pools, hard, white salted noodle and soft. AWB Crop Shaping priorities for the AH and APW main milling grades, primarily sold into noodle markets throughout Asia, include improved milling yield, noodle colour stability, dough characteristics and starch properties. Among white salted noodle markets in Japan and Korea, noodle colour, colour stability and noodle texture are key considerations. For export soft wheat grades, improving milling yield (including grain size) and flour colour while maintaining weak but extensible doughs are key considerations.

Similarly, quality conscious barley markets have closely defined delivery standards, malting characteristics and requirements for end product performance. Malt extract and fermentability are key criteria that have re-asserted WA malt barley production into key Asian markets in China, Japan and Korea with new premium malting varieties.

PRODUCER IMPERATIVES

While the production requirements vary substantially within different production regions in Western Australia, broad requirements are maximum yield potential and manageable production risk. Risk management includes both disease resistance (biotic factors such as stripe rust, septoria nodorum blotch) and environmental tolerances (abiotic factors such as drought, pre-harvest sprouting and acid soil/aluminium tolerance) for which important gains have been made but for which significant challenges still remain.

ADDRESSING MARKET AND PRODUCER IMPERATIVES – SOME EXAMPLES

Direct selection for yield potential and grain size

These are genetically very complex factors (i.e. determined by many genes). Generation of potential genetic variation for yield requires a broad germplasm base. Approximately 1000 wheat crosses and 350 barley crosses are generated each year by the breeding programs, from a wide range of parents.

As there are no reliable indirect measures, yield requires comprehensive field evaluation undertaken over repeated generations as seasonal effects are large and multiple years are very important. Lines from F_4-F_7 comprise over 120,000 wheat and 40,000 barley yield plots tested each year spread across a total of 12-14 WA locations. Promotions from this material enter wide scale tests (F_8-F_{10}) and the best approx. 25 wheat lines and 10 barley lines are subject to the most advanced wide scale stage 4 crop variety testing (CVT) at around 20-40 locations each year, depending on the crop and stage. This strategy has identified a range of widely adapted high yielding varieties establishing new industry benchmarks in a range of quality grades such as wheats; Carnamah, EGA Bonnie Rock, Tammarin Rock (AH); Westonia and Wyalkatchem (APW); Calingiri (ASWN) and EGA 2248 (ASFT) and malting barleys; Gairdner, Baudin, Hamelin and Vlamingh. Key innovations for assessing yield have been in information database software development and adoption of improved experimental trial designs and analysis, providing optimum statistical analytical tools and experiment outcomes. Highly mechanised field trial management has been achieved with timely and efficient systems for seeding (four teams at around 1000 plots per hour per team) and harvest (two teams at around 4000 plots per day per team) using agronomically relevant equipment.

Grain size is a key market requirement contributing to market quality including milling and malting performance. The traditional reliance of the export soft wheat industry on club-headed wheats established a bottle-neck for genetic gain in this grade, resulting in reduced international competitiveness through the 1990s. Industry analysis challenged the historical preference for club wheats in this grade resulting in a clear strategy to diversify the base of the ASFT germplasm pool by the inclusion and selection of improved grain size through non-club headed wheat in WA soft wheat breeding. This has resulted in the development of new varieties with benchmark characteristics of substantially improved grain size (EGA 2248 and EGA Jitarning) to maintain competitiveness in key Asian markets. Maintaining and improving grain size remains a key objective across DAFWA wheat and barley breeding with direct selection by sieving and single kernel characterisation system tools to build on excellent performance of varieties such as Westonia, Wyalkatchem and Calingiri wheat and Hamelin, Baudin and Vlamingh barley.

Combining direct and indirect selection for key quality and disease traits

Milling yield in wheat and malt extract in barley are also genetically complex and are measured directly through small scale wheat mills and barley micro-malting units. Both of these direct tests, while essential, must be rationed as they are expensive and slow to perform. DAFWA, in collaboration with national R&D programs in wheat and barley quality, has developed analytical tools for using near infra-red spectrometry (NIR) equipment. The major advantages of this spectral analysis technology are speed and high through-put, non-destructive whole grain analysis (selected samples can be used for seed) and capacity to evaluate multiple traits (calibrated correlations against directly tested samples). In this way, approximately 15,000 additional wheat samples and 6000 additional barley samples can be tested per year, enabling indirect selection for improved flour yield, protein, water absorption and flour colour and grain hardness in wheat; improved malt extract, protein, husk content, grain colour and hardness in barley. Essentially this allows key quality testing to be performed significantly earlier in the breeding cycle. Development and application of new NIR technology has greatly enhanced the opportunity to capture further quality improvements demanded by markets and build on the improvements of industry benchmark varieties such as EGA Bonnie Rock (premium choice wheat variety), Wyalkatchem (preferred APW wheat), Baudin and Hamelin (premium malting potential) developed by DAFWA.

Rust resistance targets have expanded considerably in the DAFWA program in the last 10 years as the challenge has moved from wheat leaf rust in the 1990s to include wheat stripe rust (WYR), wheat stem rust (WSR) and barley leaf rust (BLR) in the 2000s. These changes have arisen from a combination of apparent introductions and pathogen mutations for virulence. Direct selection for resistance needs to target the individual diseases, including different pathotypes in WA and eastern Australia. Industry analysis established agreed minimum disease resistance standards for wheat to enable a very large and productive wheat industry to develop with a manageable level of risk of rust losses. This resulted in a clear strategy to enhance and diversify the base of the DAFWA germplasm pool for rust resistance. In barley, essential improvements in malting quality achieved in new varieties has been accomplished as a market priority ahead of disease resistance and key varieties remain susceptible to barley leaf rust, a major industry constraint on the south coast. Key opportunities for sustainable genetic gain in rust resistance require three key components. First is capacity to reliably screen for each rust from early stages of the breeding program. This is achieved in wheat by utilising field screening capacities of 25,000 row-plots at two WA field sites outside the wheatbelt, strategically

supplemented by capacity of 10,000 glasshouse seedling tests pa. Second are key R&D linkages to access wheat and barley genes for resistance diversity (in conjunction with the University of Sydney's GRDC-funded Australian Cereal Rust Control Program) and the capacity to utilise them through additional breeding strategies including backcrossing. Third are technology solutions to pyramid combinations of rust resistance genes to provide depth and sustainability of resistance against novel pathotypes, by combinations of fully effective ('seedling') genes and partially effective ('adult') genes using molecular marker assisted selection (MAS). Here there is increasing developments in technologies of MAS where DAFWA has active collaborations in key R&D partnerships, including Murdoch University, University of Sydney, CRC for Molecular Plant Breeding, CRC for Value Added Wheat, CSIRO as well as other wheat and barley breeding organisations.

Using indirect selection for intractable traits

Pre-harvest sprouting (PHS) is a significant risk factor in wheat and barley production in a considerable portion of the WA growing environment. Research in the last five to 10 years has focussed on factors that contribute to seed dormancy which is the most stable form of PHS (distinct from effects of maturity or head type, etc.) but is also the most difficult and expensive to measure. While genetic variation exists in wheat for this trait, systems required for routine screening in breeding need to handle the scale at a reasonable cost. Current national strategies are aiming to enhance the understanding of the genetics of PHS to improve precision of selection with molecular markers. Providing a basis for expanding currently targeted breeding activities across broader germplasm pools is an objective for the future.

Barley researchers have identified a group of genes on chromosome 5HL which are associated with improved quality; especially malt extract. This gene is often found in superior quality barleys from Canada (e.g. Harrington). However this same gene is believed to be responsible for a propensity towards pre-harvest sprouting. A new form of the gene (allele), identified in DAFWA elite malting barleys, has both high malt extract and tolerance to PHS. It is being rapidly incorporated into a wide range of superior barley germplasm using MAS.

Molecular markers have been used in barley to backcross other target traits into elite barley varieties. Target traits include high thermostable and high activity beta-amylase from a wild barley (*Hordeum spontaneum* L.), acid soil tolerance and multiple disease resistance genes. Backcrossing the acid soil/Al tolerance gene (*Alta*) into elite varieties such as Baudin and Hamelin has achieved great success through employing marker-assisted selection. New acid soil/aluminium tolerant versions of malting barley varieties Baudin and Hamelin have yielded 20-30 per cent greater than their parents in large scale trials on acid soils. The target date for release of these barleys is 2009.

Changing the adaptation of premium malting quality barley

Harrington barley from Canada has been a dominant malting barley in the international market due to its superior malting quality. The major limitations for growing Harrington in Western Australia are late maturity, low yield, small grain and disease susceptibility. The Australian Winter Cereal Molecular Marker Program (AWCMMP) developed a mapping population from the cross Chebec/Harrington to identify genes controlling malting quality from Harrington, and disease resistance genes and local adaptation genes from Chebec. Superior individual doubled haploids from the mapping population with specific attributes were selected as parental lines to cross with Harrington. Individuals from BC1F5 were re-selected using molecular markers for photoperiod response, CCN, spot type net blotch resistance and malting quality. Two new breeding lines have progressed to Crop Variety Test trials. The new breeding lines have combined early maturity, with excellent malting quality and disease resistance. The markers for photoperiod response, high malting quality and CCN resistance have been successfully used to transfer the target traits with results as expected or better. However, the breeding lines do not express improved disease resistance to spot type net blotch resistance even though they contain the Rpt4 resistance gene. The next challenge is that the new breeding lines are susceptible to pre-harvest sprouting (ch 5HL above) and require the newly identified PHS tolerance allele with premium quality.

Achieving rapid delivery to market

Adoption is the key to delivering genetic gains established through R&D, incorporated through breeding so that it can be utilised through the production-marketing-consumption pipeline. Just as breeding interacts with associated R&D programs to develop technology advances, R&D programs require breeding entities. DAFWA's innovative commercialisation strategies ensures growers gain the

opportunity to adopt varieties through farmer to farmer trading after the expiration of a defined-period seed licensing agreement. Growers adopt new varieties when they have cost effective access to them, supported by credible and reliable yield and other agronomic performance data. Correct adoption decisions demand quality information and require considerable resources (e.g. GRDC's NVT program, DAFWA's CVT and agronomy programs) to provide this information. An example of the success of this strategy is the adoption of Wyalkatchem wheat in WA which grew from close to zero to over 1 M ha in just three years establishing its position as the most rapidly adopted wheat in the history of the Australian wheat industry.

FUTURE CHALLENGES

While production and market imperatives remain or increase (i.e. the dilemma of converging costs and prices), additional future challenges are likely to exist for the cereals industries in WA. Changing pathogen spectra could include new mutations or introductions of new pathogens (e.g. Karnal bunt) which could have a major bearing on production costs, productivity or marketing. Drought tolerance is already a key requirement for large sectors of the industry where regular end-of-season moisture stress is encountered. This is predicted to increase in frequency of occurrence over the next 20-50 years in some environments. Increasing effects of hostile soils are likely to become apparent with worsening salinity or acidity. Genetic gains can be readily made for individual characters but for every extra trait incorporated and selected, additional effort and material handling is required to avoid losing pace in other areas such as overall genetic gain for yield. The challenge is integrating new and existing demands to achieve ongoing progress across all the market and production requirements, of which a small selection have been discussed through this paper.

CONCLUSION

A strong market focus on grain quality (where 95 per cent of WA wheat production and 80 per cent of barley production is exported), excellent yield potential, environmental adaptation and tolerances to important biotic and abiotic stresses are objectives being realised in the GRDC supported DAFWA wheat and barley programs. DAFWA varieties, prominent in premium grades, are sown over 80 per cent of wheat areas and up to 90 per cent of barley areas in WA with some grades (noodle and export soft) entirely serviced from this program. Delivery of cereal varieties for future needs of the WA industry will required excellence in field evaluation, diversity in germplasm for high yield, quality, disease and stress resistance, diversity of breeding methods and a strong commitment to the ongoing development of new technologies and maximum integration of those technology outputs.

KEY WORDS

crop productivity, disease resistance, abiotic tolerance, grain quality

ACKNOWLEDGMENTS

DAFWA cereal breeding programs are supported by the Grains Research and Development Corporation. DAFWA staff in field breeding teams, grain products laboratories, pathology, physiology, breeding technology, biometrics, biotechnology crop variety testing, agronomy and research support units contribute to R&D development and adoption in breeding. DAFWA Cereal breeding values the contributions and ongoing collaborations of key organisations around Australia who contribute to genetic improvement in barley and wheat in WA.

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Paper reviewed by: Bevan Buirchell

LongReach plant breeders wheat variety trials – 2006

Matu Peipi and **Matt Whiting**, LongReach Plant Breeders

KEY MESSAGES

LongReach Plant Breeders has conducted trials in all the main production environments of the Australian wheat belt since it commenced operations in 2002. The LongReach breeding program reached full scale in 2005. Approximately 40 per cent of the LongReach breeding investment is targeted at varieties for Western Australian growers. LongReach Plant Breeders is a division of Syngenta Seeds Pty Ltd.

AIM

To evaluate new wheat germplasm adapted to the main Western Australian Agricultural Zones and develop and release commercial varieties to WA farmers.

METHOD

In winter 2006, LongReach conducted 22 field trials across the WA wheat belt, with the aim of testing new germplasm at various stages of development. Nine of these trial sites were Elite line evaluations, each planted with a total of 74 entries, including LongReach wheat lines closest to release (first year NVT entries in 2007), as well as commercially available controls to enable agronomic, disease, yield and quality comparisons. These trials were planted by independent contractors in carefully selected paddocks provided by farmer cooperators. Various assessments, including establishment, foliar disease resistance, maturity, height and lodging, were made through out the season. Each of the trial sites has been harvested and subsequently analysed for yield and will also be tested for receival standards. Samples from each development stage will be fully evaluated against industry standards for wheat quality and suitability for classification into WA commodity grades.

Trial details

Location	Nine trial sites located on farms in diverse locations (Arrino, Buntine, Cadoux, Esperance, Goomalling, Hyden, Katanning, Kellerberrin, Mingenew).
Plot size and design	Plot size = 10 m long x 1.2 m wide; 3 replicate randomised complete blocks for each trial.
Soil type	A range of soil types representative of each Ag Zone.
Sowing date	All within the first 22 days of June 2006.
Seeding rate	Target 75 kg/ha.
Fertiliser (kg/ha)	Rate and product is varied based on soil analysis results.
Paddock rotation	Paddocks selected to reflect district practice and situations facing farming enterprises.

RESULTS

The yield results of some of the new LongReach wheat lines are shown in Table 1 in comparison with commercial varieties. The list shows only the top 10 ranked varieties with their yield in tonnes/hectare and expressed as a percentage of the site mean yield. Three LongReach lines, LongReach Guardian, LPB04-0208 and LPB0056 were better than the site mean yield at all seven sites, and showed an ability to yield across the WA wheatbelt comparable with the named varieties.

CONCLUSION

The LongReach breeding objectives emphasise consistent field performance, attractive end-use quality and diverse disease resistance, and these targets are reflected in the evaluations conducted during the variety development process. Currently the LongReach breeding pipe line carries a diverse

range of materials from numerous local and international sources, including derivatives of proven WA wheat lines. The 2007 trial program will continue testing a full range of germplasm, assessing each line for a range of agronomic features and post harvest traits. Promising lines will continue to be included in the NVT network to enable growers to evaluate their suitability within each AgZone. LongReach Plant Breeders aim to have a number of high quality milling wheats, with specific suitability to WA environments, available for commercial release within the next two years.

LongReach currently has three commercially available wheat varieties: Sentinel^{3R}, LongReach Catalina and LongReach Guardian.

Sentinel^{3R}, an ASW milling wheat in WA, is a mid-season to longer-season variety suited to the medium to higher rainfall environments, with good acid soil tolerance. It is resistant to all current field strains of stem, stripe and leaf rust.

LongReach Catalina, is an AH milling wheat in SA and Vic and is currently APW in WA. It has useful (MR-MS) field resistance to Yellow Spot, is resistant to CCN and has multi gene resistance to all current field strains of stem and leaf rust. Catalina has been tested in a range of environments across southern Australia since 2002, and is well–adapted to the Mallee environments.

LongReach Guardian, released in 2006, has a stem rust rating of Resistant to Moderately Resistant (R-MR) and has an APW classification in SA, Victoria and NSW. It has been tested widely across WA in LongReach trials as well as in NVT's and other independent trials in 2006, with promising yield results. The current classification for Guardian in WA is Feed.

Additional variety specific information for these new LongReach releases may be obtained through AWB Seeds.

KEY WORDS

Longreach Plant Breeders, wheat breeding, wheat variety

ACKNOWLEDGMENTS

LongReach Plant Breeders acknowledges the assistance of numerous independent professional contract service providers and public agency researchers with the development of LongReach varieties and the support of farmer cooperators in all parts of the Australian wheatbelt who have provided trial sites since 2001.

Table 1. Average yield of wheat sown in seven LongReach trials across the WA wheat belt in 2006

Variety	Goomalling		Buntine		Hyden		Mingenew		Esperance		Katanning		Arrino		WA Average		
	T/HA	% of SMY	T/HA	% of SMY	T/HA	% of SMY	T/HA	% of SMY	T/HA	% of SMY	T/HA	% of SMY	T/HA	% of SMY	T/HA	% of SMY	RANK
LongReach Guardian	3.2	139	1.8	118	2.3	112	1.0	132	2.4	120	2.0	130	1.7	115	2.1	124	1
Carnamah	2.7	119	1.9	124	2.3	112	1.1	138	2.1	106	1.9	124	2.0	138	2.0	121	2
Wyalkatchem	2.5	109	1.9	119	2.4	116	0.9	119	2.8	142	1.8	116	1.8	120	2.0	120	3
LPB04-0208	2.8	120	1.9	120	2.4	115	0.9	110	2.5	128	1.7	111	1.7	115	2.0	118	4
LPB0056	2.6	114	1.7	109	2.4	115	1.1	137	2.3	116	1.8	119	1.7	115	1.9	116	5
Datatine	2.8	123	1.6	100	2.6	125	0.9	113	2.2	109	1.7	112	1.7	118	1.9	115	6
Yitpi	3.0	130	1.7	109	2.5	121	0.8	105	2.2	109	1.6	108	1.5	101	1.9	114	7
Tammarin Rock	2.2	94	2.1	132	2.4	116	1.0	129	2.2	112	1.6	107	1.8	121	1.9	114	8
Arrino	2.6	115	2.1	132	2.2	104	0.8	98	2.2	110	1.6	106	1.8	121	1.9	113	9
Calingiri	2.8	123	1.8	113	2.2	107	0.8	106	1.9	98	1.8	121	1.6	110	1.9	112	10
Site mean yield	**2.3**	**100**	**1.6**	**100**	**2.1**	**100**	**0.8**	**100**	**2.0**	**100**	**1.5**	**100**	**1.5**	**100**	**1.7**		

Notes: **% of SMY = Percent of Site Mean Yield**

Response of wheat varieties to sowing time in the northern agricultural region in 2006

Christine Zaicou, Department of Agriculture and Food, Western Australia, Geraldton

KEY MESSAGES

There was no yield penalty for sowing dry in May and having the plants emerging nearly one month later compared to wet sowing in late June.

At Mingenew, sowing on 10 July reduced the average yields to 0.8 t/ha compared to 1.1 t/ha with the late June sowing.

Wyalkatchem and EGA Bonnie Rock were higher yielding varieties and coupled with EGA Bonnie Rock's premium for quality, were also the most profitable.

It is difficult to gauge the true potential of varieties in a very dry season (Decile 1) and driest on record for both Mingenew and Buntine.

AIMS

To assist growers in making decision on variety choice and management, trials were conducted at Mingenew and Buntine to assess the response of new and potential wheat varieties to different sowing times. [Note: A similar trial located at Mullewa on the red loam did not reach maturity due to moisture stress.]

METHOD

Field based trials in 2006 were located on yellow sand plain at Mingenew and loamy sand at Buntine. Twenty-four cultivars from various breeding programs were sown at three sowing times in a randomised split block design. At Mingenew (Agzone 1), time of sowing 1 (TOS1) was sown in late May on less than 10 mL of rain and did not emerge until the following rain in late June. Time of sowing 2 (TOS2) was sown with the late June rains and emerged a few days after TOS1. Time of sowing 3 (TOS 3) was sown into moisture on 10 July and emerged a few days later. The growing season rainfall from May to October was 146 mm. At Buntine (Agzone 4), TOS1 was sown in mid May and established well. TOS2 was sown in late May but did not emerge until late June. TOS3 was sown in late June and emerged a few days later. The growing season rainfall from May to October was 94 mm.

Note: Screenings include whole and cracked grain. Gross income was calculated on the average yield and quality for each treatment using AWB Golden Rewards – Base rate APW$250, AHP$260, AH$255 and ASW$237.

RESULTS AND CONCLUSIONS

Yield penalty and time of sowing

In 2006, there was no yield penalty by sowing the varieties in dry soil conditions in mid May (TOS1) with emergence one month later in late June compared to sowing into moist soil conditions in late June at Mingenew. The first and second time of sowings emerged in late June (within a few days of each other) and the yields were not significantly different (1.21 t/ha and 1.09 t/ha). A similar result was also observed at Buntine with TOS2 (sown in late May and emerging in late June) (0.58 t/ha) and TOS3 (0.44 t/ha) emerging a few days following the late June sowing.

At Mingenew, sowing on 10 July reduced the average yields to 0.8 t/ha compared to 1.1 t/ha with the late June sowing.

Traditionally, the yield potential of a crop sown in mid May will be much greater than for a crop sown in late June. However, at Buntine in 2006, TOS1 (mid May) emerged directly following seeding and experienced extended dry periods through May and June, and again in September leading to extremely low yields across the times of sowing.

Screening (whole and cracked grain) increased and hectolitre weight decreased with delayed sowing time at both sites. However some varieties tended to have a lower risk of screenings. These included Arrino, Calingiri, Carnamah, GBA03.1129, Sentinel, Tammarin Rock, Wyalkatchem and Yitpi (Table 1 and 2). Note: These are preliminary screenings and the rankings may change with the removal of cracked grains (Table 1).

There was no yield penalty for sowing dry in May and having the plants emerging nearly one month later compared to wet sowing in late June. However, it is important for growers to manage the risk of erosion with dry sowing and early sowing in a dry season.

Target high yielding premium varieties

Wyalkatchem and EGA Bonnie Rock were the higher yielding APW and AH varieties and coupled with the price premium for EGA Bonnie Rock's quality, were also the most profitable. Wyalkatchem tended to have a lower risk of screenings compared to EGA Bonnie Rock.

It is difficult to gauge the true potential of varieties in a very dry season (Decile 1) and lowest on record for both Mingenew and Buntine. Young yielded relatively well however it had a higher risk of screenings, as did EGA Wentworth.

Binnu, the recently released ASWN wheat yielded well compared to Calingiri, however it has a higher risk of screenings than either Arrino or Calingiri. Due to the 2006 season being so dry protein levels were high and payments were based on ASW.

Growers have several newer premium variety options available, including Young, Binnu and EGA Wentworth, however the risk of small grain screenings with these particular varieties needs to be considered.

KEY WORDS

wheat varieties, agronomy, crop management, time of sowing

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Table 1. Effect of sowing time/emergence date on yield, quality and economic returns of wheat varieties sown in Mingenew on yellow sand plain in 2006

		Grain yield (t/ha)			Protein (%)			Screenings (%)*			Hectolitre wt (kg/hL)			Gross income ($/ha)		
		TOS1	TOS2	TOS3	TOS1	TOS2	TOS3	TOS1	TOS2	TOS3	TOS1	TOS2	TOS3	TOS1	TOS2	TOS3
AH	Carnamah	1.26	1.06	0.7	15.1	15.6	16.3	4.6	10.5	9.3	78.2	75.5	76.0	330	262	174
	EGA Bonnie Rock	1.37	1.22	0.94	15.4	16.0	16.1	4.6	9.6	15.5	80.3	79.0	77.8	367	295	212
	EGA Eagle Rock	1.16	1.04	0.62	15.6	16.1	16.2	6.9	9.0	14.2	78.5	78.6	77.6	296	255	142
	GBA Sapphire	1.14	1.04	0.75	15.5	15.4	15.8	6.8	18.9	18.8	79.8	78.7	77.5	286	213	153
	Tammarin Rock	1.25	1.22	0.90	14.8	15.3	15.1	3.9	4.0	10.7	78.0	79.0	75.9	319	323	215
	Yitpi	1.20	1.16	0.88	14.8	15.4	16.0	6.5	10.1	7.1	78.5	77.6	75.5	309	286	224
APW	Ellison	1.00	0.87	0.62	17.0	17.4	18.0	7.1	13.4	8.2	79.6	77.5	77.4	250	189	152
	EGA Wentworth	1.04	0.94	0.62	15.9	16.2	16.3	9.7	22.1	20.9	77.8	76.3	76.2	250	193	126
	Wyalkatchem	1.41	1.3	0.84	15.2	15.5	15.5	2.5	6.6	10.4	80.5	79.3	76.2	365	326	201
	Young	1.30	1.15	0.85	15.2	15.4	16.3	8.3	15.7	26.5	80.1	78.5	77.0	319	241	212
ASW	AGT Scythe	1.13	1.08	0.68	15.8	15.9	16.9	7.5	14.3	17.0	74.8	73.0	71.7	264	233	140
	Guardian	1.32	1.14	0.89	14.7	15.0	15.3	9.8	16.5	22.3	80.3	78.9	77.9	300	238	181
	H46	1.16	1.06	0.83	15.3	15.9	15.5	7.7	13.9	23.3	80.3	79.2	77.7	272	227	171
	Sentinel	1.13	1.04	0.73	15.4	15.8	15.9	8.0	10.6	9.8	78.0	77.8	76.4	265	231	175
ASWN	Arrino	1.22	1.22	0.77	16.0	16.2	16.5	2.5	7.1	12.3	79.5	77.8	75.4	302	288	169
	Binnu	1.33	1.11	0.87	14.6	15.2	15.5	9.2	14.1	20.3	78.8	78.1	76.0	306	240	178
	Calingiri	1.37	1.17	0.89	14.4	15.3	15.3	4.3	6.3	7.7	80.0	79.4	78.0	337	280	207
	WAWHT2773	1.33	1.17	0.83	15.4	15.9	16.2	4.4	9.4	12.3	79.6	78.1	75.8	337	280	207
Unclassified	GBA03.1129	1.10	1.08	0.76	16.2	16.6	16.8	3.1	6.8	8.3	78.6	77.5	75.9			
	GBA3.09.AH	1.15	0.97	0.67	15.4	15.9	16.6	7.2	18.7	15.0	80.1	77.9	78.0			
	WAWHT2713	1.03	0.98	0.75	15.3	15.6	15.7	10.2	11.7	8.5	77.5	76.9	71.9			
	WAWHT2750	1.32	1.12	0.76	15.4	15.4	16.1	2.6	6.0	6.9	78.1	77.2	75.1			
	Average within each TOS	1.21	1.09	0.78	15.3	15.7	16.0	6.4	11.8	13.9	79.0	77.8	76.4			
	TOS (lsd)	0.16			0.3			1.6			0.7					
	Var (lsd) within TOS	0.14			0.62			2.1			0.9					
	%CV	10.2			2.4			11.9			0.6					

Table 2. Effect of sowing time/emergence date on yield, quality and economic returns of wheat varieties sown in Buntine on loamy sand in 2006

		Grain yield (t/ha)			Protein (%)			Screenings (%)*			Hectolitre wt (kg/hL)			Gross income ($/ha)		
		TOS1	TOS2	TOS3	TOS1	TOS2	TOS3	TOS1	TOS2	TOS3	TOS1	TOS2	TOS3	TOS1	TOS2	TOS3
AH	Carnamah	0.57	0.60	0.47	14.0	15.2	15.7	10.9	13.1	17.3	80.8	78.1	75.6	149	131	97
	EGA Bonnie Rock	0.56	0.64	0.53	15.4	15.8	16.0	13.5	12.2	15.4	81.1	80.7	79.1	129	148	121
	EGA Eagle Rock	0.42	0.38	0.37	15.3	16.2	16.7	7.1	10.7	13.5	80.6	79.9	78.4	107	90	86
	GBA Sapphire	0.40	0.60	0.50	15.0	14.7	16.0	7.6	11.9	15.9	82.0	79.9	78.7	100	141	105
	Tammarin Rock	0.48	0.56	0.51	14.2	14.9	15.3	9.9	13.7	14.5	80.3	77.6	77.1	119	129	109
	Yitpi	0.55	0.72	0.43	15.1	15.3	17.4	11.3	14.4	12.6	79.9	78.7	77.6	132	167	102
APW	Ellison	0.41	0.48	0.42	16.1	16.2	17.4	7.8	14.4	15.1	82.0	79.3	78.0	100	111	90
	EGA Wentworth	0.47	0.55	0.47	14.8	16.3	16.8	7.9	16.9	23.8	81.6	78.4	77.0	115	114	97
	Wyalkatchem	0.49	0.60	0.55	15.1	15.8	16.2	5.6	10.2	13.2	80.9	79.2	77.5	125	144	119
	Young	0.41	0.54	0.36	15.3	15.7	15.6	9.7	15.8	21.3	80.2	79.6	78.6	99	114	75
ASW	AGT Scythe	0.61	0.63	0.48	13.4	15.3	15.3	11.3	16.5	20.2	80.7	75.5	73.7	136	133	99
	Guardian	0.50	0.52	0.45	14.5	15.6	16.0	11.4	18.8	24.9	80.5	79.7	78.1	120	106	92
	H46	0.54	0.62	0.50	14.7	15.2	15.4	6.8	16.1	19.1	82.3	80.5	79.6	129	131	102
	Sentinel	0.51	0.47	0.37	15.6	15.5	16.5	9.5	17.0	16.3	79.5	77.9	77.8	117	98	78
ASWN	Arrino	0.46	0.55	0.49	14.9	15.6	16.4	4.8	9.1	12.2	81.7	79.1	77.9	111	127	108
	Binnu	0.53	0.55	0.41	14.5	15.2	16.4	9.2	17.8	24.9	81.4	78.6	76.8	123	112	83
	Calingiri	0.60	0.56	0.42	14.8	15.2	15.4	8.4	12.3	13.8	80.4	78.6	77.1	139	123	91
	WAWHT2773	0.66	0.59	0.46	14.9	16.7	16.2	7.1	12.4	15.3	80.7	78.2	77.0			
Unclassified	GBA03.1129	0.49	0.58	0.48	15.7	15.6	15.3	8.8	11.4	12.3	80.4	78.7	77.4			
	GBA3.09.AH	0.43	0.52	0.40	14.8	16.1	16.2	6.0	12.6	16.4	81.7	79.8	77.9			
	WAWHT2713	0.46	0.36	0.25	15.9	17.1	17.2	9.4	13.4	11.7	78.2	77.6	77.6			
	WAWHT2750	0.52	0.54	0.44	15.6	15.7	15.4	7.8	9.6	11.1	80.2	78.0	77.0			
	Average within each TOS	0.51	0.56	0.44	14.9	15.6	16.1	8.8	13.7	16.3	80.8	78.8	77.6			
	TOS (lsd)	0.08			0.25			0.6			1.0					
	Var (lsd) within TOS	0.10			1.12			3.1			0.9					
	%CV	6.7			4.5			14.6			0.7					

Response of wheat varieties to sowing time in the central agricultural region in 2006

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KEY MESSAGES

- The newly released noodle wheat variety Binnu yielded very similar to Arrino and Calingiri at both Merredin and Wongan Hills, but the screenings were a little higher than the other noodle varieties under the dry conditions of 2006.
- Average grain yield from late May sowing out-yielded late June sowing by 33 per cent at Merredin and early July out-yielded late July by 24 per cent at Wongan Hills.
- Arrino, Binnu, Calingiri, Wyalkatchem, EGA Tammarin Rock, EGA Bonnie Rock were higher yielding varieties at Wongan Hills at all times of sowing. However, Westonia, WAWHT2773, and WAWHT2750 performed well at Merredin relative to Wyalkatchem and Carnamah.

AIMS

To investigate how new wheat varieties respond to sowing times and environments in the Central Agricultural Region.

METHOD

Two experiments were conducted at Merredin and Wongan Hills research station including 24 varieties sown at three times of sowing. Varieties were selected on the basis of preliminary information provided by breeding sources including interstate and private companies. The first time of sowing only at Merredin was sown after irrigating the trial site to generate information on early May sowing. First time of sowing was completed at Wongan Hills close to the break. Subsequent sowings were at 20-37 days as rainfall allowed. Soil type and crop rotation at Wongan Hills (Agzone 2) was shallow sandy duplex after lupins and clay loam after field peas at Merredin (Agzone 4). Data on grain yield, and grain quality were recorded and analysed using Genstat.

Note: Screenings include whole and cracked grain. Gross income was calculated on the average yield and quality for each treatment using AWB Golden Rewards-Base scale: APW $250, AHP $260, AH $255, ASWN $255 and ASW $237.

RESULTS

Growing season rainfall from April-October was 229 mm at Merredin and 158 mm at Wongan Hills. Low rainfall in October and November were associated with severe yield reductions and high screenings in the latest sowings at both sites.

Grain yields are given for Merredin in Table 1 and Wongan Hills in Table 2. At the Merredin site, most of the AH varieties achieved more than 13 per cent protein at all sowing times. However, all noodle wheat varieties recorded above the delivery standard of 11.5 per cent at all times of sowing except Binnu (11.5 per cent) at early May sowing. Screenings were low in early and late May sowing but high in Late June sowing. At the early May sowing at Merredin AGT Scythe, WAWHT2750, Westonia, WAWHT2773 and Wyalkatchem occupied the top ranked group for grain yield. Grain yield decline with subsequent sowing times was significantly greater in Ellison, Calingiri, WAWHT2773 and EGA Wentworth.

The grain yield of the new noodle variety Binnu exceeded the check at Wongan Hills when sown in early July (Table 2). But the gross income was lower than Arrino and Calingiri at Wongan Hills (Table 2). Binnu is slightly earlier maturing than Arrino and resistant to stripe and leaf rust but screenings were higher than Arrino and Calingiri. The highest yielding released variety at Wongan Hills was Arrino followed by Tammarin Rock, Wyalkatchem and Binnu. Other varieties that performed well in terms of grain yield were Bonnie Rock, Yitpi, Young, Calingiri and Guardian. However, the

gross income of Arrino, Wyalkatchem, Yitpi and Tammarin Rock were higher than Bonnie Rock and Eagle Rock at Wongan Hills. (Table 2). Most of the varieties had low screenings and high hectolitre weight (exceeding 74 kg/hL minimum standard).

CONCLUSION

These results can support variety choices for 2007, based on the considerations that influence gross returns and risks - grain yield, grain quality and disease ratings.

KEY WORDS

wheat varieties, wheat agronomy, crop management, time of sowing, grain yield, protein

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Table 1. Effect of sowing time on grain yield, quality and economic returns of wheat at Merredin

		Grain yield (t/ha)			Protein (%)			Screenings (%)			HLW			Gross income		
		8 May	29 May	28 Jun	8 May	29 May	28 Jun	8 May	29 May	28 Jun	8 May	29 May	28 Jun	8 May	29 May	28 Jun
AH	Carnamah	1.33	1.29	1.04	12.2	13.3	14.7	5.5	3.2	8.7	83	81	75	340	343	260
	EGA Bonnie Rock	1.49	1.35	0.93	12.9	12.9	15.6	1.2	2.9	11.9	84	83	79	402	358	219
	EGA Eagle Rock	1.36	0.97	0.8	13.5	14.3	16.5	2.8	3.9	12.8	82	80	77	360	257	186
	GBA Sapphire	1.44	1.41	0.86	12.6	13.2	16.5	2.7	2.6	26.6	84	83	77	379	374	175
	Tammarin Rock	1.39	1.42	1.08	13	12.8	15.6	1.2	2.4	17.5	82	81	73	375	375	221
	Yitpi		1.44	0.8	13.4	14	16.4	2.1	3	6.7	84	81	78		386	202
APW	Ellison	1.39	1.37	0.68	13.7	14.2	15.5	1.5	3.2	7.9	85	82	78	366	356	169
	EGA Wentworth	1.52	1.41	0.74	12.6	13.9	15.4	3.4	5.5	25.5	84	81	75	392	365	174
	Westonia	1.6	1.5	0.9	12.1	12.8	15	4.6	2.8	12.5	82	79	75	410	389	212
	Young		1.52	0.93	12.4	13.1	15.2	8.4	3.7	25.3	84	83	76		392	190
	Wyalkatchem	1.45	1.26	1.04	13.1	13.2	15.7	2	1.4	11.8	83	83	74	381	331	245
ASW	AGT Scythe	1.78	1.34	0.81	11.7	13.9	16.5	2.5	4.8	12.3	83	77	72	440	326	178
	H46	1.15	1.21	0.97	12.8	12.7	14.2	3	4.2	22.5	82	83	79	285	292	198
	Sentinel	1.47	1.35	0.91	12.8	13.5	15.2	1.4	3.7	9.9	82	80	77	370	333	207
ASWN	Arrino	1.4	1.25	1.03	12.3	13	14.4	1.6	1.7	16.4	83	82	76	351	314	210
	Binnu	1.46	1.16	0.9	11.5	12	15.4	4.2	4.8	18.2	83	81	75	371	282	184
	WAWHT2773	1.6	1.55	0.78	11.8	13.2	16.1	1.1	1.9	10.8	83	82	76	398	392	159
	Calingiri	1.49	1.29	0.78	12.7	13.6	15.4	1.7	2	8.3	83	80	75	372	324	183
Unclassified	GBA03.1129	1.34	1.39	1.02	13.3	13.8	15.5	1.7	2	10.4	82	80	77			
	GBA3.09.AH	1.5	1.26	0.83	13.3	14.1	14.8	2.1	3.7	20.5	84	83	78			
	WAWHT2713	1.41	1.23	0.84	13.9	14.5	16.2	4.3	7.7	10.3	82	79	78			
	WAWHT2750	1.65	1.27	0.9	13	13.4	16.3	1.1	1.3	8.2	81	81	73			
	Average within each TOS	1.47	1.33	0.89												
	TOS (lsd)		0.06			1.5			5			1.7				
	Var (lsd) within TOS		0.12			0.7			3.1			1.2				
	Var TOS (lsd)		0.22			1.4			5.8			2.2				
	Var TOS (lsd diff mean)		0.22			1.2			5.4			2.1				
	%CV		5.9			3.4			22.1			1				

Table 2. Effect of sowing time on grain yield, quality and economic returns of wheat at Wongan Hills

		Grain yield (t/ha)			Protein (%)			Screenings (%)			HLW			Gross income		
		26 May	2 Jul	22 Jul	26 May	02 Jul	22 Jul	26 May	2 Jul	22 Jul	26 May	2 Jul	22 Jul	26 May	2 Jul	22 Jul
AH	Carnamah	2.92	1.9	1.44	11.2	12.2	14	8.9	10.8	3.8	79	76	83	710	418	384
	EGA Bonnie Rock	**3.1**	2.13	1.54	11.6	13.8	13.7	5.5	10.7	3.9	81	78	83	801	484	414
	EGA Eagle Rock	2.93	2.08	1.5	12.6	12.9	14.2	3	4.5	3	81	81	82	772	543	401
	GBA Sapphire	2.72	1.84	1.36	12.6	13.6	12.9	7.5	9.6	3.2	79	80	83	683	453	360
	Tammarin Rock	**3.15**	**2.26**	1.71	13.1	13.7	13.4	5	11.5	5.5	80	76	80	819	547	428
	Yitpi	**3.07**	**2.23**	1.67	12.3	13.8	13.7	7.8	6.6	4.3	81	81	82	768	565	436
APW	Ellison	2.52	1.88	1.22	11.4	13.2	14.2	7.9	7.2	7.3	80	81	83	620	468	304
	EGA Wentworth	2.87	1.91	1.44	12.2	13.4	13.3	8.9	11.6	3.5	79	77	83	692	418	373
	Young	2.84	**2.34**	**1.86**	11.8	13.8	13	5.9	6.4	4.9	80	78	81	710	583	474
	Wyalkatchem	**3.06**	**2.28**	**1.78**	11.6	13.4	12.4	2.6	10.5	2.7	80	78	82	786	547	465
ASW	AGT Scythe	2.68	1.9	1.67	11.8	13.7	13.3	11	9.2	5.4	75	74	79	586	439	403
	Guardian	2.8	2.02	1.64	11.7	14	13.9	5.8	6.8	4.3	79	76	83	672	479	403
	H46	2.81	2	1.62	11.4	13	13.4	7.2	11.9	5.8	82	79	83	666	456	389
	Sentinel	2.48	1.59	1.12	12.6	13.4	14.1	8.1	8.2	5.2	79	79	82	580	372	272
ASWN	Arrino	**3.06**	**2.3**	**1.87**	11.5	12.6	13.6	2.3	7.4	1.4	80	77	82	793	545	468
	Binnu	**2.95**	**2.43**	1.69	11.2	13.4	12.5	7.7	12.9	4.5	80	78	82	681	525	414
	WAWHT2773	2.74	2.01	1.68	11.9	13.5	13.6	4.9	5.5	3	79	77	82	666	485	416
	Calingiri	**2.97**	**2.31**	1.63	12	12.5	12.7	4.5	6.3	5.2	80	78	81	722	550	393
Unclassified	GBA03.1129	2.87	2.04	1.14	12	13.9	14.3	5.9	7.7	4.1	79	78	82			
	GBA3.09.AH	2.62	1.89	1.72	12	12.7	13.4	6.4	10.7	2.9	80	80	83			
	WAWHT2713	2.86	1.96	1.51	12.5	13.6	12.9	6.4	5	3.4	80	82	83			
	WAWHT2750	2.62	1.92	1.69	12	13.7	13.8	14	20	1.8	79	75	82			
	Average within each TOS	2.83	2.05	1.56												
	TOS (lsd)		0.35			3.7			3.9			3				
	Var (lsd) within TOS		0.18			2.9			2.1			0.9				
	Var TOS (lsd)		0.35			5.7			4.6			3.1				
	Var TOS (lsd diff mean)		0.3			5.1			3.5			1.6				
	%CV		4.7			2.9			2.4			0.6				

Response of wheat varieties to sowing time in the Great Southern and Lakes region

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KEY MESSAGES

Sowing times in 2006 ranged from late May to mid July producing average yields from 1.6 t/ha at Katanning and Newdegate to 0.6 t/ha at Jerramungup.

The highest yielding varieties at all three sites and sowing times were Wyalkatchem, Young and WAWHT2750. Calingiri also performed well at GSARI and Jerramungup while Yitpi performed well at NRS.

The new noodle wheat Binnu, yielded similar to Calingiri at Katanning and slightly higher than Arrino at Newdegate. However Binnu's screenings can be slightly higher than Arrino and Calingiri.

With the classification of Young changing from ASW to APW, the variety may become competitive with Wyalkatchem. But growers must proceed with caution as screenings may be higher with Young than Wyalkatchem and Young is susceptible to a new stripe rust strain in the Eastern States.

AIMS

To investigate the performance of new wheat varieties across a range of sowing times in the southern agricultural region of WA. To identify any specific risks with new varieties.

METHOD

Field based trials were located on duplex soils at the Great Southern Agriculture Research Institute (GSARI) and the Newdegate Research Station (NRS) and a shallow loam at Jerramungup in 2006. The trials examined 24 wheat varieties from different breeding programs three sowing times. All sowing times were 'late', ranging from late May at Jerramungup to mid to late July at all three sites.

Note: In the tables 'Screenings' include whole and cracked grain. Gross income was calculated on the average yield and quality for each treatment using AWB Golden Rewards – Base rate APW $242, AH $247, ASWN $ 247, ASoft $232 and ASW $229.

RESULTS AND CONCLUSIONS

Season

Between 120 and 220 mm of rain was received at the start of 2006 in the southern agriculture region. This was followed by approximately 185 mm at Katanning, 160 mm at Newdegate Research Station and 130 mm at Jerramungup. The season was relatively short with the late start to seeding and a very dry spring at all sites. Due to patchy rainfall, some growers in the region were able to sow earlier.

Grain yield

The only significant yield response to time of sowing occurred at GSARI where the average grain yields ranged from 1.6 t/ha sown mid May to 0.7 t/ha sown mid July (Table 1). The yield penalty was less at NRS (1.6 t/ha to 1.1 t/ha) and Jerramungup (1.1 t/ha to 0.6 t/ha) (Tables 2 and 3).

Overall the highest yielding varieties were Wyalkatchem, Young and a potential release, WAWHT2750 (progeny of Perejori). The higher yielding varieties tended to be of shorter maturity, although Calingiri was amongst the highest yielding varieties at Katanning and Jerramungup, and Yitpi at NRS (Tables 1, 2 and 3).

Binnu yielded similar to Calingiri at GSARI (Arrino was not present) and slightly higher than Arrino at NRS. Both the shorter maturing noodle wheats, Arrino and Binnu significantly out yielded Calingiri at the later sowing dates at NRS in 2006.

Grain quality

As the sowing times were delayed grain protein levels increased, screenings generally increased at GSARI or fluctuated at NRS and Jerramungup. The screenings results must be treated with caution as they include both whole and cracked grain. Whole grains ‘only’ is a better reflection on the propensity of a variety to produce screenings, as cracked grain is affected by harvest machinery settings. Preliminary results indicate that most of the screenings at GSARI is whole grain while NRS and Jerramungup have a large amount of cracked grain hence the variation.

The preliminary screenings data from GSARI reflects the fact that Wyalkatchem is not prone to high screening. Other varieties less prone to screenings are EGA Eagle Rock, EGA Jitarning, Yitpi plus some of the potential new varieties. However, the new premium wheat varieties Binnu and Young can be more prone to screenings. These results are supported by similar trials in the northern region.

Grain protein levels below 11.5 per cent for ASWN where achieved at the mid June sowings at GSARI and NRS for the current named varieties. However, the potential Udon wheat WAWHT2773 was above the acceptable ASWN protein specification even at the mid June sowing.

Grain protein levels for all four soft wheat varieties grown at GSARI were all above the maximum of 9.5 per cent for all sowing times. This, coupled with the high screenings, severely reduced the gross income of the soft wheats. In short seasons such as 2006, it is recommended not to grow soft wheat due to the high risk of not meeting the soft wheat standards.

As Young has been reclassified from an ASW to APW, the variety may become competitive with Wyalkatchem. However screenings may be higher with Young than Wyalkatchem and Young is susceptible to a new stripe rust strain in the Eastern States.

KEY WORDS

wheat varieties, wheat agronomy, time of sowing

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Table 1. Yield and quality results from Katanning (Great Southern Agriculture Research Institute) in 2006. Soil type was sandy/duplex. Summer and growing season rainfall (May-Oct) was 120 mm and 186 mm respectively. Sowing dates were TOS1: 13 June; TOS2: 29 June; TOS3: 19 July. Previous crop was canola

		Grain yield (t/ha)			Protein (%)			Screenings (%)*			Hectolitre wt (kg/hL)			Gross income		
		TOS1	TOS2	TOS3	TOS1	TOS2	TOS3	TOS1	TOS2	TOS3	TOS1	TOS2	TOS3	TOS1	TOS2	TOS3
AH	Carnamah	1.7	1.2	0.7	11.9	13.6	14.1	10	9	11	76	76	75	397	289	144
	EGA Bonnie Rock	1.6	1.5	0.7	11.8	12.3	13.7	9	11	15	80	79	78	386	308	144
	EGA Eagle Rock	1.4	1.2	0.6	13.1	14.0	14.4	5	6	17	77	78	77	353	301	123
	GBA Sapphire	1.3	1.1	0.7	12.0	13.0	13.4	14	12	15	78	78	78	267	226	144
	Tammarin Rock	1.8	1.6	0.6	11.9	13.1	12.7	10	9	22	76	76	74	420	384	123
	Yitpi	1.5	1.5	0.9	11.2	12.9	13.1	10	7	5	76	78	78	345	369	226
APW	EGA Wentworth	1.4	1.3	0.6	11.6	12.4	12.5	21	13	13	79	79	79	287	267	123
	Wyalkatchem	2.0	1.5	0.7	11.0	12.8	13.7	3	5	11	80	77	78	496	370	144
	Young	1.8	1.6	0.6	11.1	12.9	13.6	10	10	29	80	79	74	411	370	123
ASW	AGT Scythe	1.6	1.2	0.6	12	13.1	14.4	9	13	17	78	75	74	357	245	123
	Guardian	1.8	1.5	0.8	10.8	11.8	12.8	8	13	25	81	80	78	400	308	164
	H46	1.7	1.3	0.5	10.9	12.6	13.9	10	13	41	81	77	75	368	267	103
ASWN	Binnu (WAWHT2734)	1.7	1.5	0.6	10.9	11.9	13.9	10	9	20	78	77	76	371	334	123
	Calingiri	1.9	1.4	0.8	11.1	12.9	12.9	7	8	7	79	78	78	430	316	181
	WAWHT2773	1.6	1.2	0.7	11.8	12.7	13.9	8	10	12	79	77	76	360	264	143
ASoft	Bullaring	1.6	1.3	0.7	10.7	12.2	11.8	10	12	19	76	75	76	338	267	144
	Datatine	1.5	1.1	0.5	10.3	12.0	13.1	10	13	19	78	76	73	315	226	103
	EGA 2248	1.7	1.3	0.9	11.3	11.9	12.6	10	17	9	78	78	78	364	267	185
	EGA Jitarning	1.5	1.2	0.8	10.7	11.8	11.9	7	10	9	77	77	77	330	257	174
Unclassified	GBA03.1129	1.4	1.1	0.7	13.0	14.5	14.5	7	5	9	76	77	76			
	GBA3.09.AH	1.4	1.1	0.5	11.4	13.0	13.2	14	11	10	79	78	78			
	WAWHT2713	1.5	1.0	0.6	12.0	13.6	13.9	6	6	5	80	79	73			
	WAWHT2750	1.6	1.5	0.8	12.0	12.9	13.7	7	3	7	76	75	77			
	Average	**1.6**	**1.3**	**0.7**	**11.5**	**12.9**	**13.4**	**10**	**10**	**15**	**78**	**77**	**77**			
	TOS (lsd)	0.5			0.5			12	ns		4	ns				
	Var (lsd)	0.2			0.9			5			3					
	Var TOS (lsd)	0.6	ns		1.5	ns		11			6	ns				
	Var (lsd) within TOS	0.4	ns		1.5	ns		9			6	ns				
	%CV	18			7			39			4					

Table 2. Yield and quality results from Newdegate Research Station in 2006. Soil type was sandy/duplex. Summer and growing season rainfall (May-Oct) was 222 mm and 163 mm respectively. Sowing dates were TOS1: 20 June; TOS2: 10 July; TOS3: 24 July. Previous crop was lupins

		Grain yield (t/ha)			Protein (%)			Screenings (%)*			Hectolitre wt (kg/hL)			Gross income		
		TOS1	TOS2	TOS3	TOS1	TOS2	TOS3	TOS1	TOS2	TOS3	TOS1	TOS2	TOS3	TOS1	TOS2	TOS3
AH	Carnamah	1.5	1.2	1.2	11.5	14	14.2	7	8	7	79	80	79	362	294	298
	EGA Bonnie Rock	1.4	1.1	1.1	11.7	13.9	13.7	8	5	5	79	79	79	341	285	285
	EGA Eagle Rock	1.4	1.3	1.1	13.1	14.8	15.6	4	2	2	81	81	80	356	340	287
	GBA Sapphire	1.6	1.4	0.9	11.8	12.9	13	3	2	2	82	83	82	405	363	234
	Tammarin Rock	1.8	1.2	1.4	11.5	13.6	12.7	8	5	6	79	79	79	428	304	350
	Yitpi	1.7	1.6	1.3	11.3	13.3	13.5	8	7	6	81	80	79	399	394	325
APW	EGA Wentworth	1.6	1.4	1.0	11.4	12.9	13.5	4	3	3	79	81	79	394	353	252
	Stiletto	1.5	1.3	1.0	11.8	13.6	14.6	6	4	5	82	82	80	363	324	247
	Westonia	1.4	1.1	1.2	11.2	13.6	13.3	8	7	5	79	80	80	328	265	296
	Wyalkatchem	1.7	1.5	1.3	11.6	13.6	14.5	4	3	3	78	79	78	419	378	328
	Young	1.7	1.7	1.6	11.8	13.4	13.4	5	4	4	79	79	80	415	424	399
ASW	AGT Scythe	1.5	1.5	1.3	12.1	13.7	14	7	8	7	79	78	77	344	339	298
	Guardian	1.6	1.5	1.2	10.5	12.1	13.1	6	6	7	82	81	80	364	348	275
	H46	1.4	1.3	1.2	11.1	13.2	13.6	6	3	3	82	82	82	321	312	288
ASWN	Arrino	1.7	1.4	0.9	11.0	13.0	14.5	4	2	2	79	78	78	445	340	218
	Binnu (WAWHT2734)	1.8	1.5	1.1	11.1	13.6	13.8	6	3	4	79	79	79	436	364	261
	Calingiri	1.4	1.3	1.1	11.2	13.4	13.8	5	5	4	79	79	79	349	304	261
	WAWHT2773	1.5	1.4	1.3	11.7	13.4	13.9	5	4	3	79	80	80	351	332	312
ASoft	EGA Jitarning	1.6	1.4	0.8	10.3	11.9	12.0	4	4	5	79	80	79	364	325	184
Unclassified	GBA03.1129	1.4	1.0	1.1	12.6	14.2	14.3	5	5	4	81	82	82			
	GBA3.09.AH	1.6	1.0	0.9	11.7	13.6	13.1	2	2	2	80	80	81			
	WAWHT2713	1.5	1.1	0.5	12.0	13.7	15.5	4	6	5	82	81	78			
	WAWHT2750	1.7	1.5	1.4	11.6	13.9	14.2	3	3	3	79	80	79			
	Average	**1.6**	**1.3**	**1.1**	**11.6**	**13.4**	**13.8**	**5**	**4**	**4**	**80**	**80**	**79**			
	TOS (lsd)	0.39	ns		0.27	ns		1.1	ns		2.1	ns				
	Var (lsd)	0.2			0.96			1.0			0.8					
	Var TOS (lsd)	0.41			0.27	ns		1.8			2.2					
	Var (lsd) within TOS	0.26			1.1	ns		1.6			1.3					
	%CV	12			5			22			1					

Table 3. Grain yield at Jerramungup (Nathan Brown, Needilup) in 2006. Soil type was shallow loam. Summer and growing season rainfall (May-Oct) was 212 mm and 133 mm respectively. Sowing dates were TOS1: 25 May; TOS2: 27 July ; TOS3: 19 July. Paddock was pasture in 2005.

		Grain yield (t/ha)			Protein (%)			Screenings (%)*			Hectolitre wt (kg/hL)			Gross income		
		TOS1	TOS2	TOS3	TOS1	TOS2	TOS3	TOS1	TOS2	TOS3	TOS1	TOS2	TOS3	TOS1	TOS2	TOS3
AH	Braewood	0.8	0.6	0.4	13.7	14.1	14.8	4	5	4	81	79	78	205	152	103
	Carnamah	1.0	0.9	0.5	13.5	13.3	13.8	10	6	6	74	76	76	238	225	125
	EGA Bonnie Rock	1.1	1.1	0.7	12.9	13.3	13.8	7	4	7	78	80	77	276	286	177
	EGA Eagle Rock	1.0	1.0	0.6	14.0	14.9	15.3	5	3	6	77	79	76	254	259	151
	EGA Gregory	0.9	0.9	0.5	12.5	13.2	13.4	7	5	8	76	79	75	220	227	122
	GBA Sapphire	1.0	0.9	0.7	13.7	13.6	13.9	7	4	10	76	79	79	247	230	167
	Tammarin Rock	1.2	1.2	0.6	13.0	14.0	14.5	9	6	6	74	76	75	288	301	151
	Yitpi	1.2	0.9	0.5	13.6	14.1	14.3	6	4	2	78	77	77	300	231	131
APW	Annuello	1.1	1.0	0.6	13.9	13.7	14.4	9	6	15	78	79	76	258	244	123
	EGA Wentworth	1.1	1.0	0.7	13.6	13.6	13.7	14	6	13	76	79	77	225	244	143
	Ellison	0.9	1.0	0.7	14.3	14.9	15.5	5	3	6	78	80	76	222	252	146
	Wyalkatchem	1.3	1.2	0.6	13.0	13.0	14.8	4	3	3	76	78	76	324	302	151
	Young	1.2	1.1	0.8	12.8	13.5	13.9	12	6	14	78	80	77	246	268	164
ASW	AGT Scythe	1.1	1.1	0.7	13.7	13.9	14.4	10	6	6	74	77	74	242	255	162
	Guardian	1.1	1.1	0.6	12.7	12.3	12.8	12	8	12	77	81	77	226	249	123
	H46	1.1	0.9	0.8	12.8	13.8	13.8	12	9	10	77	77	77	226	201	176
	Sentinel	1.1	0.9	0.5	13.0	12.8	13.9	5	7	13	76	76	71	258	206	103
ASWN	Calingiri	1.2	1.0	0.7	12.6	13.9	13.1	3	4	5	78	78	77	288	238	165
Unclassified	GBA03.1129	1.1	0.9	0.6	14.4	14.5	14.5	5	2	4	77	79	77			
	GBA3.09.AH	1.1	1.1	0.6	13.5	14.1	14.2	5	4	9	78	80	77			
	WAWHT2713	1.0	0.6	0.5	13.8	14.7	15.0	5	4	4	78	76	72			
	WAWHT2750	1.3	1.2	0.6	13.3	14.1	14.7	4	2	4	74	76	75			
	Average	**1.1**	**1.0**	**0.6**	**13.3**	**13.8**	**14.2**	**7**	**5**	**8**	**77**	**78**	**76**			
	TOS (lsd)	0.5	ns		2.9	ns		7.5	ns		3.4	ns				
	Var (lsd)	0.1			1.2			2.6			1.2					
	Var TOS (lsd)	0.5			2.8	ns		7.7			3.6					
	Var (lsd) within TOS	0.2			0.8	ns		4.4			2.2					
	%CV	12.6			2			41								

Response of wheat varieties to sowing time in Esperance region in 2006

Christine Zaicou[a]**, Ben Curtis**[b] and **Ian Hartley**[b], Department of Agriculture and Food, Western Australia; [a]Geraldton and [b]Esperance

KEY MESSAGES

- Growing season rainfall was low (decile 1) with a quick dry finish to the season at Scaddan. Only 146.6 mm of growing season rain was recorded in 2006 and average yields only declined from 2.7 t/ha for a mid may sowing to 2.3 t/ha for a mid June sowing in 2006.
- EGA Wentworth yields were good and screenings were not a problem at Scaddan with the early May to mid June sowings.
- It is difficult to gauge the true potential of the varieties in a very dry season like 2006, however Wyalkatchem and Yitpi were in the top yielding varieties

AIMS

To assist growers in making decision on variety choice and management, a trial was conducted at Scaddan to assess the response of new and potential wheat varieties to different sowing times. (Note: Similar trials are also located in the northern, central and southern agricultural regions which are reported elsewhere in this document.)

METHOD

A 2006 field based trial was located on alkaline soil in Scaddan with twenty four cultivars from various breeding organisations. The trial included three sowing times (16 May, 29 May and 14 June) in a randomised split block design. The growing season rainfall from May to October was 146.6 mm (decile 1). Plots were harvested and measurements of yield and grain quality were recorded for each of the varieties.

Note: Screenings include whole and cracked grain. Gross income was calculated on the average yield and quality for each treatment using AWB Golden Rewards – Base rate APW$250, AHP$260, AH$255 and ASW$237.

RESULTS AND CONCLUSIONS

Yield penalty and time of sowing

Season 2006 at Scaddan looked promising with the opportunity for mid May, late May and mid June sowing. However, the growing season rainfall was low (decile 1) with a quick dry finish to the season. Only 146.6 mm of growing season rain was recorded in 2006, compared to 278 mm in 2005. Average yields declined from 2.7 t/ha to 2.3 t/ha in 2006 with a mid May to mid June sowing. In comparison, average yields declined from 3.2 t/ha to 2.8 t/ha with a mid May to late June sowing in 2005 (Amjad and Curtis, Crop Updates 2006). Proteins increase the delayed sowing and screenings were not a major factor on grain quality in 2006.

Varieties and their performance in 2006

It is difficult to gauge the true potential of the varieties in a very dry season like 2006. However, as expected the shorter season varieties Wyalkatchem. Young and Yitpi yielded well. Growers would need to consider their levels of rust resistance if adopting these varieties as the resistance of Wyalkatchem and Yitpi to stem rust is low.

Based on large scale testing in 2004, EGA Went worth (APW), Ellison (APW) and EGA Gregory (AH) were considered as promising varieties. In 2006, Ellison's performance was amongst the poorer performing varieties. However, Ellison's strengths are it's resistance to stem, stripe and leaf rust along with moderate tolerance to sprouting.

EGA Wentworth also has resistance to stem and leaf rust (mod resistance to stripe rust) and its yields in 2006 were good. Screenings were not a problem at Scaddan, however at other locations throughout the State, EGA Wentworth screenings (whole and cracked grain) were higher than for other varieties with late June sowings.

EGA Gregory also has resistance to stem, leaf and stripe rust, however its yields were lower compared to the other varieties for each sowing time.

Yitpi and Young were not sown at the first time of sowing because seed was not available. However these varieties performed well at the later sowing times.

KEY WORDS

wheat varieties, agronomy, crop management, time of sowing

ACKNOWLEDGMENTS

GRDC for financial support and Esperance Research Support Unit for trial implementation and management.

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Table 1. Effect of sowing time/emergence date on yield, quality and economic returns of wheat varieties sown at Scaddan on alkaline mallee soils in 2006

		Grain yield (t/ha)			Protein (%)			Screenings (%)			Hectolitre wt (kg/hL)			Gross income		
		TOS1	TOS2	TOS3	TOS1	TOS2	TOS3	TOS1	TOS2	TOS3	TOS1	TOS2	TOS3	TOS1	TOS2	TOS3
AH	Annuello	2.80	2.65	2.28	10.6	11.5	11.3	4.4	4.5	6.2	79.4	75.4	78.2	704	679	568
	Braewood	2.71	2.43	2.11	10.2	11.1	11.7	5.9	7.3	6.4	80.8	79.9	80.4	666	599	528
	Carnamah	2.65	2.78	2.30	10.5	10.4	11.5	6.3	6.4	7.5	80.3	80.0	77.8	654	682	566
	EGA Bonnie Rock	2.73	2.38	2.37	10.9	13.1	11.6	4.8	8.4	6.4	81.0	78.8	80.7	702	609	605
	EGA Eagle Rock	2.53	2.38	2.16	11.4	11.2	12.2	3.4	5.1	3.3	79.2	78.0	77.9	656	601	563
	EGA Gregory	2.64	2.31	2.19	10.2	10.5	11.4	5.5	7.4	7.4	80.8	78.5	78.2	651	565	538
	GBA Sapphire	2.64	2.85	2.34	10.7	11.2	11.1	4.0	4.1	4.4	80.7	80.4	80.2	666	728	594
	Tammarin Rock	2.74	2.69	2.46	10.6	11.1	11.5	5.9	6.6	6.4	79.5	79.8	79.8	677	667	615
	Yitpi	n/a	2.80	2.73	n/a	11.4	11.2	n/a	8.1	7.4	n/a	79.3	80.5	n/a	690	672
APW	EGA Wentworth	2.73	2.84	2.48	10.3	10.8	11.2	4.4	5.2	7.8	80.6	80.4	78.3	677	713	601
	Ellison	2.37	2.10	1.98	11.3	12.1	12.2	8.7	8.6	9.6	80.7	78.4	78.6	568	505	471
	Wyalkatchem	3.02	3.10	2.57	11.0	10.9	11.2	3.4	4.1	5.6	80.6	79.1	77.2	770	786	642
	Young	n/a	3.00	2.58	n/a	11.2	11.3	Na/	4.9	8.4	n/a	81.2	80.2	n/a	752	626
ASW	AGT Scythe	2.78	2.76	2.24	10.6	11.0	11.4	8.0	8.1	9.8	77.9	77.3	76.2	633	639	507
	Guardian	3.01	2.80	2.75	10.1	11.4	11.1	6.3	8.7	7.1	82.0	80.2	81.6	700	643	644
	H46	2.74	2.83	2.34	10.4	11.4	11.4	3.9	3.1	6.3	81.3	81.0	80.4	660	697	555
	Sentinel	2.43	2.19	1.84	9.7	10.3	11.6	5.9	8.0	10.3	80.2	78.1	77.7	551	502	417
ASWN	Calingiri	2.89	2.76	2.29	10.5	10.4	11.5	4.6	5.9	6.3	79.0	78.9	77.7	741	697	568
Unclassified	GBA03.1129	2.66	2.78	2.39	11.2	11.9	12.2	5.3	5.6	5.3	80.0	79.3	79.7			
	GBA3.09.AH	2.74	2.53	2.46	10.1	11.8	11.3	3.1	6.0	4.2	80.5	78.3	79.0			
	WAWHT2713	2.60	2.22	2.22	11.3	11.4	11.3	7.1	9.7	7.6	79.5	77.0	77.4			
	WAWHT2750	2.71	2.80	2.49	10.2	11.7	11.4	5.3	4.7	3.1	78.6	77.2	77.6			
	Ave TOS	2.74	2.65	2.33	10.6	11.2	11.4	5.4	6.4	6.9	80.4	79.0	78.9			
	TOS (lsd)	0.26			0.3			1.4			0.58					
	Var TOS (lsd)	n			1.1			ns			ns					
	Var (lsd) within TOS	ns			1.1			ns			ns					
	%CV	8.2			6.2			25.6			1.6					

Performance of wheat varieties in National Variety Testing (NVT) WA: Year 2

Peter Burgess, Agritech Crop Research

KEY MESSAGES

Across most regions of the State, mid season varieties such as Guardian, Annuello, Correll, Yitpi and Binnu performed similarly in terms of yield and showed regional and seasonal adaptation when compared to quicker varieties such as Wyalkatchem, Young, Arrino and Westonia.

Early stripe rust infection at the Munglinup site had a significant influence on variety performance and yield with a lesser impact on screenings and hectolitre weight. Varieties with MR – R ratings for stripe rust were among the best performers in terms of green leaf retention and final yield. Varieties relying on Adult Plant Resistance (APR) for stripe rust, e.g. Annuello, Wyalkatchem, AGT Scythe showed a yield penalty due to the early infection killing off leaf area leaving leaves totally necrotic during the vegetative and grain fill stage. Susceptible varieties suffered a significant yield penalty. Stripe rust also developed at Scaddan, Mt Madden, Holt Rock, Narembeen, Cunderdin, Mukinbudin and Kellerberrin; however the dry sharp finish to the growing season had a greater influence on variety yield and quality than did stripe rust at these sites.

Stem rust and Wheat Streak Mosaic Virus were evident across a number of central and southern regions and in some cases around NVT sites. Variety performance was not influenced or affected by either pathogen. Frost was not a factor at any site in 2006.

In the dry 2006 season, Guardian produced consistently higher screenings and Correll produced a low hectolitre weights across a range of sites. Screening levels were variable across the State and were not regional, site, soil type or environmentally specific.

There are a number of quick and mid season maturity varieties coming through the Australian Grain Technology (AGT), Longreach Plant Breeder (LRPB) and Nugrain breeding programs that perform similarly in terms of yield and quality to Wyalkatchem across a range of soil types and environments. The varieties Wyalkatchem, Westonia and Arrino were the best of the WA benchmark varieties with Binnu showing promise in some areas.

It is advisable to use the yield and quality data and information generated from the NVT trial program in conjunction with a range of variety information when making management decisions on variety selection and retention.

AIM

To provide a field evaluation system, inclusive for all potential new release wheat varieties, independent of public and private breeding programs.

METHOD

A total of 44 sites across WA were selected to evaluate wheat varieties entered into the NVT. The site selection criteria were soil type, DAFWA Agzone and active grower group location. Only varieties currently available to growers, or close to release, were eligible for inclusion. The trials were located on grower properties and conducted as per district practise and grower sowing time. Nutrition was not limiting. General bread wheat varieties at a range of maturities were sown at a single timing. All nutrition and weed control was the same across all varieties. There was no fungicide applied to any of the trials. The National Biometricians Group was contracted by ACAS to biometrically analyse all data. Data is now available to growers on the ACAS data base: www.nvtonline.com.au.

RESULTS

Refer to tables at the end of the article for results.

DISCUSSION

Northern and Central; Agzones 1-4

In the northern region Agzone 1 heavy land site (East Carnamah) and Agzone 4 (Mullewa) the average site yield was 0.750 t/ha. Wyalkatchem was the best performing variety, with Bonnie Rock as a close contender. All other varieties were well off the pace at the low yielding sites.

The northern region Agzone 1 light land sites (West Mingenew, Binnu) were similar to that of the northern heavy land sites, low site yields (0.9 t/ha) and Wyalkatchem being the best performing variety. The long season variety Calingiri performed equal to Wyalkatchem and again shows its adaptability to the northern sandplain soils and environmental conditions.

In the central Agzone 4 heavy land sites (Mukinbudin, Wyalkatchem, Kellerberrin, Dalwallinu) the average yield was around 1.4 t/ha. There was a number of midseason varieties Yitpi, Correll, Binnu, Guardian and Annuello along with some of the quicker varieties Young, Scythe and Arrino that performed equal to, or better than, Wyalkatchem.

In the Agzone 2 central heavy sites (Toodyay, Narembeen, Goomalling) all varieties, regardless of maturity performed similar or worse than Wyalkatchem. The site average yield of the three sites was 2.25 t/ha. The light land Agzone 2 site (Cunderdin) with a site average yield of 3.5 t/ha showed the same result as the Agzone 2 heavy land sites.

Agzone 2 and 4 light land sites (Calingiri, Coorow, Regans Ford, Wongan Hills, Merredin) with a site average of 3 t/ha, variety performance was similar to Agzone 4 heavy land sites, with mid and short season varieties performing similarly.

Wodgil soils

Guardian, Annuello, Yitpi, Correll (mid season varieties) and Young (short season) all show acid soil adaptation similar to the local varieties Arrino, Westonia, Wyalkatchem and Tammarin Rock. Of the WA wheats the shorter season varieties were the best performers in this low yielding environment.

Southern: Agzones 2, 3 and 5

In terms of yield, Wyalkatchem dominated Holt Rock (Agzone 5), Corrigin and Kulin (Agzone 2), with Carinya and Binnu both performing equal to Wyalkatchem at the Holt Rock site.

Mid and short season varieties mentioned previously, performed well at all other Agzone 2, 3 and 5 sites (Katanning, Lake Grace, Mt Barker, West Kojonup, Borden). AGT Scythe showed greater adaptability to the southern sites compared to the northern sites, particularly on the heavy land sites (Wickepin, Brookton, Williams). All southern sites were generally 2 t/ha-3 t/ha site average yield.

South Coast: Agzones 5 and 6

Munglinup (Site average 3.6 t/ha) was under significant disease pressure for most of the growing season. Young, Binnu, Guardian, Yitpi, Correll and Carinya are MR-R to stripe rust. This level of resistance was reflected in final yield with these varieties around 20% higher yielding than Wyalkatchem at this site. AGT Scythe is a variety that has APR. Significant early stripe rust infection during the vegetative stage did not allow this variety to utilise this attribute. Annuello was a similar story with both varieties lower yielding than Wyalkatchem. When viewing the South Coast Light land table, it must be remembered that the high disease Munglinup site has skewed the results towards disease resistant lines.

At all other Agzone 5 and 6 sites, heavy and light (Jerramungup, Salmon Gums, Scaddan, Mt Madden, Gibson and South Stirlings), Wyalkatchem was a consistent performer with Young outperforming Wyalkatchem at many of the sites. There was little consistency in yield from most of the other varieties, regardless of maturity.

CONCLUSION

Across most regions of the State, mid season varieties such as Guardian, Annuello, Correll, Yitpi and Binnu performed similarly in terms of yield and showed similar regional and seasonal adaptation when compared to the quicker varieties, Wyalkatchem, Young, Arrino and Westonia.

Early stripe rust infection at the, Munglinup site had a significant influence on variety performance with varieties showing MR-R ratings for disease resistance among the best performers. Varieties relying on Adult Plant Resistance (APR) for stripe rust (e.g. Annuello, Wyalkatchem and AGT Scythe) were unable to maintain green leaf area during the vegetative and grain fill stage due to the virulence of the disease. Yield of these varieties was significantly reduced at Munglinup compared to sites where the varieties were grown in the absence of stripe rust.

Guardian showed a tendency to produce higher levels of screenings. The screenings were not specific to environment or soil type.

Correll produced lower hectolitre weights, particularly on lighter soils and under harsh growing conditions.

Variety performance was not influenced or affected by stem rust or wheat streak mosaic virus at any site. Frost was not a factor at any site in 2006.

KEY WORDS

National Variety Testing, wheat, yield, ACAS, varieties

ACKNOWLEDGMENTS

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Table 1. State average NVT wheat variety yield performance as % of Wyalkatchem (40 locations). Average yield of Wyalkatchem was 2.324 t/ha in 2006 and 3.276 t/ha in 2005

Variety	2006			2005
	Agzone	Yield	Rank	Yield
Guardian	1, 2, 3, 4, 5, 6	101%	2	111%
Wyalkatchem	**1, 2, 3, 4, 5, 6**	**100%**	**3**	**100%**
Young	1, 2, 3, 4, 5, 6	100%	3	101%
Yitpi	2, 3, 4, 5, 6	99%	4	not grown
Binnu	1, 2, 3, 4, 5, 6	98%	5	not grown
Correll	1, 2, 3, 4, 5, 6	98%	5	101%
EGA Bonnie Rock	1, 4	98%	5	97%
Bullaring	2, 3, 5	97%	6	112%
Annuello	1, 2, 3, 4, 5, 6	96%	7	not grown
Tammarin Rock	4	96%	7	97%
Arrino	1, 2, 3, 4, 5, 6	95%	8	105%
Westonia	1, 2, 3, 4, 5	95%	8	104%
AGT Scythe	1, 2, 3, 4, 5, 6	94%	9	101%
H46	5, 6	94%	9	88%
Calingiri	1, 2, 3, 4, 5, 6	93%	10	106%
EGA Blanco	1, 2, 4	93%	10	102%
EGA Wentworth	1, 2, 3, 4, 5, 6	92%	11	99%
Datatine	1, 2, 3, 4, 5, 6	91%	12	108%
Carinya	1, 2, 3, 4, 5, 6	89%	13	96%
Carnamah	1, 2, 3, 4, 5, 6	89%	13	103%
Derrimut	2	86%	16	not grown
EGA Eagle Rock	1, 2, 3, 4, 5, 6	85%	17	93%
GBA Sapphire	1, 2, 3, 4, 5, 6	85%	17	97%
Janz	1, 2, 3, 4, 5, 6	84%	18	not grown
EGA Gregory	1, 2, 3, 5, 6	82%	19	91%
Giles	4, 5, 6	82%	19	not grown
Cascades	4, 6	79%	21	92%
EGA Castle Rock	1, 2, 3, 4, 5, 6	79%	21	not grown
EGA Wylie		not grown		82%
GBA Shenton		not grown		94%

Table 2. Heavy Soil North – NVT wheat variety yield performance as % of Wyalkatchem. Average yield of Wyalkatchem was 1.652 t/ha in 2006 and 3.315 t/ha in 2005. Locations: Nabawa (2005); Morawa (2005); Mullewa; Three Springs (2005); Carnamah East; Miling (2005); Dalwallinu; Toodyay; Goomalling; Wyalkatchem; Mukinbudin; Kellerberrin and Narembeen

Variety	2006		2005
	Yield	Rank	Yield
Correll	102%	6	98%
Young	102%	6	97%
Binnu	101%	7	not grown
EGA Bonnie Rock	101%	7	93%
Wyalkatchem	**100%**	**8**	**100%**
Arrino	99%	9	100%
Derrimut	99%	9	not grown
Guardian	99%	9	104%
Annuello	97%	11	not grown
EGA Wentworth	95%	13	100%
Tammarin Rock	95%	13	95%
AGT Scythe	94%	14	101%
Yitpi	94%	14	not grown
Carnamah	92%	16	99%
GBA Sapphire	92%	16	96%
Westonia	92%	16	97%
Carinya	90%	18	95%
Calingiri	89%	19	102%
Cascades	89%	19	92%
Janz	89%	19	not grown
Datatine	88%	20	99%
EGA Blanco	87%	21	97%
EGA Gregory	87%	21	not grown
Barham (VO2697R)	85%	23	not grown
EGA Eagle Rock	85%	23	91%
Bullaring	84%	24	102%
EGA Castle Rock	81%	27	not grown
Camm	not grown		86%
EGA Wylie	not grown		81%
GBA Hunter	not grown		89%
GBA Shenton	not grown		91%

Table 3. Light Soil North – NVT wheat variety yield performance as % of Wyalkatchem. Average yield of Wyalkatchem was 2.096 t/ha in 2006 and 3.243 t/ha in 2005. Locations: Binnu; Mingenew; Mingenew North (2005); Yuna; Eneabba; Coorow; Regans Ford; Wongan Hills; Calingiri; Cunderdin and Merredin

Variety	2006		2005
	Yield	Rank	Yield
Yitpi	104%	4	not grown
Calingiri	102%	6	108%
Annuello	101%	7	not grown
Bullaring	101%	7	107%
Guardian	101%	7	118%
Westonia	101%	7	101%
Wyalkatchem	**100%**	**8**	**100%**
EGA Blanco	98%	10	106%
Correll	97%	11	99%
EGA Bonnie Rock	97%	11	94%
Young	96%	12	94%
Arrino	94%	14	103%
Tammarin Rock	94%	14	100%
Binnu	92%	16	not grown
EGA Wentworth	92%	16	94%
Datatine	90%	18	107%
AGT Scythe	89%	19	98%
EGA Eagle Rock	89%	19	91%
Derrimut	86%	22	not grown
Carinya	84%	23	93%
Carnamah	83%	24	107%
EGA Gregory	82%	25	not grown
Barham (VO2697R)	81%	26	not grown
Janz	81%	26	not grown
GBA Sapphire	75%	30	93%
EGA Castle Rock	74%	31	not grown
Cascades	66%	32	90%
GBA Shenton	not grown		95%

Table 4. Heavy Soil South – NVT wheat variety yield performance as % of Wyalkatchem. Average yield of Wyalkatchem was 2.490 t/ha in 2006 and 3.728 t/ha in 2005. Locations: Brookton; Wickepin and Williams

Variety	2006		2005
	Yield	Rank	Yield
AGT Scythe	106%	4	103%
Young	106%	4	99%
Arrino	104%	6	91%
Guardian	103%	7	121%
Binnu	101%	8	not grown
Annuello	100%	9	not grown
Wyalkatchem	**100%**	**9**	**100%**
Yitpi	100%	9	not grown
Bullaring	97%	12	102%
Westonia	97%	12	98%
Correll	96%	13	103%
EGA Blanco	95%	14	90%
Carnamah	93%	16	91%
Datatine	93%	16	116%
Calingiri	91%	18	93%
Carinya	91%	18	91%
EGA Wentworth	91%	18	97%
EGA Eagle Rock	89%	20	88%
EGA Gregory	86%	23	92%
GBA Sapphire	86%	23	100%
EGA Castle Rock	83%	25	not grown
Janz	80%	28	not grown
Derrimut	78%	29	not grown
Camm	not grown		94%
Cascades	not grown		85%
EGA Bonnie Rock	not grown		96%
EGA Wylie	not grown		91%

Table 5. Light Soil South – NVT wheat variety yield performance as % of Wyalkatchem. Average yield of Wyalkatchem was 2.762 t/ha in 2006 and 3.129 t/ha in 2005. Locations: Wagin (2005); Corrigin; Holt Rock; Kulin; Newdegate (2005); Lake Grace; Katanning; Kojonup West; Mt Barker and Borden

Variety	2006		2005
	Yield	Rank	Yield
Wyalkatchem	**100%**	**3**	**100%**
Guardian	99%	4	98%
Young	98%	5	115%
Binnu	96%	7	not grown
Bullaring	96%	7	124%
Yitpi	95%	8	not grown
AGT Scythe	93%	10	112%
Correll	93%	10	112%
EGA Wentworth	93%	10	111%
Annuello	91%	12	not grown
Carinya	91%	12	110%
EGA Blanco	91%	12	107%
Calingiri	89%	14	109%
Datatine	89%	14	117%
Carnamah	88%	15	112%
GBA Sapphire	88%	15	111%
Arrino	86%	17	110%
H46	85%	18	80%
Janz	85%	18	not grown
Westonia	85%	18	121%
Derrimut	83%	20	not grown
EGA Eagle Rock	82%	21	103%
EGA Castle Rock	81%	22	not grown
Giles	81%	22	not grown
Barham (VO2697R)	78%	24	97%
EGA Gregory	78%	24	101%
Camm	not grown		122%
Cascades	not grown		106%
EGA Bonnie Rock	not grown		111%
EGA Wylie	not grown		86%
GBA Hunter	not grown		109%
GBA Shenton	not grown		106%

Table 6. Heavy Soil South Coast – NVT wheat variety yield performance as % of Wyalkatchem. Average yield of Wyalkatchem was 2.732 t/ha in 2006 and 4.030 t/ha in 2005. Locations: Mt Madden; Jerramungup; Scaddan and Salmon Gums

Variety	2006		2005
	Yield	Rank	Yield
Wyalkatchem	**100%**	**1**	**101%**
Yitpi	98%	3	not grown
Young	98%	3	101%
Binnu	97%	4	not grown
Bullaring	96%	5	108%
AGT Scythe	94%	7	104%
Correll	93%	8	100%
Guardian	90%	11	not grown
Arrino	89%	12	100%
EGA Wentworth	89%	12	104%
H46	89%	12	86%
Carinya	88%	13	96%
Carnamah	86%	15	98%
Datatine	86%	15	103%
EGA Wylie	85%	16	88%
Janz	85%	16	not grown
Calingiri	83%	18	95%
EGA Eagle Rock	82%	19	88%
Annuello	80%	22	not grown
Giles	79%	23	not grown
Westonia	78%	23	97%
EGA Gregory	77%	24	93%
EGA Castle Rock	75%	26	not grown
GBA Shenton	not grown		81%

Table 7. Light Soil South Coast – NVT wheat variety yield performance as % of Wyalkatchem. Average yield of Wyalkatchem was 3.477 t/ha in 2006 and 4.230 t/ha in 2005. Locations: South Stirlings; Munglinup and Gibson

Variety	2006		2005
	Yield	Rank	Yield
Young	111%	1	98%
H46	106%	5	95%
Binnu	105%	6	not grown
Guardian	104%	7	not grown
Yitpi	102%	9	not grown
Carinya	101%	10	95%
Correll	101%	10	87%
Wyalkatchem	**100%**	**11**	**100%**
EGA Eagle Rock	99%	12	88%
AGT Scythe	98%	13	89%
Carnamah	98%	13	100%
EGA Wentworth	96%	15	97%
Arrino	95%	16	106%
GBA Sapphire	94%	17	97%
Annuello	92%	19	not grown
Janz	92%	19	not grown
Calingiri	89%	22	104%
Datatine	89%	22	96%
Giles	88%	23	not grown
EGA Gregory	79%	27	77%
EGA Castle Rock	78%	28	not grown
Cascades	69%	29	91%
EGA Wylie	not grown		62%

Table 8. Wodjil Soil – NVT wheat variety yield performance as % of Wyalkatchem. Average yield of Wyalkatchem was 1.057 t/ha in 2006 and 1.312 t/ha in 2005. Locations: Maya East; Koorda and Bodallin

Variety	2006		2005
	Yield	Rank	Yield
Guardian	111%	1	not grown
Annuello	106%	3	not grown
Westonia	106%	3	105%
Arrino	103%	5	122%
EGA Bonnie Rock	102%	6	106%
Yitpi	101%	7	not grown
Correll	100%	8	106%
Wyalkatchem	**100%**	**8**	**100%**
Tammarin Rock	99%	9	98%
Young	98%	10	110%
Calingiri	95%	12	127%
Binnu	94%	13	not grown
Datatine	93%	14	123%
Carnamah	83%	23	95%
EGA Blanco	79%	26	106%
AGT Scythe	77%	28	86%
Cascades	76%	29	76%
EGA Eagle Rock	76%	29	101%
GBA Sapphire	75%	30	72%
Carinya	74%	31	81%
Giles	74%	31	not grown
EGA Wentworth	73%	32	80%
Janz	67%	35	not grown
EGA Castle Rock	66%	36	not grown
GBA Shenton	not grown		84%

Flowering dates of wheat varieties in Western Australia in 2006

Darshan Sharma, Brenda Shackley and **Christine Zaicou**, Department of Agriculture and Food, Western Australia, Northam, Katanning and Geraldton

KEY MESSAGES

Flowering dates vary with sowing date as well as location.

Comparison with earlier data shows that seasonal conditions also influence these dates. The warmer and drier conditions generally tended to hasten development for most of the currently grown varieties in WA.

The data presented here may be used only as a guide in respective regions to estimate relative flowering date for given time of seasonal break.

AIMS

A renewed emphasis has been given to wheat phenology with an aim to improve flowering predictability of wheat varieties in Western Australia.

METHOD

Experiments including four sowing times were conducted at three locations differing in day length and minimum and maximum temperatures (Geraldton, Northam and Katanning). Varieties were sown in unreplicated one metre long rows with three repeated checks. Data was recorded for the number of fully emerged heads and the number of heads exhibiting anthesis at periodic intervals.

RESULTS

Time to the occurrence of 50 per cent heading or anthesis was calculated and is shown in Tables 1 and 2 for 20 prominent varieties in the State. These data are a guide to the relative flowering dates in 2006 only. Figure 1 looks at flowering dates for Calingiri and Westonia between 2005 and 2006 in Geraldton, indicating that flowering dates for a particular variety can vary by over two weeks depending on the seasonal conditions.

Delayed sowing in unseasonally dry conditions resulted in heads not fully emerging out of the boots for some long duration varieties such as Marombi and Sunbrook. Although anthesis in such cases did take place, such varieties are almost certainly unfit for late sowing in WA.

The duration from heading to flowering was generally greater in the south and under good growing conditions (irrigated site at Northam) and at earlier sowing times.

Varietal relativities for the flowering dates can change with time of sowing as well as with location (Figures 2a, 2b and 2c) and year (Figure 1).

CONCLUSION

Besides sowing date, days to head emergence and flowering depend upon location, season and varietal response.

Analysis of these datasets will be conducted to develop improved parameters for the FLOWERCAL model, which can then be used to produce reliable predictions.

KEY WORDS

flowering date, anthesis, head emergence, wheat, agronomy, new varieties, phenology

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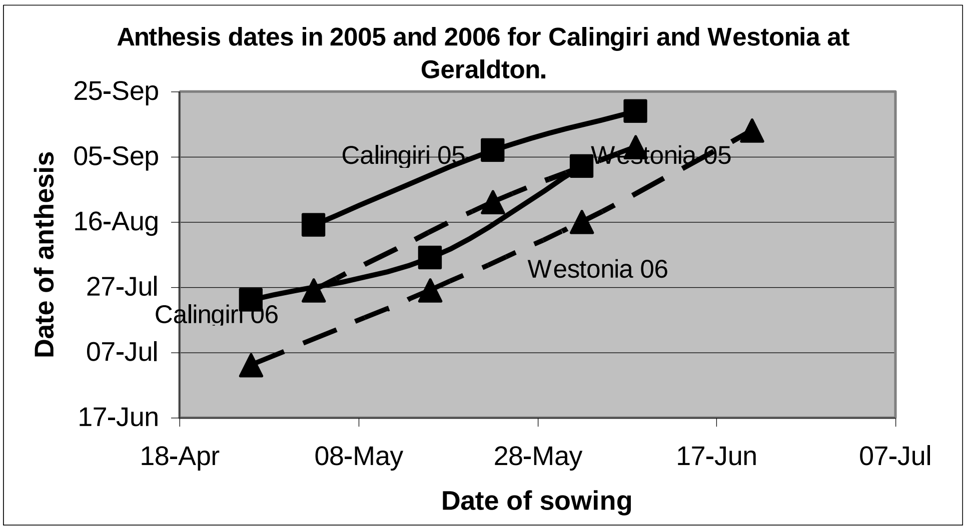

Figure 1. Comparison of anthesis dates over seasons.

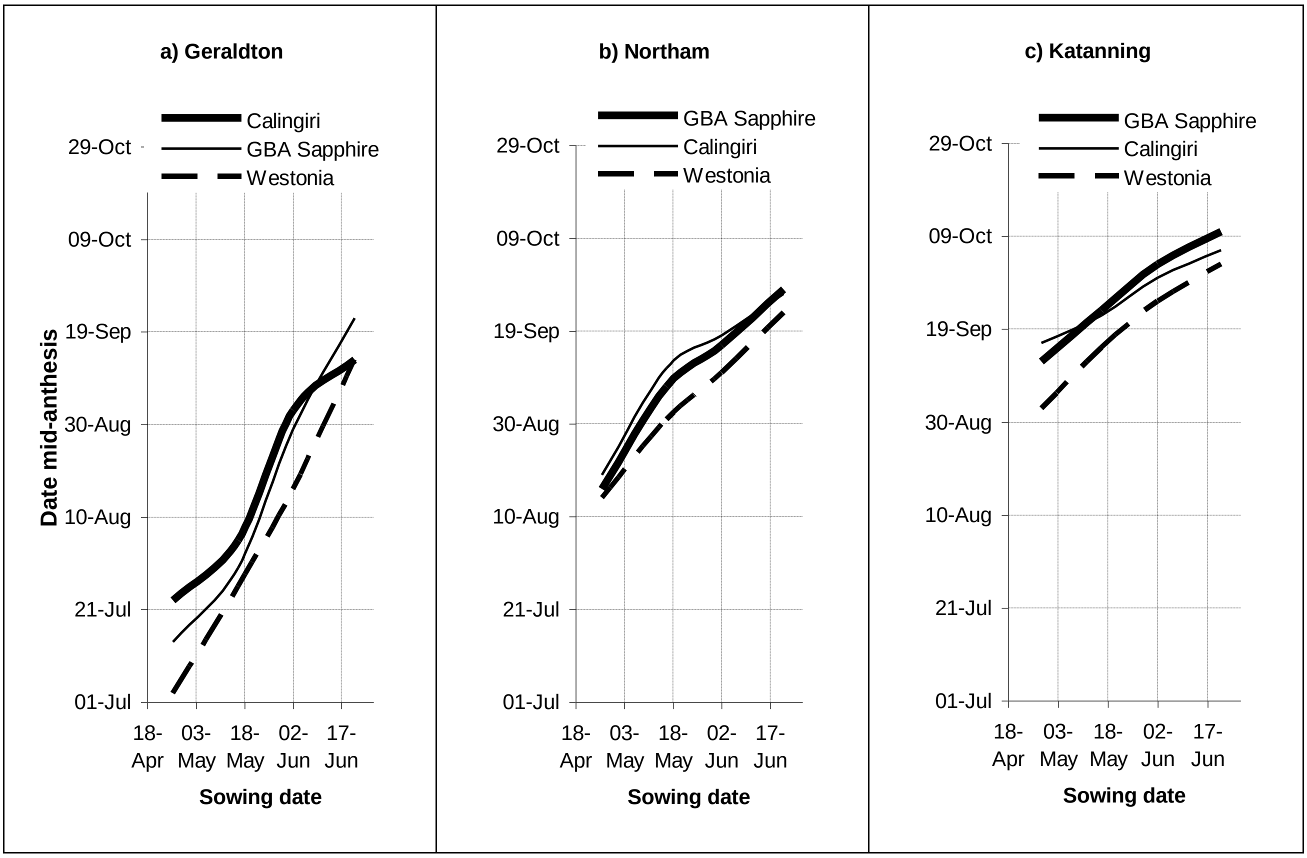

Figure 2. Comparison of anthesis dates of three varieties as influenced by time of sowing and location.

Table 1. Heading date (50 per cent heads fully emerged) for wheat cultivars at different sowing dates at three locations in Western Australia in 2006. Empty cells indicate data either not available or the total numbers of fully emerged heads was less than 50 per cent of the total heads present in the marked area

	Cultivar	Geraldton				Northam				Katanning			
		26 April	16 May	2 June	21 June	26 April	16 May	2 June	21 June	28 April	16 May	2 June	21 June
AH	Braewood	6 Aug	16 Aug		20 Sep	6 Sep	17 Sep	25 Sep	11 Oct	11 Sep	21 Sep		11 Oct
	Carnamah	7 Jul	30 Jul	1 Sep	12 Sep	6 Aug	30 Aug	10 Sep	25 Sep	5 Sep	5 Sep	20 Sep	2 Oct
	EGA Bonnie Rock	9 Jul	10 Aug	15 Aug	6 Sep	9 Aug	27 Aug	6 Sep	20 Sep	24 Aug	5 Sep	17 Sep	8 Oct
	EGA Eagle Rock	6 Jul	27 Jul	27 Aug	16 Sep	25 Aug	3 Sep	11 Sep	24 Sep	31 Aug	15 Sep	28 Sep	8 Oct
	EGA Gregory	22 Jul	6 Aug	1 Sep	22 Sep	14 Sep	4 Sep	19 Sep	27 Sep	6 Sep	17 Sep	30 Sep	9 Oct
	GBA Sapphire	13 Jul	30 Jul	25 Aug	22 Sep	10 Aug	30 Aug	12 Sep	25 Sep	31 Aug	14 Sep	30 Sep	7 Oct
	Tammarin Rock	6 Jul	25 Jul	20 Aug	10 Sep	5 Aug	24 Aug	5 Sep	18 Sep	19 Aug	7 Sep	13 Sep	30 Sep
	Yitpi	4 Aug	5 Aug	5 Sep	30 Sep	20 Aug	2 Sep	16 Sep	29 Sep	2 Sep	15 Sep	2 Oct	8 Oct
APW	Annuello	12 Jul	1 Aug		10 Sep	16 Aug	9 Sep	14 Sep	25 Sep	8 Sep	12 Sep	27 Sep	5 Oct
	EGA Wentworth	19 Jul	30 Jul	28 Aug	25 Sep	11 Aug	2 Sep	11 Sep	23 Sep	30 Aug	12 Sep	26 Sep	4 Oct
	Ellison	1 Aug	12 Aug	5 Sep	2 Oct	6 Sep	11 Sep	19 Sep		1 Sep	20 Sep		
	Spear	1 Aug	31 Aug	7 Sep	27 Sep	20 Aug	3 Sep	16 Sep		4 Sep	12 Sep	1 Oct	10 Oct
	Stiletto	30 Jul	14 Aug	6 Sep	24 Sep	11 Aug	29 Aug	14 Sep	29 Sep	6 Sep	15 Sep	30 Sep	8 Oct
	Wedgetail		11 Sep	20 Sep	12 Oct	15 Sep	22 Sep	30 Sep	24 Oct	23 Sep	30 Sep		18 Oct
	Westonia	3 Jul	23 Jul	15 Aug	8 Sep	8 Aug	23 Aug	6 Sep	19 Sep	22 Aug	8 Sep	18 Sep	30 Sep
	Wyalkatchem	12 Jul	29 Jul	20 Aug	21 Sep	13 Aug	29 Aug	10 Sep	22 Sep	22 Aug	8 Sep	19 Sep	30 Sep
	Young	6 Jul	23 Jul	20 Aug	10 Oct	8 Aug	27 Aug	2 Sep	17 Sep	25 Aug	8 Sep	15 Sep	30 Sep
ASW	AGT Scythe	24 Jul	3 Aug	22 Aug	20 Sep	14 Aug	29 Aug	10 Sep	22 Sep	24 Aug	5 Sep	24 Sep	3 Oct
	H46	5 Jul	28 Jul	20 Aug	5 Sep	5 Aug	27 Aug	6 Sep	19 Sep	19 Aug	1 Sep	19 Sep	28 Sep
	Sentinel	29 Jul	22 Aug	1 Sep	24 Sep	29 Aug	9 Sep	19 Sep	2 Oct	12 Sep	20 Sep	2 Oct	9 Oct
ASWN	Arrino	17 Jul	22 Jul	21 Aug	6 Sep	13 Aug	28 Aug	4 Sep	17 Sep	24 Aug	1 Sep	19 Sep	29 Sep
	Binnu (WAWHT2734)	13 Jul	30 Aug	28 Aug	7 Sep	9 Aug	31 Aug	5 Sep	21 Sep	4 Sep	8 Sep	22 Sep	30 Sep
	Calingiri	24 Jul	3 Aug	1 Sep	13 Sep	20 Aug	4 Sep	16 Sep	24 Sep	10 Sep	14 Sep	28 Sep	4 Oct
A Soft	Bullaring	28 Jul	1 Aug	17 Sep	15 Sep	24 Aug	4 Sep	11 Sep	23 Sep	30 Aug	11 Sep	25 Sep	8 Oct
	Datatine	23 Jul	6 Aug	27 Aug	13 Sep	25 Aug	5 Sep	12 Sep	27 Sep	5 Sep	16 Sep	1 Oct	
	EGA 2248	22 Jul	24 Jul	19 Aug	16 Sep	11 Aug	23 Aug	4 Sep	19 Sep	27 Aug	1 Sep	19 Sep	2 Oct
	EGA Jitarning	7 Aug	18 Aug	7 Sep	5 Oct	29 Aug	9 Sep	19 Sep	3 Oct	10 Sep	25 Sep	3 Oct	9 Oct

Long duration   Medium duration   Short duration

Table 2. Anthesis date (50% heads showing yellow anthers) for wheat cultivars at different sowing dates at three locations in Western Australia in 206. Empty cells indicate data either not available or the total numbers of heads reaching apparent anthesis stage was less than 50 per cent of the total heads present in the marked area

	Cultivar	Geraldton				Northam				Katanning			
		26 April	16 May	2 June	21 June	26 April	16 May	2 June	21 June	28 April	16 May	2 June	21 June
AH	Braewood	7 Aug	17 Aug		20 Sep	6 Sep	20 Sep	29 Sep	8 Oct	20 Sep	27 Sep	6 Oct	12 Oct
	Carnamah	15 Jul	31 Jul	4 Sep	15 Sep	12 Aug	4 Sep	13 Sep	29 Sep	10 Sep	14 Sep	25 Sep	5 Oct
	EGA Bonnie Rock	17 Jul	13 Aug	16 Aug	10 Sep	14 Aug	31 Aug	9 Sep	23 Sep	1 Sep	13 Sep	21 Sep	7 Oct
	EGA Eagle Rock	6 Jul	29 Jul	28 Aug	16 Sep	20 Aug	4 Sep	15 Sep	26 Sep	10 Sep	20 Sep	1 Oct	5 Oct
	EGA Gregory	23 Jul	7 Aug	2 Sep	23 Sep	9 Sep	12 Sep	24 Sep	29 Sep	14 Sep	24 Sep	2 Oct	11 Oct
	GBA Sapphire	14 Jul	30 Jul	29 Aug	22 Sep	16 Aug	7 Sep	16 Sep	28 Sep	12 Sep	23 Sep	3 Oct	10 Oct
	Tammarin Rock	12 Jul	28 Jul	20 Aug	12 Sep	13 Aug	30 Aug	9 Sep	22 Sep	30 Aug	14 Sep	21 Sep	1 Oct
	Yitpi	5 Aug	12 Aug	6 Sep	30 Sep	21 Aug	7 Sep	19 Sep	1 Oct	11 Sep	24 Sep	3 Oct	11 Oct
APW	Annuello	16 Jul	1 Aug		12 Sep	21 Aug	14 Sep	18 Sep	29 Sep	16 Sep	24 Sep	4 Oct	8 Oct
	EGA Wentworth	20 Jul	30 Jul	31 Aug	26 Sep	21 Aug	12 Sep	16 Sep	27 Sep	11 Sep	21 Sep	1 Oct	7 Oct
	Ellison	4 Aug	14 Aug	7 Sep	2 Oct	4 Sep	16 Sep	22 Sep	9 Oct	11 Sep	24 Sep	3 Oct	16 Oct
	Spear	2 Aug	1 Sep	8 Sep	27 Sep	21 Aug	8 Sep	20 Sep	9 Oct	14 Sep	24 Sep	3 Oct	10 Oct
	Stiletto	30 Jul	16 Aug	7 Sep	26 Sep	17 Aug	4 Sep	17 Sep	2 Oct	14 Sep	24 Sep	2 Oct	10 Oct
	Wedgetail		12 Sep	20 Sep	14 Oct	13 Sep	25 Sep	2 Oct	15 Oct	27 Sep	2 Oct	6 Oct	20 Oct
	Westonia	3 Jul	26 Jul	16 Aug	13 Sep	14 Aug	31 Aug	10 Sep	23 Sep	2 Sep	15 Sep	25 Sep	3 Oct
	Wyalkatchem	18 Jul	30 Jul	21 Aug	21 Sep	17 Aug	2 Sep	13 Sep	25 Sep	2 Sep	15 Sep	22 Sep	3 Oct
	Young	6 Jul	22 Jul	22 Aug	25 Sep	13 Aug	31 Aug	9 Sep	20 Sep	3 Sep	15 Sep	22 Sep	3 Oct
ASW	AGT Scythe	27 Jul	6 Aug	24 Aug	22 Sep	16 Aug	3 Sep	15 Sep	26 Sep	2 Sep	14 Sep	28 Sep	5 Oct
	H46	3 Jul	27 Jul	20 Aug	14 Sep	11 Aug	1 Sep	13 Sep	23 Sep	29 Aug	12 Sep	25 Sep	3 Oct
	Sentinel	30 Jul	26 Aug	3 Sep	25 Sep	30 Aug	14 Sep	24 Sep	5 Oct	16 Sep	26 Sep	4 Oct	9 Oct
ASWN	Arrino	17 Jul	25 Jul	22 Aug	8 Sep	22 Aug	3 Sep	10 Sep	23 Sep	8 Sep	14 Sep	24 Sep	3 Oct
	Binnu (WAWHT2734)	17 Jul	2 Sep	01 Sep	8 Sep	18 Aug	8 Sep	10 Sep	27 Sep	15 Sep	19 Sep	27 Sep	4 Oct
	Calingiri	23 Jul	5 Aug	2 Sep	13 Sep	19 Aug	11 Sep	18 Sep	27 Sep	16 Sep	22 Sep	30 Sep	6 Oct
A Soft	Bullaring	30 Jul	3 Aug	17 Sep	25 Sep	23 Aug	12 Sep	17 Sep	28 Sep	8 Sep	19 Sep	30 Sep	11 Oct
	Datatine	24 Jul	6 Aug	31 Aug	20 Sep	30 Aug	14 Sep	18 Sep	2 Oct	13 Sep	22 Sep	3 Oct	9 Oct
	EGA 2248	22 Jul	23 Jul	20 Aug	17 Sep	18 Aug	31 Aug	11 Sep	24 Sep	7 Sep	15 Sep	25 Sep	2 Oct
	EGA Jitarning	11 Aug	20 Aug	8 Sep	6 Oct	31 Aug	12 Sep	24 Sep	3 Oct	16 Sep	27 Sep	3 Oct	10 Oct

Long duration   Medium duration   Short duration

Prospects for perennial wheat: A feasibility study

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KEY MESSAGES

Perennial wheat has potential to provide considerable economic and sustainability benefits to farming systems, has a positive outlook for high returns on research investment, and any major risks are capable of being managed (e.g. disease issues, persistence). Most aspects of the performance of perennial wheat require validation in field experiments and demonstrations to increase confidence prior to investing in a breeding and systems development effort. We believe there is significant benefit in pursuing the perennial wheat in a further 'Proof of Concept' study.

AIMS

There is a need for perennial plants in future Australian farming systems to improve their flexibility, sustainability and profitability. Perennial wheat was identified as a top priority for investigation as a perennial grain crop. This one-year project aimed to provide a framework to evaluate the potential for development of perennial wheat, including abiotic and biotic constraints, economic analysis, and agronomic and systems issues. The project aimed to build capacity through personnel, test the availability of germplasm, identify feasibility testing requirements, and develop a strategy for future research as a basis to consider a subsequent three-year 'proof of concept' project. In this paper we provide a summary of the key findings and conclusions from this study.

METHOD

Perennial wheat is not an established technology anywhere in the world at present, so the challenge is to explore its potential benefits and problems in Australian farming systems. There were four components in this one-year study:

Review of the prospects of perennial wheat: Potential benefits, opportunities, constraints and risks

A comprehensive review was conducted to analyse the literature on perennial wheat development, addressing issues such as limitations to grain production, risks of biotic stresses, potential production and environmental benefits, breeding considerations, description of important traits and possible farming systems.

Preliminary economic analysis

Profitability of conventional wheat-based systems was compared with perennial wheat under different grain price, yield and cost scenarios, using gross margins analysis and whole farm bio-economic modelling. Based on these results, a cost-benefit analysis for investment in perennial wheat was also conducted.

Perennial wheat workshop

A workshop was held to engage key researchers with experience and interests relevant to development of perennial wheat in Australia.

Visit to USA

A trip to the United States of America was undertaken to obtain experience and understanding from institutions involved in development of perennial wheat and other perennial grain crops.

RESULTS

Potential benefits

The potential benefits of perennial wheat are clear (Bell *et al.* 2007a, b) and arise in three main areas:

Cost and risk reductions – Reduced fuel costs, more efficient capture of nutrients and weed management benefits. Greater diversification and reduced production risk provided by flexibility about tactical decisions based on seasonal conditions.

Profit enhancement – In mixed crop-livestock systems via the provision of higher quality stubble or forage at the break of season from perennial wheat enabling stock numbers to increase and deferring grazing annual pastures until later in their growing season.

Sustainability benefits – Reducing drainage below the root zone and associated problems such as salinity, waterlogging and sub-soil acidification, reduced nitrate leaching, improved nutrient capture, maintenance of soil health and protection against soil erosion are anticipated.

Challenges

Initially, perennial wheat is expected to have a lower grain yield and quality than annual wheat. However, a longer growing season, increased capture of resources and on-going breeding should reduce any yield and quality disadvantages in the longer-term. Without high yields and/or premium prices, however, little incentive exists for perennial wheat in crop-only enterprises. Lower grain production will be offset by the provision of superior forage for livestock. For example, higher quality stubble and early grazing of the crop allow dual-purposes of grazing and grain production from perennial wheat which have significant economic benefits and can increase farm profit substantially.

Management of biotic stresses is an important concern, with perennial wheat potentially harbouring pests and diseases that could infect other crops. It would be a prerequisite that cultivars of perennial wheat meet strict disease resistance requirements, as in annual wheat breeding programs. The perennial grasses that are potential parents of perennial wheat boast high levels of disease resistance, and have often been the source of disease resistance for annual wheat. While disease and pests pose distinct challenges for perennial wheat, the risks can be minimised by a prerequisite for minimum disease standards.

Return on research and development investment

Based on the most probable assumptions for the development of perennial wheat, the benefit/cost ratio is 11 and net present value is $103m. Thus, perennial wheat appears to be a good research investment with a high potential return, despite some uncertainties about the scale of application, the likelihood of success and the research costs. These uncertainties can be managed, with the proof of concept stage providing the information needed to generate greater confidence about these issues, and investment intensity can then be matched to the more certain prospects.

Scale of application

A basic aim would be for 600,000 ha of perennial wheat sown at peak adoption to deliver the benefit/cost ratio and net present value described above. This area is based on the assumption of 20 per cent of each farm, peak adoption of 60 per cent over an applicable area of 25 per cent of the winter cropping zone of Southern Australia. Scale of applicability is a key factor affecting the return on investment for perennial wheat and confidence in the viability of these assumptions will be improved via evaluation of perennial wheat across a range of environments.

Collaboration and freedom to operate

Active perennial wheat breeding is underway at the Land Institute and Washington State University in the USA. This provides a source of expertise and pre-breeding material. US collaborators have already shared their experience and desire to assist with parallel developments in different environments and systems. They have indicated a willingness to provide access to germplasm and breeding material, which would provide a relatively cheap basis for preliminary evaluation of perennial

wheat materials in Australia. However, some progress on materials with better adaptation to Australian conditions may be required. A number of key personnel in Australia with a range of skills and interests in the prospect of perennial wheat have been engaged and are excited to participate in subsequent projects.

Outline for plans in 'Proof of Concept' stage

Three main activities are planned for Stage 2 of 'Prospects for Perennial Wheat'.

Germplasm acquisition and development – A diverse sample of pre-breeding materials will be collected, cleared through quarantine, assessed and subjected to general testing for broad adaptation to Australian conditions. The suitability of imported germplasm from the US may be questionable because of the different conditions, and there may be merit in an effort to develop preliminary materials with an Australian adapted background.

Ideotype testing – This will involve evaluation of individual plants of preliminary materials in key regional environments across Australia and evaluation of key agronomic traits such as growth pattern, phenology, grain yield and harvest index, persistence, drought adaptation, forage quality and disease susceptibility. This information will provide validation for the capacity to develop suitable plant types and the scale of applicability of perennial wheat to different environmental conditions across Australia.

Extrapolation and validation – Results from the limited number of test sites would be collated and modelling tools used to extrapolate this information more widely across different environments and seasonal conditions. Validation of assumptions regarding production and sustainability benefits will also be made, by quantifying plant response and resource capture. With these data, robust simulations can be obtained to explore performance, seasonal and site variability, situations of adaptive advantage, and confident predictions of expected returns from perennial wheat.

Other contributors:

For their participation, ideas and discussions in the perennial wheat workshop:

Dr Ray Hare, DPI NSW, Tamworth (Wheat Breeding)
Assoc. Prof. Phil Eberbach, Charles Sturt University (Crop Eco-physiology)
Dr Richard Richards, CSIRO Plant Industries, Canberra (Wheat Breeding/Physiology)
Dr Wal Anderson, DAFWA, Albany (Dryland Wheat Agronomy)
Dr Brian Dear, DPI NSW, Wagga Wagga (Legumes, Grasses and Crops Program in Salinity CRC)
Dr Neil Fettel, DPI NSW, Condobolin (Dryland Wheat Agronomy)
Dr Steven Simpfendorfer, DPI NSW, Tamworth (Cereal Pathology)
Dr Tim Colmer, University of Western Australia, Perth (Crop Physiology)
Dr Robert Loughman, DAFWA, Perth (Wheat Pathology)

CONCLUSION

Based on the outcomes of this one-year desktop pre-feasibility study, the value of further investment in a subsequent and larger feasibility study is clear. This 'Proof of Concept' second phase would be designed to address key issues highlighted in this pre-feasibility study and to validate the requirements for further research investment in perennial wheat. Stage 3 of this process would be pursued if results are promising and would respond to the findings from the Proof of Concept stage and potentially initiate a breeding program.

Extended project plan for Prospects for Perennial Wheat

Stage 1 – *Pre-feasibility study*	1 year – Desktop
Stage 2 – *Proof of Concept*	3 years – Preliminary field and glasshouse evaluation
Stage 3	3 years – Responds to results from Stage 2 and/or initiate breeding program

FURTHER READING

Wade, L.J., Bell, L.W., Ewing, M.A., Byrne, F. (nee Flugge) (2007). 'Prospects for Perennial Wheat: Pre-Feasibility Study – A Case for Further Research.' CRC for Plant-based Management of Dryland Salinity M081, University of Western Australia, Crawley, 81 p.

Part 1. Review of the Prospects of Perennial Wheat in Australian Farming Systems: Potential Benefits, Constraints and Risks, p. 4-42.
Provides an analysis of the literature on perennial wheat development, addressing issues such as limitations to grain production, risks of biotic stresses, potential production and environmental benefits, breeding considerations, description of important traits and possible farming systems.

Part 2. Preliminary Economic Analysis of Perennial Wheat in Australian Farming Systems, p. 43-64.
A comparison of profitability of conventional wheat-based systems with perennial wheat under different grain price, yield and cost scenarios using gross margins analysis and whole farm bio-economic modelling. Based on these results a cost-benefit analysis for investment in perennial wheat was also conducted.

Part 3. Perennial Wheat Workshop Summary, p. 65-74.
A report on the agenda, discussions and outcomes of the workshop conducted to engage key researchers with experience and interests relevant to development of perennial wheat in Australia.

Part 4. Trip Report for Visit To USA – Len Wade, p. 75-81.
A summary of experiences and understanding gained from a trip to the United States of America to institutions involved in development of perennial wheat and other perennial grain crops.

Forthcoming journal articles

Bell, L.W., Wade, L.J. and Ewing, M.A. (2007a). Prospects for perennial wheat in Australian farming systems: Potential Benefits, Opportunities, Constraints and Risks. *Australian Journal of Agricultural Research* (in review).

Bell, L.W., Byrne, F. (nee Flugge), Ewing, M.A. and Wade, L.J. (2007b). A preliminary economic analysis of perennial wheat in Australian farming systems. *Australian Journal of Experimental Agriculture* (in review).

KEY WORDS

perennial wheat, farming systems, economic analysis, sustainability, return to investment

ACKNOWLEDGMENTS

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Barley agronomy highlights: Time of sowing x variety

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KEY MESSAGES

- New feed barley options are becoming available that out yield current feed barley varieties.
- The new feed barley variety Fleet was the highest yielding variety across sites and sowing dates in 2006 and was closely followed by the 'soon to be released' feed barley varieties from the Department of Agriculture and Food – WABAR2310, WABAR2321 and WABAR2288.
- Hamelin produced similar grain yields to Stirling, whilst Baudin and Vlamingh became lower yielding as seeding was delayed into June and July.
- Gairdner was the lowest yielding malting barley variety in 2006 and performed poorly once seeding was delayed into June and July.

AIMS

Barley production has continued to climb in Western Australia and now averages close to 2 million tonnes per annum. Western Australia has consolidated its position as the major barley producing State in Australia, accounting for 33 per cent of the national crop in 2004/05. The value of Western Australia's barley exports was $461 million, and the value of malt exports was another $52 million. Baudin is now grown on 21 per cent of the barley acreage, whilst Hamelin is sown on 7 per cent. Growers will begin production of Vlamingh in 2007. The new Eastern State varieties Buloke and Flagship have not yet received accreditation to be grown for export or domestic sale as malting varieties in Western Australia.

Identifying which barley variety option will lead to the greatest return for a grower is a complex question. In some instances, the price premium paid for malting will more than offset the lower yields of some malting varieties when compared to a suggested feed variety. In other situations, the substantially higher yield of feed varieties, or the low likelihood of a malting variety being included in the malting grade, may justify the choice of a feed variety.

At a feed price of $150/t and a malt premium of $30/t, feed barley needs to yield 1.20 times or 20 per cent more than a malting barley for the same gross return assuming 100 per cent of the malting barley meets malting specifications and they have the same input costs. At a 50 per cent probability of meeting malting specifications, feed barley needs to yield only 10 per cent more than malting barley for the same gross return.

Over the last three years there has been a swing to feed barley varieties such as Mundah and Yagan (particularly in lower rainfall regions) due to the low probability of achieving the malting premium. The yield advantage of Mundah over Stirling is around 10 per cent in AgZones 2, 4 and 5 (Farmnote 06/118). Growers now have access to high yielding feed varieties with improved levels of disease resistance in many cases (i.e. Dash, Capstan and Barque) which offer growers lower input cost cropping programs.

Get it right however and very few feed barley varieties can deliver gross returns better than malting barley at current premiums. Management guidelines on how growers can maximise the success of growing a malting variety go a long way towards providing growers and industry with the confidence they need to sow malting barley at the right time for the right market. As growers look to increase their acreage of Baudin, Hamelin, adopt Vlamingh and potentially grow Buloke and Flagship, they need support on how to manage their crops to maximise their probabilities of success. This can be done by providing variety specific management guidelines that provides information on response to date of seeding, soil type, seeding rate, nitrogen management and leaf disease management, and the effect of interactions between those management tools.

Standard variety evaluation trials (CVT and NVT) only provide a one-dimensional interpretation of variety performance. They tell you nothing about the impact that date of seeding has on relative grain yield and grain quality. This paper provides a snapshot of the time of sowing by variety research that the barley agronomy project at the Department of Agriculture and Food is undertaking. These trials are planned to continue in 2007 and 2008. The question being asked is which variety should I sow when and what are the consequences for grain yield and grain quality? How does sowing date influence the choice of barley variety (and grade of barley variety)? In undertaking this research we have selected what we consider the best nine malting varieties and the best nine feed varieties to compare.

METHOD

Design: 18 varieties x 3 times of sowing x 3 replicates

Eighteen barley varieties were sown over three dates of seeding across eleven locations in 2006 (Table 1). The dates of seeding were usually three to four weeks apart. Trials were sown at Calingiri, Cadoux, Merredin, Brookton, Morbinning, Corrigin, Katanning, Newdegate, Salmon Gums, Scaddan and Gibson. Nine malting (including two potential malting) varieties were included – Stirling, Hamelin, Gairdner, Baudin, Vlamingh, Schooner, Buloke, Flagship and WI3416-1572. Nine feed barley varieties were included – Barque, Capstan, Dash, Fleet, Molloy, Mundah, WABAR2310, WABAR2321 and WABAR2288. The seed was treated with triadimenol as Zorro® at 400 mL/100 kg seed and sown to establish 150 plants/m^2. Flutriafol as Impact was applied to the in-furrow fertiliser at 400 mL/ha. In-crop foliar fungicide was used where deemed necessary. Trials were sown as either a split plot column design (varieties sown in replicates across a single bank) or a block row column design (varieties sown in replicates across three banks) with time of sowing as the main plot and varieties randomised within.

Table 1. Site details for barley agronomy time of sowing trials sown in the 2006 season

Site	AgZone	Date sown			*Soil type*
		TOS1	TOS2	TOS3	
Calingiri	2	24 May	23 June	17 July	*brown loamy gravel*
Cadoux	4	23 May	22 June	18 July	*red loamy duplex*
Merredin RS	4	22 May	28 June	17 July	*red non-cracking clay*
Brookton	3	31 May	28 June	20 July	*red duplex sandy gravel*
Morbinning	2	31 May	27 June	20 July	*yellow shallow sandy duplex*
Corrigin	2	6 June	29 June	20 July	*grey deep sandy duplex*
Katanning RS	2	1 June	29 June	7 July	*brown shallow sandy duplex*
Newdegate RS	5	25 June	11 July	24 July	*grey shallow sandy duplex*
Esperance Downs RS	6	8 May	24 May	15 June	*grey deep sandy duplex*
Scaddan	5	16 May	29 May	14 June	*alkaline loamy duplex*
Salmon Gums	*5*	*12 May*	*24 May*	*14 June*	*alkaline sandy duplex*

Plots were sown with a small plot seeder sowing 6 to 8 rows of seed. Plant establishment counts were taken at four weeks after seeding. Plots were harvested with a small plot harvester, weighed and sub-sampled. The grain sub-samples was cleaned over a 1.5 mm sieve and measured for average grain weight, hectolitre weight, screenings, grain brightness and grain protein.

RESULTS

Rainfall received

The first opportunity to sow a trial ranged from early May in the Esperance region to late June in the Lakes area (Table 1). The last seeding opportunity for the third date of seeding was in late July. Total rainfall received between 1 May and 30 October ranged between 115 mm at Salmon Gums to 246 mm at Gibson (Figure 1). Trials located at Esperance Downs, Scaddan and Salmon Gums received 60 per cent of their rainfall during the period between May to July (seeding period) and 40 per cent during the period between August to October (grain filling period). The other sites received 40 per cent of their rainfall during the seeding period and 60 per cent during the grain filling period.

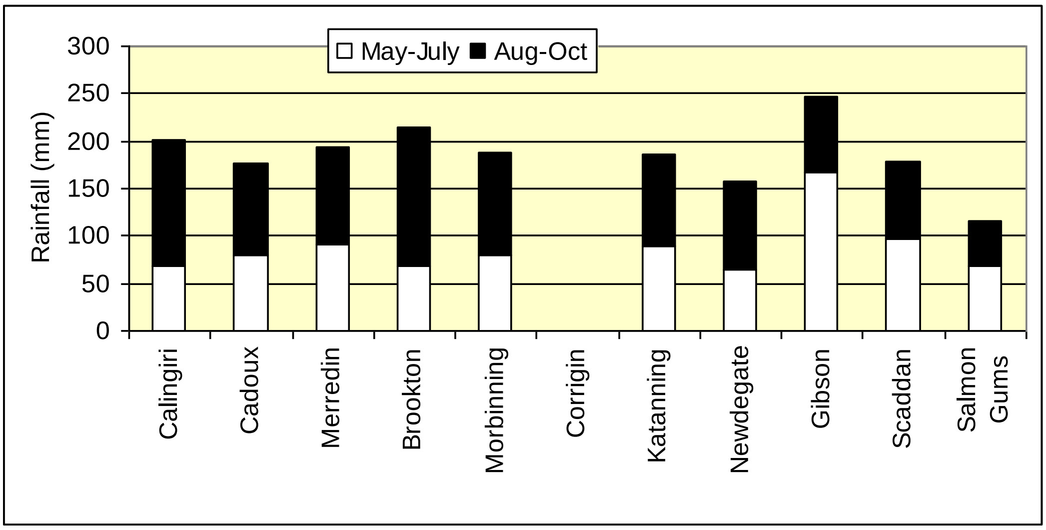

Figure 1. Rainfall received during the seeding period (May to July) and the grain filling stage (August to October) for the 11 time of sowing by variety trials sown in 2006. Note: Rainfall data from Corrigin had not been received when this paper was submitted.

Grain yield across sites and dates of seeding

At almost all sites there was a rapid decline in grain yield if seeding was delayed by three weeks or delayed by six weeks (Table 2). This is not always the case in seasons with more rainfall during the growing season. At the five sites (Calingiri, Cadoux, Merredin, Brookton and Morbinning) which all had a late May, a late June and a late July sowing date, the average decline in yield was 0.5 t/ha per sowing date.

Table 2. Grain yield (t/ha) achieved at each of the eleven sites sown in 2006 and differences in the average yield achieved by the nine malting varieties and the nine feed varieties at each site. Grain yields are raw data with no spatial analysis

Site	Grain yield (t/ha)								
	Overall yield			Malt varieties			Feed varieties		
	TOS1	TOS2	TOS3	TOS1	TOS2	TOS3	TOS1	TOS2	TOS3
Calingiri	3.78	3.43	2.49	3.67	3.26	2.32	3.90	3.61	2.67
Cadoux	2.03	1.35	0.62	1.97	1.33	0.61	2.08	1.37	0.63
Merredin	2.18	1.07	0.73	2.08	1.05	0.61	2.27	1.09	0.85
Brookton	2.62	2.34	1.71	2.56	2.27	1.69	2.68	2.41	1.73
Morbinning	2.21	2.23	1.98	2.17	2.18	1.99	2.25	2.27	1.97
Corrigin	2.28	1.39	0.95	2.19	1.42	0.93	2.36	1.37	0.98
Katanning	2.95	2.57	1.83	2.85	2.51	1.76	3.06	2.63	1.90
Newdegate	0.98	0.66	0.63	0.90	0.65	0.61	1.06	0.68	0.65
Salmon Gums	2.13	1.88	1.20	2.04	1.84	1.17	2.23	1.93	1.23
Gibson	3.10	2.76	2.52	3.07	2.63	2.40	3.13	2.89	2.64
Scaddan	3.49	2.99	2.70	3.30	2.83	2.58	3.68	3.15	2.83

Which varieties performed well in 2006?

Across all sites and all times of sowing, the feed barley variety Fleet (Mundah/Keel//Barque) had the highest yield potential in 2006 in our time of sowing trials. Fleet particularly excelled in trials that were located in the southern region (Newdegate, Salmon Gums, Gibson and Scaddan) were its average yield was 117 per cent of Stirling compared to the sites located in the central region (Calingiri, Cadoux, Merredin, Brookton, Morbinning, Corrigin, Katanning) where it averaged 110 per cent of Stirling. Please note our analyses are of raw data that has not been spatially adjusted for any site trends. Grain quality data was not available at the time of writing this paper.

The new feed barley releases available to growers in 2008 from the Department of Agriculture and Food were not that far behind Fleet in terms of yield potential. The short season Mundah replacement WABAR2310 (Doolup//Windich/Morex) out yielded Mundah at all the sowing dates, by an average of

5 per cent. The mid season Doolup and Molloy replacement WABAR2321 (WABAR2023//Windich/Morex) out yielded Molloy at all sowing dates by an average of 7 per cent. The late season Fitzgerald and Onslow replacement WABAR2288 (Tantangara/VB9104) out yielded Dash and Capstan at all sowing dates by an average of 13 per cent and 10 per cent respectively. It is interesting to note that despite being a late maturing variety, WABAR2288 had the capacity to yield across a wider range of sowing dates and environments than other lines of similar maturity including Baudin and Gairdner. The yield of the new feed varieties was the same as Fleet in the central region trials and lower in the southern region trials.

Table 3. Grain yield (t/ha and % of Stirling) of the 18 varieties averaged across sites sown in May, June or July and across all sites. Grain yields are raw data with no spatial analysis

Variety	Grain yield (t/ha)				Grain yield (% Stirling)			
	May	June	July	Average	May	June	July	Average
Stirling	2.60	2.06	1.26	2.02	100%	100%	100%	100%
Hamelin	2.62	2.05	1.37	2.06	101%	99%	109%	102%
Gairdner	2.57	1.70	0.87	1.77	99%	83%	69%	87%
Baudin	2.66	1.85	1.18	1.94	102%	90%	94%	96%
Vlamingh	2.62	1.91	1.22	1.96	101%	93%	97%	97%
Schooner	2.55	2.00	1.34	2.01	98%	97%	107%	99%
Buloke	2.80	2.12	1.42	2.15	108%	103%	113%	107%
Flagship	2.69	1.99	1.29	2.03	103%	97%	103%	101%
WI3416-1572	2.47	1.92	1.37	1.95	95%	93%	109%	97%
Barque	2.86	2.00	1.36	2.11	110%	97%	108%	105%
Capstan	2.78	1.88	1.17	1.99	107%	91%	93%	98%
Dash	2.72	1.87	1.01	1.92	105%	91%	80%	95%
Fleet	2.92	2.23	1.49	2.26	112%	108%	119%	112%
Molloy	2.79	2.06	1.23	2.08	107%	100%	98%	103%
Mundah	2.72	2.14	1.34	2.11	105%	104%	106%	105%
WABAR2310	2.83	2.26	1.44	2.23	109%	110%	115%	110%
WABAR2321	2.88	2.20	1.44	2.22	111%	107%	115%	110%
WABAR2288	2.87	2.12	1.44	2.18	111%	103%	115%	108%

Amongst the malting barley varieties currently received in Western Australia Hamelin, Stirling and Schooner were the highest yielding varieties across all sites and sowing dates. They had similar grain yields. Gairdner was the worst performing of the malting varieties. As seeding was delayed its grain yield dropped from 99 per cent of Stirling with May sowing, to 83 per cent with June sowing and 69 per cent with July sowing.

Of the three 'malt type' varieties being considered for release in Western Australia – Buloke, Flagship and WI3416-1572 – Buloke performed strongly at all sowing dates and out yielded all currently grown malting varieties. Flagship performed better than expected based on data from previous seasons, whilst WI3416-1572 was not as good as was expected. For WI3416 this could in part be explained by the poor germination of the seed at early seeding dates and lower establishment rates.

KEY WORDS

barley, varieties, time of sowing

ACKNOWLEDGMENTS

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Paper reviewed by: Kellie Winfield

Barley agronomy highlights: Weeds and row spacing

Blakely Paynter[1] and **Andrea Hills**[2], Department of Agriculture and Food, Western Australia; Northam[1] and Esperance[2]

KEY MESSAGES

- Increasing the row spacing (i.e. 18 to 36 cm) can decrease the yield of barley. At three of the five sites sown, doubling the row spacing decreased the yield of barley by between 0.3 to 1.2 t/ha (or 8 to 27 per cent) with little effect on grain quality.
- There was a trend towards decreasing grain yield as the ryegrass competition increased from a low pressure (4 to 20 plants/m^2) to a medium pressure (112 to 124 plants/m^2). However, this effect was only significant at two of the five sites. There was nearly a 20 per cent reduction in grain yield at Katanning and Meckering due to ryegrass competition with little effect on grain quality.
- Above ground plant architecture does not appear to influence the response of barley (within the same maturity group) to increasing row spacing or ryegrass competition. Thus we observed no differences between Baudin, Gairdner, Dash and Vlamingh in their response to a doubling of the row spacing in which they were sown or an increase in ryegrass numbers present.

AIMS

The presence of weeds in the farming system can influence the decision to grow malt or feed type varieties. Competition with weeds not only decreases yield potential but it can cause malt barley varieties to be downgraded to feed through decreases in grain quality (i.e. increased screenings or competition for nitrogen affecting grain protein levels). Barley, however, is regarded as being more competitive against weeds than wheat due to differences in early vigour.

With the advent of GPS guided farming, growers are looking to use wider rows to allow selective spraying of weeds in the inter-row. Research conducted by DAFWA shows that as cereals are sown onto wider rows their grain yield often decreases. The bulk of this work has been done with wheat and if conducted with barley has mostly used early maturing varieties like Stirling.

Differences in canopy structure in barley are generally more pronounced than those in modern wheat varieties. Barley varieties may differ in their early growth habit (i.e. prostrate, semi-erect and erect), their height at maturity by up to 40 cm, leaf angle and shape (i.e. floppy, erect, large, skinny) and maturity group (with differences in flowering date of up to four weeks). Within the same maturity group differences in canopy structure may influence above ground weed competitiveness through differences in light interception and shading. A large number of farmers perceive Baudin to be less competitive against weeds than other barley varieties. They believe the combination of its prostrate early growth and the shortness of its straw does not allow it to smother weeds. As the weeds seed heads can be seen above the canopy the assumption is it is less competitive.

This paper provides a snapshot of some of the research undertaken by the barley agronomy group during the 2005 growing season. It looks at weed competition in narrow versus wide rows and asks the question – how do differences in above ground plant architecture influence the response of barley to sowing in narrow versus wide rows with and without the presence of ryegrass competition?

METHOD

Design: 4 varieties x 2 row spacing x 2 ryegrass densities x 4 replicates

Row spacing trials (date sown) were established at Meckering (10 May), Katanning (1 June), Mt Madden (25 May), Cascade (20 May) and Gibson (24 May) in 2005. Sites with a known low ryegrass presence were selected. Safeguard ryegrass was top dressed onto the soil surface across the plot pre-seeding at 1 g/m^2 to the 'plus' ryegrass plots. Double width plots were sown by a small plot air-seeder in two configurations – normal row spacing and wide row spacing (2 x normal row

spacing). The normal row spacing was the standard setup used by DAFWA Research Support Unit (i.e. 18, 24 or 25 cm) with seed and fertiliser drilled out of each tyne (Table 1). Wide row spacing was achieved by blocking the air-seeder head so that seed and fertiliser was drilled out of every second tyne. No tynes were removed in the wide row plots, so that the ryegrass establishment was similar across the row spacing treatments. The four barley varieties – Baudin, Dash, Gairdner and Vlamingh – were sown to establish a target plant density of 150 plants/m^2. Trials were sown as a strip plot design with ryegrass as the main plot splitting each 20 m plot into 2 x 10 m plots and row spacing and variety randomised in replicates over two banks.

Plots were sown with a small plot seeder sowing 6 to 8 rows of seed. Plant establishment counts were taken at four weeks after seeding. Hand cuts taken at maturity were dried, weighed and separated into two components – barley and ryegrass. The barley component was assessed for tiller number and grain number per ear, whilst the ryegrass component was only assessed for tiller number. Plots were harvested with a small plot harvester, grains weighed and sub-sampled. The grain sub-samples was cleaned over a 1.5 mm sieve and measured for average grain weight, hectolitre weight, screenings, grain brightness and grain protein.

RESULTS

Ryegrass and barley establishment and differences in plant growth habit

The normal row spacing at which the barley was sown ranged from 18 cm to 25 cm. Wide row plots saw the row spacing increase to 36, 48 or 50 cm (Table 1). There was only a small difference in the number of barley plants established between the narrow and wide row plots, with an average of 115 plants/m^2 established across all treatments. The addition of ryegrass increased the number of ryegrass plants present from 10 to 116 plants/m^2 (or from low to moderate weed competition).

Table 1. Setup of row spacing trials – row spacing (cm), average barley establishment (plants/m^2) and average ryegrass establishment (plants/m^2) at each of the five sites

Site	Row spacing (cm)		Barley establishment (plants/m^2)		Ryegrass establishment (plants/m^2)	
	Normal	Wide	Normal	Wide	Nil	Plus
Cascade	24	48	129	135	14	124
Gibson	24	48	146	129	4	112
Katanning	18	36	80	87	5	114
Meckering	18	36	122	107	4	113
Mt Madden	25	50	108	107	20	116

The four varieties sown differed in their above ground plant architecture (hence the reason for being chosen for this study) but had a similar duration to awn emergence (Table 2). Baudin and Gairdner are barley varieties with a prostrate early growth habit, floppy leaves but different plants heights during flowering. They also had much greater coverage of the soil surface than the erect varieties Dash and Vlamingh during the first 10 to 12 weeks of plant growth. Dash and Vlamingh are barley varieties with an erect early growth habit, erect leaves and different plant heights during flowering.

Table 2. Measurements relating to different above ground canopy structures at early growth, stem elongation and at awn peep of four varieties of similar maturity

Variety	Early growth habit	Stem elongation			Awn emergence		
		Height (cm)	Width (cm)	Canopy closure (1-5)	Leaf structure	Height (cm)	Canopy closure (1-5)
Baudin	prostrate	21	27	3.2	floppy	52	2.5
Gairdner	prostrate	18	26	3.2	floppy	54	2.7
Dash	erect	26	24	2.7	erect	54	2.5
Vlamingh	erect	25	23	2.5	erect	60	2.4
lsd (0.05)	-	1	1	0.2	-	1	0.1

Table 3. Table of mean squares and significance for ryegrass tillers per m² at maturity, grain yield (kg/ha), average grain weight (mg, db) and grain protein (%, db) across the five sites

Source	d.f.	Ryegrass tillers (no./m²)		Grain yield (kg/ha)		Average grain weight (mg, db)		Grain protein (%, db)	
		m.s.	f-prob	m.s.	f-prob	m.s.	f-prob	m.s.	f-prob
Site (S)	4	318,804	0.002	46,036,337	0.001	2,889	0.001	186.01	0.001
Error a	15	44,309		990,398		33		3.20	
Ryegrass (R)	1	2,351,151	0.001	10,684,218	0.001	6	ns	2.01	ns
S x R	4	204,350	0.007	1,880,330	0.004	17	ns	0.81	ns
Error b	15	37,904		300,690		50		2.32	
Variety (V)	3	52,249	0.006	4,969,017	0.001	2,513	0.001	8.66	0.001
Row spacing (RS)	1	545,328	0.001	11,301,512	0.001	18	ns	5.85	0.001
S x V	12	8,282	ns	577,680	ns	38	0.001	0.62	ns
R x V	3	23,495	ns	89,122	ns	15	ns	0.09	ns
S x RS	4	74,583	0.001	3,953,586	0.001	6	ns	0.55	ns
R x RS	1	85,879	0.009	16,542	ns	21	ns	0.01	ns
V x RS	3	925	ns	305,370	ns	14	ns	0.88	ns
S x R x V	12	18,062	ns	121,104	ns	11	ns	0.13	ns
S x R x RS	4	12,281	ns	92,690	ns	13	ns	0.10	ns
S x V x RS	12	14,162	ns	361,622	ns	7	ns	0.53	ns
R x V x RS	3	30,906	ns	7,148	ns	8	ns	0.35	ns
S x R x V x RS	12	17,387	ns	85,672	ns	6	ns	0.24	ns
Error c	210	12,265		326,366		12		0.35	

Row spacing

Doubling the row spacing of the barley (without any reduction in the amount of fertiliser used or seed sown or in the absence or presence of ryegrass), decreased the grain yield of barley at three of the five sites (Tables 3 and 4). The reduction in yield at Gibson was 1.21 t/ha (27 per cent reduction), Katanning 0.30 t/ha (8 per cent reduction) and Mt Madden 0.37 t/ha (18 per cent reduction). Reductions in grain yield were usually associated with a decrease in the number of tillers per m² and grains per ear.

There was no interaction with variety, that is, all four varieties (despite having different above ground canopy structures) responded similarly to the change in row spacing (Table 3). This suggests that within the same maturity group, the movement to wider rows is not likely to influence variety choice.

In general, increasing the row spacing did not greatly influence grain quality (Tables 3 and 4).

The number of ryegrass tillers present at maturity was higher under wider rows than under narrow rows, but there was an interaction with site (Tables 3 and 4). At Cascade, Gibson and Katanning the number of ryegrass tillers present at maturity was double that present under narrow rows. This indicates that barley sown in wider rows is less competitive against ryegrass than when sown in narrow rows as the same number of ryegrass plants established at seeding under both systems. It also means that wider row systems may be more susceptible to increasing ryegrass seed numbers in the seed bank if alternative inter-row or other IWM practices are not implemented.

Table 4. Number of ryegrass tillers per m² at maturity, grain yield (t/ha), average grain weight (mg, db) and screenings (% < 2.5 mm) of four varieties sown at normal and wide row spacing at five sites in 2005

	Ryegrass tillers (no./m²)		Grain yield (t/ha)		Average grain weight (mg, db)		Grain protein (%, db)	
Ryegrass added	**Normal**	**Wide**	**Normal**	**Wide**	**Normal**	**Wide**	**Normal**	**Wide**
Cascade	108	292*	3.50	3.54	37.4	38.0	11.1	11.3
Gibson	126	240*	4.51	3.30*	39.8	39.8	11.1	11.7*
Katanning	124	188*	3.73	3.43*	35.7	36.1	11.1	11.2
Meckering	34	42	3.86	3.81	40.9	41.1	9.7	10.0
Mt Madden	50	98	2.03	1.66*	35.0	35.3	14.3	14.6
lsd (0.05)	86		0.42		0.6		0.7	
lsd (0.05) – site	55		0.28		0.6		0.3	

* At sites with an asterisk and shaded, the wide row plots were different from the narrow row plots.

Ryegrass competition

Across all sites, the average reduction in grain yield by increasing the number of ryegrass plants that the barley had to compete with was 0.37 t/ha. However, there was an interaction between site and ryegrass (Table 3). There was only a significant reduction in the grain yield of the barley at two of the five sites sown. At Katanning and Meckering, ryegrass competition reduced the grain yield by 0.81 and 0.64 t/ha respectively (Table 5), or a yield reduction of 20 per cent and 15 per cent. The trend at two of the other sites (Gibson and Mt Madden) was also towards a reduction in grain yield with ryegrass competition, but the change in yield was not significant. Reductions in grain yield were usually associated with a decrease in the number of tillers per m^2 and grains per ear.

As with row spacing, the impact of a medium level of ryegrass competition had only a small effect on the screenings level of the barley and on grain protein levels (Tables 3 and 5). Across the five sites the average increase in screenings due to ryegrass was 2 per cent. The increase in screenings was only evident at two sites – Katanning and Meckering. At the other three sites there was no effect.

There was no interaction with variety, that is, all four varieties (despite having different above ground canopy structures) responded similarly to changes in ryegrass competition from a low level to a medium level (Table 3).

This means that within the same maturity group, differences in above ground plant architecture do not appear to influence the competitiveness of barley against ryegrass. It also suggests that Baudin is as competitive against ryegrass as Dash, Vlamingh and Gairdner barley.

The number of ryegrass tillers present at maturity was however lower under Baudin than under the other three varieties (96 v 141 tillers/m^2). This suggests that Baudin is able to suppress ryegrass by reducing tiller production. Assuming a similar number of panicles are set per tiller, this means that the number of ryegrass seeds returned to the seed bank may have been lower under Baudin than other varieties.

Table 5. **Number of ryegrass tillers per m^2 at maturity, grain yield (t/ha), average grain weight (mg, db) and grain protein (%, db) of four varieties sown under low (nil) and medium (plus) ryegrass pressure**

Ryegrass added	Ryegrass tillers (no./m^2)		Grain yield (t/ha)		Average grain weight (mg, db)		Grain protein (%, db)	
	Nil	Plus	Nil	Plus	Nil	Plus	Nil	Plus
Cascade	118	283*	3.52	3.41	37.9	37.5	11.2	11.2
Gibson	51	315*	3.97	3.85	40.3	39.2*	11.7	11.1
Katanning	1	307*	3.98	3.18*	36.7	35.1*	11.2	11.2
Meckering	2	74	4.45	3.51*	41.4	40.7	10.0	9.8
Mt Madden	48	99	1.97	1.72	35.7	34.5*	14.5	14.5
lsd (0.05)	86		0.42		0.8		0.8	
lsd (0.05) – site	55		0.28		1.0		0.8	

* At sites with an asterisk and shaded, the 'plus' ryegrass plots were different from nil ryegrass plots.

KEY WORDS

barley, ryegrass, row spacing, weed competition

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Barley agronomy highlights: Weeds and barley variety

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KEY MESSAGES

- As a general rule, the competitiveness of barley against ryegrass increases as the density of barley established increases. In this study differences between varieties in their competitive ability (as measured by yield loss) against ryegrass were observed at different barley plant densities.
- At plant densities suggested for growing barley in Western Australia (120 to 150 plants/m^2) the early spring maturity variety Hamelin was more competitive against ryegrass than all of the medium spring maturity varieties Baudin, Buloke, Flagship, Gairdner and Vlamingh. Within the medium spring varieties, Baudin and Buloke appeared to be slightly more competitive against ryegrass than Flagship, Gairdner and Vlamingh.
- At low barley plant densities there were no differences between varieties in their relative competitiveness against ryegrass.
- Delayed sowing did not alter the relative competitiveness of varieties against ryegrass.

AIMS

The presence of weeds in the farming system can influence the decision to grow malt or feed type varieties. Competition with weeds not only decreases yield potential but it can cause malt barley varieties to be downgraded to feed through decreases in grain quality (i.e. increased screenings or competition for nitrogen affecting grain protein levels). Barley, however, is regarded as being more competitive against weeds than wheat due to differences in early vigour.

A large number of farmers perceive Baudin to be less competitive against weeds than other barley varieties. They believe the combination of its prostrate early growth and the shortness of its straw does not allow it to smother weeds. As the weeds seed heads can be seen above the canopy the assumption is it is less competitive.

This paper provides a snapshot of some of the research work undertaken by the barley agronomy group during the 2005 growing season. The weed competitiveness of six malting barley varieties was investigated to address the question of if the relative competitiveness of malting barley varieties against ryegrass change with increased plant density and/or delay seeding.

METHOD

Design: 6 varieties x 3 seeding rates x 2 times of sowing x 2 ryegrass densities x 3 replicates

Weed competition trials were established at Calingiri, Beverley, Katanning, Mt Madden and Gibson. Sites with a known low ryegrass presence were selected. Safeguard ryegrass was top dressed onto the soil surface across the plot pre-seeding at 1 g/m^2 on the 'plus' ryegrass plots. The six barley varieties – Baudin, Buloke, Flagship, Gairdner, Hamelin and Vlamingh – were sown at two dates of seeding usually three weeks apart at three planting densities. Seed weight for each variety and plot was adjusted with an aim to establish 75, 150 or 300 plants/m^2. Trials were sown as a strip-split plot design with time of sowing as the main plot, ryegrass as the sub-plot splitting each 20 m plot into 2 x 10 m plots and varieties and seeding rates randomised as sub-sub-plots sown in two banks.

Plots were sown with a small plot seeder sowing 6 to 8 rows of seed. Plant establishment counts were taken at four weeks after seeding. Hand cuts of plants taken at maturity (from all sites except Beverley) were dried, weighed and separated into two components – barley and ryegrass. The barley component was assessed for tiller number and grain number per ear, whilst the ryegrass component was only assessed for tiller number. Plots were harvested with a small plot harvester, grains weighed and sub-sampled. The grain sub-samples was cleaned over a 1.5 mm sieve and measured for average grain weight, hectolitre weight, screenings, grain brightness and grain protein.

RESULTS

Barley and ryegrass establishment

Table 1. Sowing dates, the average number of barley plants/m² established at each site for each target plant density and the number of ryegrass plants/m² established in the nil and plus ryegrass plots at each of the five sites in 2005

Site	Sowing dates		Barley establishment (no/m²) at each seeding density			Ryegrass establishment (no/m²)	
	TOS1	TOS2	75	150	300	Nil	Plus
Beverley	24 May	14 June	48	75	115	4	122
Calingiri	18 May	15 June	70	109	163	2	143
Gibson	24 May	14 June	66	110	184	16	93
Katanning	1 June	21 June	65	112	174	7	90
Mt Madden	25 June	16 July	66	106	171	49	179

Average barley plant establishment was below what was expected, especially at Beverley. This was not due to a low germinability of the seed, but due to the soil conditions at seeding being too wet. Despite this, differences in plant establishment were achieved. The average plant density achieved across all sites (except Beverley) was 67, 109 and 173 plants/m² (target densities were 75, 150 and 300 plants/m²). Background ryegrass numbers at each of the sites (except Mt Madden) were low, averaging 7 plants/m². Adding ryegrass to the surface of the soil before seeding increased the number of plants established by around 109 plants/m² per site.

Table 2. Table of mean squares and significance for grain yield (kg/ha), average grain weight (mg, db) and grain protein (%, db) for all five sites sown

Source	d.f.	Grain yield (kg/ha)		Average grain weight (mg, db)		Grain protein (%, db)	
		m.s.	f-prob	m.s.	f-prob	m.s.	f-prob
Site (S)	4	216,900,000	0.001	1,170.02	0.001	379.12	0.001
Error a	10	4,222,000		11.40		2.58	
TOS (T)	1	106,200,000	0.001	854.95	0.001	77.86	0.001
S.T	4	9,371,000	0.013	498.85	0.001	14.05	0.003
Error b	10	1,699,000		12.05		1.72	
Ryegrass (R)	1	109,400,000	0.001	879.18	0.001	20.26	0.001
S.R	4	2,527,000	0.022	153.79	0.001	3.76	0.037
T.R	1	557,300	ns	4.54	ns	1.05	ns
S.T.R	4	1,558,000	ns	7.16	ns	0.96	ns
Error c	20	693,100		7.45		1.19	
Variety (V)	5	7,805,000	0.001	587.76	0.001	17.24	0.001
Seedrate (SR)	2	24,130,000	0.001	236.45	0.001	11.84	0.001
S.V	20	1,003,000	0.001	86.66	0.001	2.80	0.001
T.V	5	501,600	0.001	15.67	0.001	0.63	0.011
R.V	5	349,000	0.001	6.72	0.001	0.36	ns
S.SR	8	1,414,000	0.001	10.01	0.001	0.43	0.041
T.SR	2	2,466	ns	4.34	ns	0.18	ns
R.SR	2	221,200	ns	6.77	0.012	0.20	ns
V.SR	10	157,100	0.042	5.25	0.001	0.43	0.025
S.T.V	20	499,900	0.001	4.18	0.001	1.80	0.001
S.R.V	20	115,000	ns	2.58	0.031	0.21	ns
T.R.V	5	177,600	ns	1.91	ns	0.05	ns
S.T.SR	8	78,690	ns	2.98	0.05	0.70	0.001
S.R.SR	8	195,100	0.016	2.10	ns	0.13	ns
T.R.SR	2	69,030	ns	0.98	ns	0.06	ns
S.V.SR	40	140,900	0.005	2.37	0.018	0.25	ns
T.V.SR	10	65,210	ns	0.72	ns	0.45	0.02
R.V.SR	10	197,200	0.009	1.23	ns	0.26	ns
S.T.R.V	20	99,900	ns	1.73	ns	0.37	0.024
S.T.R.SR	8	64,760	ns	0.98	ns	0.11	ns
S.T.V.SR	40	118,100	0.043	1.39	ns	0.21	ns
S.R.V.SR	40	81,800	ns	1.24	ns	0.18	ns
T.R.V.SR	10	54,370	ns	1.23	ns	0.12	ns
S.T.R.V.SR	40	87,670	ns	1.27	ns	0.13	ns
Error d	680	56,070,000		1,041.49		143.07	

Weed competitiveness and sites

The average reduction in grain yield across all five sites due to the addition of another 109 ryegrass plants/m^2 to the background level was 637 kg/ha, equivalent to a 20 per cent reduction. The impact of ryegrass was larger at Beverley, Calingiri and Gibson than at Katanning and Mt Madden (Table 2 and 3). At Beverley, Calingiri and Gibson, the average reduction in grain yield was 782 kg/ha or a reduction in yield of 23 per cent. At the other two sites the reduction in yield was only 418 kg/ha or 18 per cent.

At the four sites where dry matter cuts were taken (Calingiri, Gibson, Katanning and Mt Madden), the average yield reduction was 571 kg/ha. At these sites the 'plus' ryegrass plots had 50 less barley tillers/m^2, 0.8 less barley grains per ear and the grains were on average 1 mg lighter than those from where ryegrass was not added at seeding. The barley plots also had 278 more ryegrass tillers/m^2.

Table 3. Impact of ryegrass addition (nil or plus ryegrass) on grain yield (t/ha), average grain weight (mg, db), screenings (% < 2.5 mm) and grain protein (%, db) at five sites sown in 2005

Ryegrass added	Grain yield (t/ha)		Average grain weight (mg, db)		Screenings (% < 2.5 mm)		Grain protein (%, db)	
	Nil	Plus	Nil	Plus	Nil	Plus	Nil	Plus
Beverley	2.50	1.60*	42.9	38.1*	9.8	22.6*	11.7	11.7
Calingiri	4.22	3.49*	39.3	38.3*	25.7	26.3	13.2	12.6*
Gibson	4.25	3.54*	43.7	43.0	7.2	7.6	11.9	11.4*
Katanning	2.96	2.60*	39.2	37.9*	10.3	13.3	11.3	11.1
Mt Madden	1.96	1.48*	38.0	36.7*	27.1	31.5*	14.5	14.4
lsd (0.05)	0.46		0.9		3.8		0.4	
lsd (0.05) – site	0.24		0.8		3.2		0.3	

* At sites with an asterisk and shaded, the 'plus' ryegrass plots were different from nil ryegrass plots.

The impact on grain quality was more variable and site specific (Tables 2 and 3). At four of the five sites, ryegrass addition reduced average grain weight by over 1 mg per grain. This reduction in weight however only translated to increased screenings at two of the sites (Beverley and Mt Madden). There was a general trend towards reducing grain protein with ryegrass competition, but it was only significant at two of the five sites.

The impact of ryegrass on grain yield was not influenced by seeding date (Table 2). The impact of ryegrass on grain quality was also not affected by delayed seeding (Table 2). Delayed seeding did not impact the number of ryegrass tillers produced.

There was a site specific interaction between seeding rate and ryegrass competition (Table 2). The impact of ryegrass on grain yield reduction was the same at each plant density at Beverley, Gibson, Katanning and Mt Madden. It was only at Calingiri that the yield reduction due to ryegrass decreased as the number of barley plants established increased. Grain yield reduction decreased from 23 per cent to 18 per cent to 12 per cent as the barley density increased from 70 to 109 to 163 barley plants/m^2.

There was no interaction between seeding rate, ryegrass and site on grain protein (Table 2). As barley plant density increased there was a general trend of a decreasing impact of ryegrass on average grain weight. This was not translated through to an impact on screenings in the 2005 season.

As the number of barley plants established increased there was a strong reduction in the number of ryegrass tillers produced at maturity. This effect was consistent across sites. Ryegrass tiller number decreased from 208 to 171 and to 128 tillers/m^2, as the barley density increased.

Weed competitiveness and varieties

There was an interaction between varieties and ryegrass for grain yield, average grain weight and screenings, but not for grain protein (Table 2). Ryegrass competition had a lower impact on the grain yield of Hamelin barley than it did the other five varieties (Table 4). The yield reduction in Hamelin was only 490 kg/ha compared to 666 kg/ha, or 16 per cent v 21 per cent.

There was also an interaction between variety, seeding rate and ryegrass for grain yield, but not for average grain weight, screenings or grain protein (Table 2). This interaction for grain yield was similar across sites. The impact of ryegrass on grain yield appeared to be lower in Buloke, Baudin and Hamelin as the number of barley plants/m^2 established increased. The average yield reduction across the six varieties due to ryegrass competition at the lowest barley density was 23 per cent. At higher barley densities it was only 13 per cent for Hamelin, 16 per cent for Baudin, 18 per cent for Buloke and 22 per cent for Flagship, Gairdner and Vlamingh. This result suggests that at barley plant densities currently suggested for the production of barley in Western Australia, Hamelin was the most competitive variety against ryegrass, followed by Baudin and Buloke and then Flagship, Gairdner and Vlamingh. Another weed competition study presented at the 2007 Crop Updates (Paynter, B.H. and Hills, A. – Barley agronomy highlights: Weeds and row spacing) however could not find any evidence that Baudin was more competitive than Gairdner or Vlamingh at suggested plant densities.

Other than Hamelin flowering some 10 to 14 days earlier than the other five varieties tested, we were unable to demonstrate the reason for the competitive advantage of Hamelin from examining yield component data (tiller/m^2, grains/ear, grains/m^2 and average grain weight). That is, there was no single yield component where Hamelin was significantly different from all the other varieties. The improved competition of Baudin and Buloke at suggested barley densities may have been related to tiller number. Baudin (707 tillers/m^2) and Buloke (677 tillers/m^2) produced more tillers per m^2 than the other four varieties (572 tillers/m^2).

Another contributing factor for Hamelin and Baudin may have been that the number of ryegrass tillers/m^2 at maturity measured under Hamelin and Baudin (136 ryegrass tillers/m^2) was lower than Buloke, Flagship, Gairdner and Vlamingh (185 ryegrass tillers/m^2). This suggests that Hamelin and Baudin may be able to suppress ryegrass better than some varieties at some sites.

The impact of ryegrass competition on average grain weight and screenings was lower in Baudin, Buloke and Hamelin than in Flagship, Gairdner and Vlamingh (Table 4). Average grain weight was reduced by only 1.5 mg compared to 2.1 mg and screenings by 2.9 per cent to 5.3 per cent.

Table 4. Impact of ryegrass addition (nil or plus ryegrass) on grain yield (kg/ha), average grain weight (mg, db), screenings (% < 2.5 mm) and grain protein (%, db) of six barley varieties

Ryegrass added	Grain yield (t/ha)		Average grain weight (mg, db)		Screenings (% < 2.5 mm)		Grain protein (%, db)	
	Nil	Plus	Nil	Plus	Nil	Plus	Nil	Plus
Baudin	3.54	2.87*	38.1	36.8*	15.2	17.8*	12.2	11.9*
Buloke	3.33	2.59*	42.6	40.9*	20.9	24.2*	12.3	12.1*
Flagship	3.07	2.49*	42.8	40.7*	16.6	23.0*	12.5	12.4*
Gairdner	3.07	2.38*	40.8	38.9*	23.5	29.0*	12.3	12.0*
Hamelin	3.13	2.64*	40.2	38.6*	9.2	12.0*	13.0	12.5*
Vlamingh	2.93	2.29*	39.2	36.8*	10.8	15.4*	12.9	12.6*
lsd (0.05)	0.13		0.5		1.8		0.2	
lsd (0.05) – ryegrass	0.08		0.4		1.3		0.1	

* Varieties with an asterisk and shaded, the 'plus' ryegrass plots were different from nil ryegrass plots.

There was no evidence that varieties react differently with grain yield and grain quality to ryegrass competition as seeding is delayed (Table 2).

KEY WORDS

barley, ryegrass, seeding rate, time of sowing, weed competition

ACKNOWLEDGMENTS

Technical support for this research was provided by Sue Cartledge and David Dodge. Research trials were managed by Department RSU. The research is supported by the Department and the GRDC.

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Paper reviewed by: Abul Hashem

Agronomic performance of dwarf potential milling oat varieties in varied environments of WA

Raj Malik[1], Blakely Paynter[2] and **Kellie Winfield[2]**, Department of Agriculture and Food, Western Australia; [1]Katanning and [2]Northam

KEY MESSAGES

- In 2006, Kojonup yielded lower than expected. This was most noticeable at Beverley and Katanning, which had less than 200 mm in-crop rainfall where Kojonup grain yields averaged 12 per cent lower than Carrolup.
- Despite the unexpected poor grain yield, Kojonup produced grain that meet industry grain quality targets (minimum hectolitre weight of 51 kg/hL and a maximum screenings of 10 per cent) more consistently than Carrolup, Possum and Mitika.
- Mitika and Possum, bred for eastern Australia, yielded higher than Kojonup at sites with less than 200 mm in-crop rainfall and similarly at the site with above 200 mm rainfall (Calingiri).
- Kojonup is currently being commercially evaluated for reclassification as milling (Oat1).
- The evaluation of Mitika has been postponed by the Western Australian oat industry to give priority to Kojonup, and Possum is unlikely to be evaluated as a milling variety.
- Wandering was the highest yielding variety in both 2005 and 2006.

BACKGROUND

Currently only non-dwarf varieties such as Mortlock, Carrolup and Pallinup are received into the Western Australian milling grade (Oat1) whilst dwarf oats such as Dalyup and Wandering can only be received into the feed grade (Oat2). However, dwarf oats are higher yielding, have decreased lodging risk and reduced shedding risk than non-dwarf varieties. The development of dwarf milling oats therefore has the potential to offer growers improved yields and improved agronomy.

Three new dwarf varieties – Kojonup, Possum and Mitika – with potential to be received as milling quality – have become available to the Western Australian oat industry. This poses a series of questions, including:

- relative benefit over current non-dwarf milling varieties such as Carrolup;
- relative benefit over current dwarf feed varieties such as Wandering;
- adaptation to the Western Australian environment;
- yield, grain quality and agronomic stability in varied growing conditions (average, wet and dry).

Time of seeding (TOS) and soil type experiments can be very useful in providing information on the stability and risk assessment of new lines being released for the milling market.

AIMS

The aim of this study was to evaluate the performance and stability of new dwarf varieties (potential milling) to changes in time of seeding and soil type in different environments of Western Australia.

METHOD

A series of field experiments were conducted in 2004, 2005 and 2006 to evaluate the performance of three new dwarf varieties (Kojonup, Possum and Mitika) for grain yield and quality attributes. Small plot trials were spread across the wheatbelt representing medium to high rainfall zones (Calingiri, Beverley and Katanning). Harvested samples were cleaned over a 1.5 mm slotted sieve before standard laboratory protocols were used to analyse the grain samples for physical quality

(i.e. hectolitre weight, screenings, average grain weight and colour). In addition measures of straw strength, lodging and head loss resistance and plant height at maturity were made. In this paper data is only presented from the soil type x date of seeding trial series from 2005 and 2006.

RESULTS

The seasonal conditions experienced in Western Australia in 2005 and 2006 have been both exceptional and challenging. Average growing season rainfall (May to October) received at trial sites during the 2006 season was only half of that received during the 2005 growing season (202 mm *v* 395 mm) (Table 1). First sowing opportunities were nearly two weeks later in 2006 in contrast to 2005. Site average grain yields from the late June plantings in 2006 were nearly 1 t/ha lower than crops planted in late June in 2005. The seasonal conditions in 2005 and 2006 therefore provide an opportunity to test the newly bred oat varieties for their performance under contrasting situations.

In 2005 the yield response of Kojonup was very close to the high yielding dwarf feed variety Wandering and 13 per cent more than Carrolup. The performance of the other two dwarf varieties Possum and Mitika was between that of Carrolup and Kojonup.

In comparison to 2005, Kojonup in 2006 did not perform as expected. At Beverley and Katanning, where in season rainfall was less than 200 mm, Kojonup yields were 12 per cent less than Carrolup. In contrast, at Calingiri (season rainfall above 200 mm) Kojonup yields were 14 per cent higher than Carrolup. On the other hand the other two new dwarf varieties Possum and Mitika out yielded Carrolup at all three sites with an average yield advantage of 11 and 15 per cent compared to Wandering at 22 per cent. Therefore Kojonup may not be suitable for seasons or environments where low in-crop rainfall is experienced. This is especially so on soils with low moisture holding capacity.

Despite the poor yield performance of Kojonup in 2006, it produced grain that more consistently met the Oat1 receival limits of minimum hectolitre weight of 51 kg/ha and screenings below 10 per cent compared to Carrolup, Possum and Mitika (Table 2). In 58 per cent of comparisons Kojonup meet standard Oat1 specifications compared to Possum at 50 per cent, Mitika at 42 per cent and Carrolup at 33 per cent. This confirms previous observations that Kojonup has the better weight and grain shape of the three new dwarf varieties, and is more likely to meet receival standards with delayed seeding or soil type variability.

CONCLUSION

Kojonup has the potential to yield similar to the best feed oat varieties, such as Wandering and Dalyup, and have a higher proportion of grain meet the Oat1 specification across seasons. In seasons or environments where low in-crop rainfall is expected (i.e. less than 200 mm), Kojonup may not be the best variety choice to maximise grain yield. Kojonup is currently undergoing commercial evaluation for reclassification from feed to milling. This should be resolved early in 2007.

The other two dwarf varieties under evaluation performed much better in 2006 than was expected. It is unlikely, however, that Possum will be received as a milling variety in Western Australia. It was also noted that Possum (and in some instances Kojonup) suffered extensive leaf tip burning across trials. Commercial milling tests for Mitika are still planned, although the industry has given priority to testing Kojonup first. Mitika could be a good dual purpose variety as it has low hull lignin, therefore high feed value. In good seasons however, the grain yield of Mitika is only marginally better than Carrolup and there are question marks over its ability to meet hectolitre weight targets across seasons and sites.

KEY WORDS

oats, dwarf milling oats, non-dwarf milling oats

ACKNOWLEDGMENTS

We are grateful to Kelly Jones, Oats Technical Officer and the RSU teams for providing technical support. Financial support from DAFWA, GRDC and GRC for this project is acknowledged.

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Paper reviewed by: Steve Penny

Table 1. Grain yield (t/ha) of five oat varieties grown on different soil types at two dates of seeding at various locations in WA (2005 and 2006)

2005																
	Trial number	**05KA05 CN_1**		**05KA05 CN_2**		**05KA05 BV_1**		**05KA05 BV_2**		**05KA05 GS_1**		**05KA05 GS_2**		**Average (t/ha)**		
	Location	**Calingiri**				**Beverley**				**Katanning**						
	Rainfall (May – October) mm	**454 mm**				**350 mm**				**382 mm**						
	Soil type	**Deep sand**		**Loamy earth**		**Duplex sandy gravel**		**Shallow sandy duplex**		**Deep sandy gravel**		**Shallow sandy duplex**				
Variety		**18 May**	**22 June**	**18 May**	**22 June**	**18 May**	**22 June**	**18 May**	**22 June**	**18 May**	**22 June**	**18 May**	**22 June**	**May**	**June**	**Overall**
Carrolup	Non-dwarf milling	3.5	3.0	3.3	3.3	2.9	2.7	3.1	3.1	2.5	2.6	2.3	1.9	**2.9**	**2.8**	**2.9**
Possum	Dwarf	3.8	3.3	4.0	3.6	3.4	3.0	3.7	3.5	2.0	2.6	2.6	2.2	**3.3**	**3.0**	**3.1**
Mitika	Dwarf	3.0	2.9	3.8	3.5	3.2	2.9	3.5	3.5	2.0	2.5	2.3	2.0	**3.0**	**2.9**	**2.9**
Kojonup	Dwarf	3.2	3.6	4.2	3.3	3.5	3.1	3.8	3.6	2.8	2.9	3.2	2.4	**3.5**	**3.2**	**3.3**
Wandering	Dwarf feed	3.5	3.6	4.4	3.7	3.7	3.4	3.8	3.9	2.8	3.1	2.6	2.1	**3.5**	**3.3**	**3.4**
Average		**3.4**	**3.3**	**3.9**	**3.5**	**3.3**	**3.0**	**3.6**	**3.5**	**2.4**	**2.7**	**2.6**	**2.1**	**3.2**	**3.0**	**3.1**
lsd (< 0.05)		Soil	= 0.3	Soil x Var	= 0.4	Soil	= 0.1	Soil x Var	= ns	Soil	= ns	Soil x Var	= 0.3			
		TOS	= 0.2	TOS x Var	= ns	TOS	= 0.1	TOS x Var	= ns	TOS	= ns	TOS x Var	= 0.3			
		Soil x TOS	= ns	Soil x TOS x Var	= 0.5	Soil x TOS	= ns	Soil x TOS x Var	= ns	Soil x TOS	= 0.3	Soil x TOS x Var	= 0.4			
		Variety	= 0.2			Variety	= 0.2			Variety	= 0.1					
2006																
	Trial number	**06KA04 CN_1**		**06KA04 CN_2**		**06KA04 BV_1**		**06KA04 BV_2**		**06KA04 GS_1**		**06KA04 GS_2**		**Average (t/ha)**		
	Location	**Calingiri**				**Beverley**				**Katanning**						
	Rainfall (May – October) mm	**232 mm**				**188 mm**				**186 mm**						
	Soil type	**Ironstone gravelly**		**Shallow sandy duplex**		**Shallow sandy duplex**		**Deep sand**		**Sandy earth**		**Shallow sandy duplex**				
Variety		**3 June**	**26 June**	**3 June**	**26 June**	**7 June**	**28 June**	**7 June**	**28 June**	**1 June**	**29 June**	**1 June**	**29 June**	**Early June**	**Late June**	**Overall**
Carrolup	Non-dwarf milling	3.5	2.7	3.5	2.5	2.3	1.9	1.9	1.0	1.6	0.8	2.8	2.1	**2.6**	**1.8**	**2.2**
Possum	Dwarf	3.8	3.1	3.8	3.2	2.4	2.0	2.2	0.9	2.1	0.8	2.9	2.2	**2.9**	**2.1**	**2.5**
Mitika	Dwarf	3.7	3.2	3.8	3.4	2.7	2.3	2.2	1.0	2.1	1.1	3.0	2.2	**2.9**	**2.2**	**2.6**
Kojonup	Dwarf	4.0	3.0	4.0	2.9	2.1	1.5	1.7	0.6	1.5	0.7	2.8	1.7	**2.7**	**1.7**	**2.2**
Wandering	Dwarf feed	3.9	3.3	3.9	3.4	2.6	2.2	2.6	1.6	2.1	1.3	3.0	2.5	**3.0**	**2.4**	**2.7**
Average		**3.8**	**3.1**	**3.8**	**3.1**	**2.4**	**2.0**	**2.1**	**1.0**	**1.9**	**1.0**	**2.9**	**2.2**	**2.8**	**2.0**	**2.4**
lsd (< 0.05)		Soil	= ns	Soil x Var	= ns	Soil	= 0.2	Soil x Var	= 0.3	Soil	= 0.8	Soil x Var	= ns			
		TOS	= 0.2	TOS x Var	= 0.3	TOS	= 0.2	TOS x Var	= ns	TOS	= 0.1	TOS x Var	= ns			
		Soil x TOS	= ns	Soil x TOS x Var	= ns	Soil x TOS	= 0.2	Soil x TOS x Var	= ns	Soil x TOS	= ns	Soil x TOSx Var	= ns			
		Variety	= 0.1			Variety	= 0.1			Variety	= 0.1					

Table 2. Hectolitre weight (kg/hL) and screenings (%< 2.0 mm) of five oat varieties grown at three locations on two soil types at two seeding dates in 2006

		2006														
	Trial number	06KA04 CN_1		06KA04 CN_2		06KA04 BV_1		06KA04 BV_2		06KA04 GS_1		06KA04 GS_2				
	Location	Calingiri				Beverley				Katanning				Average		
	Soil type	Ironstone gravelly		Shallow sandy duplex		Shallow sandy duplex		Deep sand		Sandy earth		Shallow sandy duplex		(t/ha)		
Variety		**3 June**	**26 June**	**3 June**	**26 June**	**7 June**	**28 June**	**7 June**	**28 June**	**1 June**	**29 June**	**1 June**	**29 June**	**Early June**	**Late June**	**Overall**
		Hectolitre weight (kg/hL)														
Carrolup	Non-dwarf milling	54.8	52.4	55.0	52.1	49.9	50.6	53.0	51.6	50.6	49.2	56.6	54.5	**53.3**	**51.7**	**52.5**
Possum	Dwarf	53.2	50.1	53.5	50.3	49.0	50.1	50.7	51.5	51.1	50.4	54.9	53.6	**52.1**	**51.0**	**51.5**
Mitika	Dwarf	52.3	49.1	52.5	49.6	49.1	50.3	50.9	51.0	49.8	50.4	55.2	54.2	**51.6**	**50.8**	**51.2**
Kojonup	Dwarf	52.1	51.4	51.3	49.8	49.0	50.5	51.3	52.8	51.4	51.6	53.5	53.1	**51.4**	**51.5**	**51.5**
Wandering	Feed	51.4	48.9	52.0	47.2	47.2	47.7	50.2	50.2	49.2	48.5	54.0	53.9	**50.7**	**49.4**	**50.0**
Average		**52.7**	**50.3**	**52.8**	**49.8**	**48.8**	**49.8**	**51.2**	**51.4**	**50.4**	**50.0**	**54.8**	**53.9**	**51.8**	**50.9**	**51.4**
lsd (< 0.05)		Soil = ns		Soil x Var = 1.6		Soil = 1.1		Soil x Var = 1.2		Soil = 0.6		Soil x Var = 1.7				
		TOS = 0.8		TOS x Var = 1.2		TOS = ns		TOS x Var = 0.7		TOS = ns		TOS x Var = ns				
		Soil x TOS = ns		Soil x TOS x Var = ns		Soil x TOS = ns		Soil x TOS x Var = ns		Soil x TOS = ns		Soil x TOS x Var = ns				
		Variety = 0.8				Variety = 0.5				Variety = 1.2						
		Screenings (% < 2.0 mm)														
Carrolup	Non-dwarf milling	6.8	21.0	9.7	23.0	22.4	20.9	12.0	10.9	13.6	11.4	4.2	8.0	**11.5**	**15.9**	**13.7**
Possum	Dwarf	4.3	13.5	6.5	15.4	9.5	10.6	7.1	5.5	5.2	12.7	2.5	5.9	**5.8**	**10.6**	**8.2**
Mitika	Dwarf	3.5	15.9	6.2	16.7	11.5	7.0	6.6	3.8	5.2	7.4	1.9	4.1	**5.8**	**9.1**	**7.5**
Kojonup	Dwarf	5.9	11.9	7.6	14.6	8.1	6.3	5.6	2.3	5.0	11.7	4.3	6.6	**6.1**	**8.9**	**7.5**
Wandering	Feed	6.3	15.3	5.9	16.3	9.2	10.5	6.3	4.3	7.8	12.4	6.5	10.2	**7.0**	**11.5**	**9.3**
Average		**5.4**	**15.5**	**7.2**	**17.2**	**12.1**	**11.1**	**7.5**	**5.3**	**7.3**	**11.1**	**3.9**	**7.0**	**7.2**	**11.2**	**9.2**
lsd (< 0.05)		Soil = ns		Soil x Var = ns		Soil = 1.5		Soil x Var = 2.0		Soil = 2.0		Soil x Var = 3.3				
		TOS = 1.4		TOS x Var = 2.0		TOS = 0.7		TOS x Var = 1.6		TOS = 0.7		TOS x Var = 2.9				
		Soil x TOS = ns		Soil x TOS x Var = ns		Soil x TOS = ns		Soil x TOS x Var = ns		Soil x TOS = ns		Soil x TOS x Var = 4.4				
		Variety = 1.2				Variety = 1.1				Variety = 2.1						
		Average grain weight (mg)														
Carrolup	Non-dwarf milling	34.5	29.9	32.9	29.1	28.6	28.5	33.7	32.4	29.9	31.0	35.4	32.4	**32.5**	**30.5**	**31.5**
Possum	Dwarf	33.3	28.9	32.3	27.9	31.7	30.1	33.4	33.4	33.8	28.1	34.6	31.8	**33.2**	**30.0**	**31.6**
Mitika	Dwarf	34.8	29.5	33.4	28.6	31.7	32.3	34.6	35.0	33.1	31.6	35.7	33.5	**33.9**	**31.8**	**32.8**
Kojonup	Dwarf	33.9	31.1	31.8	28.9	32.5	33.4	36.7	37.0	35.1	32.1	34.6	33.1	**34.1**	**32.6**	**33.3**
Wandering	Feed	35.3	30.6	33.5	28.3	32.3	31.9	36.6	37.3	33.6	29.8	34.6	32.0	**34.3**	**31.6**	**33.0**
Average		**34.4**	**30.0**	**32.8**	**28.6**	**31.3**	**31.2**	**35.0**	**35.0**	**33.1**	**30.5**	**35.0**	**32.6**	**33.6**	**31.3**	**32.5**
lsd (< 0.05)		Soil = ns		Soil x Var = ns		Soil = 1.0		Soil x Var = 1.3		Soil = 1.0		Soil x Var = 1.7				
		TOS = 0.9		TOS x Var = 1.5		TOS = ns		TOS x Var = 1.5		TOS = 0.9		TOS x Var = 1.6				
		Soil x TOS = ns		Soil x TOS x Var = ns		Soil x TOS = ns		Soil x TOS x Var = ns		Soil x TOS = ns		Soil x TOS x Var = ns				
		Variety = 1.0				Variety = 0.7				Variety = 1.1						

Sourcing oat production information in 2007

Kellie Winfield, Department of Agriculture and Food, Western Australia, Northam

KEY MESSAGES

Over the past two years, a significant amount of information on growing oats (grain and hay) has become available to growers, researchers, agronomists and consultants. This paper lists the major sources of information available to the oat industry in 2007 (including oat web pages, Farmnotes, reports, newsletters, contacts) and where to find it.

BACKGROUND

Prior to the inception of the 'Oat Agronomy and Industry Development in the Western Region' project (2004-2007) there was very little information available on oat production in Western Australia, particularly oat hay. The extension strategy and communication program developed and implemented by the project has seen considerable information (including project research results) delivered to the oat industry through field days, media, newsletters and the web.

The future of the project is currently under review and with Oat Industry Development Officer Kellie Winfield on maternity leave until later in 2007, oat communications will be reduced in 2007. This paper lists the available sources of information for oat production in Western Australia for 2007.

OAT INFORMATION SOURCES

The following information has been made available since the inception of the Oat Agronomy and Industry Development in the Western Region Project in 2004.

Oat production in Western Australia web pages

These pages were launched in July 2006 as part of the Department of Agriculture and Food web site. To access the main index page go to www.agric.wa.gov.au and select **Crops** from the left menu, then select **Oats** from the main screen (located under 'Areas of interest').

These web pages give a comprehensive overview of the WA oat industry and information on producing oats in WA. All reports from the Oat Agronomy Project are available on these pages as well as links to relevant Farmnotes and information from other industry organisations and projects. The pages include information on Oat industry groups such as the Western Oat Alliance (WOA) and the Australian Fodder Industry Association (AFIA); as well as events; past and current copies of the Western Oat Update (WOU); varieties and oat crop establishment; harvest, hay cutting and quality for the end market, nutrition, pests, weeds and diseases, marketing and economics of oat grain and hay, research projects and contacts and biosecurity.

Western Oat Update (Oat Industry Newsletter)

The WOU is a free electrotonic newsletter from the WOA and the Department of Agriculture and Food (DAFWA) available to all members of the oat industry. The WOU is sent out every 3-4 months and includes reports on DAFWA research, hay and grain market information, WOA activities and issues as well as other relevant oat industry information.

There have been five issues since it began in September 2005, the current being December 2006. All issues are available from the Oat Production web pages through www.agric.wa.gov.au under **Western Oat Update Newsletter**. The WOU editor (Kellie Winfield) is currently on maternity leave which means the next issue will not be available until spring 2007.

Farmnotes

DAFWA Farmnotes can be accessed through www.agric.wa.gov.au under **Publications** (from the top menu) or through the Oat Production web pages. The following Farmnotes were released by the Oat Agronomy project in 2006:

- 113 Oat variety guide for Western Australia: 2006
- 179 Fuel and fertiliser prices rises and the bottom line for hay production
- 180 Determining the cutting date (watery ripe stage) for oat hay

More Farmnotes will be available online from the Oat Agronomy project in March/April 2007:

- Oat variety guide for Western Australia 2007
- Agronomic guidelines for growing oats in Western Australia
- Agronomic guidelines for growing oat hay in Western Australia
- Oaten hay quality for export and domestic markets
- Milling and feed oat quality – what are the differences?

Field days and seminars

The DAFWA Oat Agronomy Project has been involved in a number of Oat Industry Field Days including the WOA Field Day at Highbury in 2005 and the York Hay Seminar in 2006. Another Hay Seminar (presented by the WOA and AFIA) will be held at El Caballo on 6 March 2007. This seminar will see the latest research on sensory testing (animal preferences for hay) presented in conjunction with implications for oat breeding and export hay markets as well as evaluation of super conditioners and presentation of windrows, export markets and price outlook, chemical use and product safety.

To register or find more information look at the Events page on the Oat Production Web pages or contact Anne Fleming (03) 9890 6855 or anne@afia.org.au for a registration form or download a form from www.afia.org.au→ Events.

Other useful information

More information is available from other industry associations and projects:

- Australian Fodder Industry Association – www.afia.org.au
- Australian Exporters Company – www.aexco.com.au
- Australian Field Crop Association – www.afca-seeds.com.au
- National Oat Breeding Program – www.sardi.sa.gov.au
- Zwer P. and Faulkner M. (2006) Producing Quality Oat Hay (RIRDC Publication 06/002) ISSN 1440-6845 – downloadable as a PDF at www.rirdc.gov.au/fullreports/fodder.html.

OAT EXTENSION IN 2007

As the Oat Industry Development Officer (Kellie Winfield) is on leave until August 2007, oat communications from the DAFWA Oat Agronomy Project will generally be limited to Ag Memo articles. For oat production enquiries please contact Oat Research Officer Dr Raj Malik at DAFWA, Katanning on (08) 9821 3247 or rmalik@agric.wa.gov.au.

KEY WORDS

oat agronomy, oat production, oat hay

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Paper reviewed by: Blakely Paynter, Department of Agriculture and Food, Western Australia, Northam

Response of new wheat varieties to herbicides

Harmohinder Dhammu, Research Officer, Department of Agriculture and Food, Western Australia, Northam

KEY MESSAGES

- Binnu and Bullaring showed good tolerance to all treatments, similar to or better than Wyalkatchem.
- Kalka showed sensitivity to Jaguar® and Jitarning to dicamba.
- Boxer Gold and Cheetah Gold – potential new herbicides were tolerated well by all the varieties except WAWHT2773 which seems to have low crop safety margins for Boxer Gold.
- Tank mixing diuron with Dual® seems to improve crop safety over application of Dual alone.

AIM

To evaluate the herbicide tolerance of potential and recently released wheat varieties.

METHOD

Location and year	Merredin (ME), 2006	*Katanning (GS), 2006*
Soil type, pH ($CaCl_2$) and OC (%)	Clay, 5.0 and 1.17	*Duplex sandy loam , 5.2 and not tested*
Trial design	*Criss-cross, every 8th plot was untreated control.*	
Plot size (Gross) and replications	10 m x 3 m, 3	*10 m x 3 m, 3* *EAG 2248 – 5 m x 3 m, 3*
Sowing date and seeding rate	8 June and 75 kg/ha	*4 July and 75 kg/ha*
Seeding machinery	Knife points and press wheels	*Superseeder points (573 Combine)*
Fertiliser	Agras No. 1 100 kg/ha	*Agstar Extra Plus100 kg/ha* *Urea 56.4 kg/ha- 30 August*
Soil moisture (%) at seeding 0-10 cm (Gravimetric method) 10-20 cm	8.6 14.6	*12.4* *6.6*
Herbicides application date Before seeding Z12-Z13 Z13-Z14 Z15-Z16/Z21+	 7 June 28 July 17 August 21 August	 *3 and 4 July* *16 August* *16, 17 and 23 August* *23 August*
Harvesting date	21 November	*November*
Total rainfall (mm): June-November	*157.2*	*178.8*

The crop emergence across all the varieties was uneven at Merredin. At the first timing of post-emergent spraying (Z12-Z13) 90 per cent of the plants were at 2-3 leaf stage (remaining 10 per cent were at 1-1.5 leaf stage). At the crop anthesis stage at both sites, a hand held GreenSeeker® unit was used to record the effect of herbicide treatments on crop biomass. GreenSeeker® is an optical sensing system that measures crop biomass in terms of normalised difference vegetative index (NDVI).

As label rates of Dual® and dicamba (either alone in mixture with other herbicides) provide poor weed control, higher than label rates of these products were evaluated to determine if label rates could be revised for more effective weed control in wheat.

RESULTS AND DISCUSSION

The effect of herbicides at early crop growth, at flowering and on yield (Table 1) is as follows:

- Two weeks after spraying, Affinity® + MCPA caused severe spotting on the leaves exposed to spray across all the varieties at Katanning. On average 40 per cent of the leaves appeared burnt/necrotic. In some cases even the growing point was affected. As the treatment was sprayed early in the morning (8.45 a.m.), presence of dew on leaves or high leaf moisture

content or high relative humidity may have contributed to the observed severe symptoms. These effects were mitigated by the time crop reached the anthesis stage, as there was no effect on crop biomass and no significant negative effect on yield. In contrast no visual symptoms were observed with this mixture at Merredin, but it resulted in significant yield reduction in Kalka, WAWHT2773 and Wyalkatchem.

- Diuron500 + MCPA amine also caused moderate to severe spotting on the leaves exposed to spray across all the varieties at Katanning. Although the symptoms were no longer apparent at flowering, and no effect on crop biomass was detected (NDVI), this treatment resulted in significant yield reduction across all the varieties. At Merredin, this treatment caused no visual leaf symptoms, and had no negative effect on biomass and grain yield of the varieties.
- Higher than the registered rate of Metolaclor 720/Dual® (2 L/ha) caused a significant yield reduction in Jitarning at Katanning. When tank mixed with Diuron500 (1 L/ha), it was safe to all the varieties including Jitarning. This indicates that mixing of Diuron500 with Dual®, increases both crop safety and the spectrum of weeds controlled. These treatments had no negative effect on any of the varieties at Merredin. The maximum rate of Dual® registered in wheat is 0.5 L/ha and can be mixed with 1 L of Diuron500/ha. Use of diuron in mixture with Dual® Gold is not registered.
- Ally® caused 10-20 per cent stunting/biomass reduction across all the varieties, two weeks after spraying at Katanning. This effect was still evident in EGA2248 and Wyalkatchem until flowering, but did not result in a significant reduction in yield. In contrast Ally caused no visual symptoms at Merredin, but resulted in significant yield reduction across all the varieties except Wyalkatchem (marginally insignificant). Ally® caused a significant yield reduction in Kalka for the first time in trials tolerance trials.
- Jaguar®, Tigrex® and Paragon® resulted in 10-25 per cent spotting or bleaching of the leaves exposed to spray. The intensity of symptoms was more evident at Katanning than Merredin, and higher with Paragon® than other herbicides. Paragon® caused a significant yield reduction in WAWHT2740, WAWHT2273 and Wyalkatchem. In these trials a higher rate of Paragon® (0.5 L/ha) was used on the younger crop (Z13) than the registered timing of 5 leaf stage on wards. At the time of spray at Merredin, most of the plants had 3-5 leaves, and no significant negative effect on any of the varieties was recorded. Jaguar® caused a significant yield reduction in Kalka for the first time in tolerance trials.
- Hoegrass® + Achieve® caused a significant yield reduction in all varieties at Merredin except Binnu. This is the first time in tolerance trials that this treatment has caused a yield reduction in WAWHT2773 and Wyalkatchem. Dicamba and 2,4-D ester significantly reduced the yield of Jitarning and WAWHT2773. This result is congruent with previous results for 2,4-D but has not been observed previously with dicamba.
- Potential new herbicides Boxer Gold and Cheetah Gold (group A) were tolerated well by all the new varieties except WAWH 2773, which showed lower crop safety margins to Boxer Gold at Merredin.
- These results show that visual phytotoxicity symptoms are not always indicative of yield loss.

KEY WORDS

wheat, herbicide, tolerance

ACKNOWLEDGMENTS

We gratefully acknowledge GRDC for funding this project. Thanks to Leanne Young (Merredin), Vince Lambert (Katanning), Chris Roberts (Northam) and Dave Nicholson (Geraldton) for their excellent technical assistance. Thanks to Mario D'Antuono for his help in statistical analysis.

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Paper reviewed by: John Moore and Steve Penny

Table 1. Effect of herbicides on grain yield (% of untreated control) of wheat varieties (**WA = WAWHT, Wyalkat = Wyalkatchem, Sapphire = GBA Sapphire**)

No.	Herbicides (rate/ha)	Timing	Merredin (ME)					Katanning (GS)						
	06NO29		Binnu	Kalka	WA2740	WA2773	Wyalkat	Binnu	Bullaring	EGA2248	Jitarning	Sapphire	WA2773	Wyalkat
1	Untreated Control >>>>> kg/ha		1257	1328	1365	1240	1377	1273	844	1455	995	1113	1334	1283
2	Glean® 20 g	Before	112	97	93	87	97	102	97	112	109	109	88	98
3	Logran® B Power 50 g + Hasten® 0.5%	seeding	115	114	110	101	95	102	95	113	111	94	109	97
4	Stomp® 330 1.8 L	"	111	93	92	92	104	104	105	88	101	94	98	88
5	Triflur® X 2 L	"	94	115	100	106	99	91	99	109	93	95	100	104
6	Metolachor 720 (Dual®) 2 L	"	99	95	94	90	104	90	126	88	**74**	95	100	96
7	Diuron500 1 L + Metolachlor 720 2 L	"	101	143	100	116	102	106	106	101	112	113	103	109
8	Boxer* Gold 2.5 L	"	90	89	94	87	100	114	108	121	110	96	104	114
9	Boxer* Gold 5.0 L	"	101	110	99	**79**	88	102	111	99	102	105	97	107
10	Axial® 300 mL + Adigor® 0.5%	Z12-Z13	98	85	92	90	92	104	112	103	85	99	100	97
11	Achieve® WG 380 g	(ME)	122	102	111	98	98	106	107	117	108	105	112	98
12	Jaguar® 1 L	Z13-Z15	100	**81**	88	101	89	93	110	107	121	108	105	86
13	Monza® 25 g + DC Trate 2%	(GS)	112	101	92	92	106	104	101	115	108	104	101	94
14	Hoegrass® 375 2 L + BS 1000 0.25%	"	99	106	88	90	**80**	102	109	118	118	105	112	117
15	Cheetah** Gold 1 L + Hasten® 1%	"	95	95	93	91	96	90	93	96	110	87	91	93
16	Hoegrass® 200 mL+ Achieve® 200 g	"	87	**79**	**77**	**70**	**70**	117	104	118	100	103	102	102
17	Ally® 5 g + BS 1000 0.25%	Z13-Z14	**82**	**74**	**84**	**83**	84	100	90	103	97	97	89	87
18	Atlantis® 330 mL + Hasten® 1%	(ME)	100	110	99	105	95	109	100	111	106	105	103	103
19	Broadside® 1 L	Z13-Z15	104	111	90	104	121	102	103	104	114	100	98	114
20	Hussar® 200 g + BS 1000 0.25%	(GS)	93	101	105	102	94	100	115	116	99	112	94	107
21	Mataven® L 3 L	"	**81**	84	89	89	90	118	110	104	119	97	109	127
22	Paragon® 0.5 L	"	90	93	**81**	**79**	**73**	97	113	110	118	115	99	107
23	Tigrex® 1 L	"	102	113	90	109	108	103	99	97	93	100	95	108
24	Buctril® MA 1.4 L	"	104	101	**82**	100	96	101	117	112	115	95	99	104
25	Affinity® 50 g + MCPA 0.5 L	"	91	**76**	88	**83**	**78**	109	84	92	88	97	90	96
26	Eclipse® 5 g+ MCPA LVE 0.5 L	"	94	99	96	87	89	112	109	113	114	100	93	118
27	Diuron® 0.5 L + MCPA (amine) 0.5 L	"	98	98	96	92	87	**82**	**74**	**71**	**72**	**78**	**75**	**76**
28	MCPA amine 500 2 L	Z15-Z16	104	111	109	93	109	91	91	88	104	89	104	89
29	2 4-D amine 625 1.3 L	(ME)	98	98	104	110	107	98	92	87	91	102	96	101
30	2 4-D ester 800 0.7 L	Z16-Z17	107	97	96	106	101	101	86	93	**69**	100	93	87
31	Dicamba 500 0.5 L	(GS)	99	106	89	90	93	102	99	91	102	93	**82**	98
lsd (0.05) herbicides v/s Untreated			17	17	15	17	17	15	22	16	17	16	14	17

Treatments 10 and 15 + Supercharge□ 0.75%; 25 + Uptake□ oil 0.5%, figures in **bold** are significantly different from untreated control, * Registration expected in 2008 and ** in March 2007.

Herbicide tolerance of new barley varieties

Harmohinder Dhammu[1], Research Officer, **Vince Lambert[2]** and **Chris Roberts[1]**, Technical Officers, Department of Agriculture and Food, Western Australia; [1]Northam and [2]Katanning

KEY MESSAGES

- Potential new variety WABAR 2321 showed tolerance to all the herbicides.
- WABAR 2288 and WABAR 2310 showed sensitivity to dicamba applied at near twice the registered rate, and WABAR 2288 to the highest registered rate of 2,4-D amine.
- Vlamingh showed sensitivity to Ally and Axial, and Hamelin yield was reduced significantly by Hoegrass, Buctril MA, Diuron + MCPA and 2,4-D ester.
- Boxer Gold and Cheetah Gold – potential new herbicides were tolerated well by all the varieties.

AIM

To evaluate the herbicide tolerance of potential and recently released barley varieties.

METHOD

Five barley varieties (Hamelin, Vlamingh, WABAR 2288, WABAR 2310 and WABAR 2321) were sown on 4 July 2006 at Katanning Research Station, on a duplex sandy loam soil (pH ($CaCl_2$) 5.2) in 10 m wide parallel strips. 75 kg/ha of each barley variety was sown with Superseeder points (573 Combine). 100 kg/ha Agstar Extra Plus applied with the seed. A range of herbicide treatments (Table 1) were applied randomly in three meter wide strips across these varieties in three blocks, before crop seeding, 3-5, and 5-7 leaf stage on 3 and 4 July, 16 August and 23 August 2006, respectively. Every 8th plot was kept as untreated control to check the spatial variability. The varieties were also randomised in each block. At the time of trial seeding and application of pre-emergent herbicide treatments soil moisture content at 0-10 and 10-20 cm depth was 12.5 and 6.4 per cent, respectively. The soil moisture content was determined by following Gravimetric method. In the early September, manganese deficiency was observed across all the varieties, so to rectify the problem Mantrac at 0.5 L/ha was applied on 12 September. To control low density of wild radish, a blanket spray of Bromicide 200 (2 L/ha) was done on 14 September. The trial was harvested in November 2006. Total rainfall from June to November at Katanning was 179 mm.

As label rates of Dual®/Metolachlor 720® and dicamba (either alone in mixture with other herbicides) provide poor weed control, higher than label rates of these products were evaluated to determine if label rates could be revised for more effective weed control in barley.

RESULTS AND DISCUSSION

The effect of herbicides during early crop growth, at flowering and on seed yield (Table 1) of barley varieties is as follows:

- Two weeks after spraying, Affinity® + MCPA caused severe spotting on the leaves exposed to spray across all the varieties. On an average 35-55 per cent of the leaves appeared burnt/necrotic. WABAR 2321 was the most and WABAR 2288 was the least affected variety. As the treatment was sprayed early in the morning at 8.40 a.m., presence of dew on leaves or high leaf moisture content or high relative humidity might have contributed to the observed severe symptoms. The treatment effect in terms of reduced biomass (10 per cent) across all the varieties was visible up till anthesis stage, but this didn't result in a significant yield reduction in any of the varieties.
- Diuron + MCPA also caused moderate (20 per cent) spotting on the leaves exposed to spray across all the varieties. The treatment effect in terms of reduced biomass (on an average 10 per cent) across all the varieties was visible up till the crop anthesis stage, but this translated into significant yield reduction in Hamelin only.

- Ally® caused stunting/biomass reduction (20 per cent) and slight yellowing during the early crop growth and the negative effect on crop biomass continued up to crop anthesis stage with reduced intensity (10 per cent) across all the varieties. The significant yield reduction with this treatment was recorded in Vlamingh only.
- Jaguar®, Tigrex® and Paragon® caused slight spotting or bleaching on the leaves (10-15 per cent) exposed to spray, but there was no effect on grain yield of any of the varieties tested. In this trial higher rate of Paragon® (0.5 L/ha) was used at an earlier growth stage (Z13) than its registered timing of application at 5 leaf stage on wards. Results indicate that Paragon at this higher rate and applied earlier than its registered timing, seems safe on the barley varieties.
- Axial reduced grain yield of Vlamingh, 2,4-D (amine) of WABAR 2288 and Dicamba of WABAR 2288 and WABAR 2310 . The grain yield of Hamelin, a standard barley variety, was not affected by these treatments. Further testing of these varieties is needed to determine whether results are consistent or not.
- The significant yield reduction in Hamelin by Hoegrass®, diuron + MCPA, Buctril® MA and 2,4-D (ester) is in contrary to the previous results and interestingly no other barley variety in this trial was affected negatively by these herbicides. .
- Potential new herbicides Boxer Gold (tested as A14429B) and Cheetah Gold (Group A) were tolerated well by all the varieties. Cheetah Gold and Boxer Gold are expected to be registered in barley by March 2007 and early 2008, respectively.

KEY WORDS

barley, herbicide, tolerance

ACKNOWLEDGMENTS

We gratefully acknowledge GRDC for funding this project. Thanks to Dave Nicholson (Geraldton) for his technical assistance.

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Paper reviewed by: Steve Penny

Table 1. Effect of herbicides on grain yield (% of untreated control) of barley varieties at Katanning (06NO21)

No.	Herbicides (rate/ha)	Timing	Hamelin	Vlamingh	WABAR 2288	WABAR2310	WABAR 2321
1	Untreated Control >>>>> kg/ha		1100	1128	1455	1328	1244
2	Stomp® 330 1.8 L	Before	113	114	118	104	107
3	Triflur® X 2 L	seeding	115	122	101	105	107
4	Triflur® X 1 L + Lexone® 150 g	"	109	102	103	107	94
5	Dual® 720 2 L	"	110	118	94	112	103
6	Diuron 1 L + Dual® 720 2 L	"	94	130	91	92	101
7	Boxer* Gold 2.5 L	"	90	102	98	103	106
8	Boxer* Gold 5 L	"	110	109	115	129	123
9	Glean® 20 g + BS 1000 0.1%	Z13-Z15	105	107	113	112	107
10	Jaguar® 1 L	"	98	93	104	88	110
11	Cheetah** Gold 1 L + Hasten® 1%	"	113	85	94	100	103
12	Axial® 300 mL + Adigor® 0.5%	"	103	**80**	100	103	97
13	Hoegrass® 375 1.5 L + BS 1000 0.25%	"	**82**	99	89	98	104
14	Hoegrass® 200 mL+ Achieve® 200 g	"	103	114	106	104	96
15	Achieve® 380 g + Supercharge® 0.75%	"	111	104	111	106	97
16	Ally® 5 g + BS 1000 0.25%	"	89	**80**	101	86	92
17	Paragon® 0.5 L	"	99	102	112	109	103
18	Tigrex® 1 L	"	103	117	91	89	101
19	Buctril® MA 1.4 L	"	**80**	116	116	99	111
20	Affinity® 50 g+ MCPA (amine) 0.5 L	Z15-Z17	86	83	89	88	98
21	Eclipse® 5 g + MCPA LVE 0.5 L	"	104	93	98	110	106
22	Diuron 0.5L + MCPA(Amine) 0.5L	"	**78**	86	99	86	101
23	MCPA amine (50%) 2 L	"	103	97	110	99	115
24	2 4-D amine 625 1.3 L	"	95	119	**86**	99	107
25	2 4-D ester (80%) 0.7 L	"	**85**	105	94	102	106
26	Dicamba (50%) 0.5 L	"	89	101	**70**	**75**	99
lsd (0.05) Herbicides v/s untreated			15	19	13	16	18
lsd (0.05) Herbicides v/s herbicides			20	25	17	21	24
CV%			15	18	13	16	17

Treatments 14 applied with Supercharge 0.75%, 21 with Uptake oil 0.5% v/v. Figures in **bold** are significantly different from untreated control.
* Registration is expected in 2008 and ** in March 2007.

Herbicide tolerance of new oat varieties

Harmohinder Dhammu[1], Research Officer, **Vince Lambert[2]** and **Chris Roberts[1]**, Technical Officers, Department of Agriculture and Food, Western Australia; [1]Northam and [2]Katanning

KEY MESSAGES

- The oat varieties showed good tolerance to all the pre-emergent herbicides tested.
- All the varieties showed sensitivity to 2,4-D ester and dicamba, Kojonup and Possum also to 2,4-D amine and Wandering to MCPA amine.
- Jaguar® and diuron + MCPA reduced grain yield of Possum and Wandering, Eclipse® + MCPA and Igran® + MCPA of Possum, and Affinity + MCPA amine of Wandering only.
- Eclipse® (5 g/ha) applied at anthesis (Z69) showed crop safety similar to Logran® (10 g/ha).

AIM

To evaluate the herbicide tolerance of recently released oat varieties.

METHOD

Four oat varieties (Kojonup, Mitika, Possum and Wandering) were sown (randomised) on 4 July 2006 at Katanning Research Station (GSARI), on a gravelly sandy loam soil (pH ($CaCl_2$) 5.2) in three blocks (reps) of 10 m wide parallel strips. Strips were sown at 75 kg/ha with Superseeder points (573 Combine). Agstar Extra Plus at 100 kg/ha was applied with the seed. A range of herbicide treatments (Table 1) were applied randomly in three meter wide strips across the variety strips either before crop seeding (3 and 4 July) or at 3-4 leaf stage (16 August) or 4-6 leaf stage (23 August) or at the flowering stage (10 October). Every 8th plot was kept as untreated control to assess spatial variability. At the time of pre-emergent herbicide treatment application, soil moisture content at 0-10 and 10-20 cm depth was 12.0 and 6.4 per cent, respectively. The soil moisture content was determined by the gravimetric method. To determine the effect of selected pre-emergent herbicide treatments on plant density, the oat plants were counted from two randomly selected 25 cm x 25 cm quadrates per plot, seven weeks after seeding. In the early September, manganese deficiency was observed across all the varieties, so 0.5 L/ha Mantrac was applied on 12 September. Bromicide® 200 (2 L/ha) was applied on 14 September to control a low density of wild radish. The trial was harvested in November 2006. Total rainfall from June to November at Katanning was 179 mm.

As label rates of Dual®/Metolachlor 720® and dicamba (either alone in mixture with other herbicides) provide poor weed control, higher than label rates of these products were evaluated to determine if label rates could be revised for more effective weed control in oats.

RESULTS AND DISCUSSION

The effect of herbicides during early crop growth, at flowering and on grain yield (Table 1) of oat varieties was as follows:

- All the oat varieties tolerated double the registered rate (wheat and barley) of Triflur® X and Stomp®, eight times the rate of Dual®, four times the Dual rate in mixture with double the registered rate of diuron (in oats) and proposed rate of Boxer Gold (2.5 L/ha) without any visual symptoms and significant negative effect on grain yield. The higher rate of Boxer Gold (5 L/ha) caused no significant reduction in plant density, but resulted in around a 10 per cent biomass reduction/stunting during early crop growth stages, which remained evident up till crop anthesis stage. However, this treatment also had no significant negative effect on grain yield. Currently Trifluralin (Triflur® X) and pendimethalin (Stomp®) are not registered in oats. As soil applied/active herbicides don't express full activity in dry conditions (as experienced in 2006) further testing of these herbicides is required to determine if the results presented are reliable.

- Two weeks after spraying, Affinity® + MCPA caused severe spotting on the leaves exposed to spray across all varieties. On average 45-55 per cent of the leaves appeared burnt/necrotic. Mikita was most affected. As the treatment was sprayed early in the morning at 8.30 a.m., the presence of dew on leaves or high leaf moisture content or high relative humidity might have contributed to the observed severe symptoms. The treatment effect in terms of reduced biomass (10 per cent) across all varieties was visible to anthesis, but only Wandering suffered a significant yield reduction.
- Diuron500 + MCPA (amine) also caused moderate (25 per cent) spotting on the leaves exposed to spray across all the varieties. Although the symptoms were no longer apparent at flowering, and no effect on crop biomass was observed, this treatment did result in a significant yield reduction in Possum and Wandering.
- Jaguar®, Tigrex® and Paragon® caused slight spotting or bleaching on the leaves exposed to spray across all the varieties. Jaguar reduced grain yield of Possum and Wandering significantly. The negative effect of Jaguar on Wandering was also observed in a trial conducted at Newdegate in 2000.
- Eclipse® + MCPA amine and Igran® + MCPA amine reduced grain yield of Possum significantly. Wandering was not affected negatively by these herbicides.
- Dicamba and 2,4-D ester caused significant yield reductions in all varieties, 2,4-D amine reduced the yield of Kojonup and Possum and MCPA amine reduced the yield of Wandering only. The negative effect of phenoxy herbicides could be attributed to the shorter growing season in 2006.
- Eclipse® (5 g/ha) applied at Z69 (anthesis completed) was as safe as Logran® (10 g/ha) to varieties. Currently Logran is registered in oats for late wild radish control or seed set control, but Eclipse® is not registered for such a late application. These results indicate that Eclipse® could be another option for oats. However, further testing is required to confirm the results.

KEY WORDS

oats, herbicide, tolerance

ACKNOWLEDGMENTS

We gratefully acknowledge GRDC for funding this project. Thanks to John Moore, Senior Research Officer, Albany for his suggestions in the treatment planning in the trial and Dave Nicholson (Geraldton) for his technical assistance.

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Paper reviewed by: John Moore and Steve Penny

Table 1. Effect of herbicides on grain yield (% of untreated control) of oat varieties at Katanning

No.	Herbicides (rate/ha)	Timing	Kojonup	Mitika	Possum	Wandering
1	Untreated control >>>>>>>>>> kg/ha		430	795	879	900
2	Treflur® X 2 L	Before	115	142	126	100
3	Treflur® X 4 L	seeding	161	117	102	125
4	Stomp® 330 1.8 L	"	135	109	104	108
5	Stomp® 330 3.6 L	"	146	114	91	111
6	Metolacholr 720 (Dual®) 2 L	"	120	114	101	91
7	Metolacholr 720 (Dual®) 4 L	"	149	108	88	93
8	Diuron500 2 L	"	111	108	95	100
9	Diuron500 2 L + Metolacholr 720 2 L	"	121	114	108	114
10	Boxer* Gold 2.5 L	"	139	134	96	104
11	Boxer* Gold 5.0 L	"	70	126	122	81
12	Glean® 20 g+ BS 1000 0.1%	Z13-Z14	152	117	126	105
13	Jaguar® 1 L	"	87	112	**77**	**79**
14	Tigrex® 1 L	"	115	102	120	105
15	Paragon® 0.5 L	"	156	87	89	106
16	Buctril® MA 1.4 L	Z14-Z16	79	106	87	92
17	Diuron500 0.5 L + MCPA (amine) 0.5 L	"	145	93	**78**	**77**
18	Eclipse® 5 g + MCPA LVE (50%) 0.5L	"	88	107	**71**	87
19	Igran® (50%) 0.85 L + MCPA (amine) 0.6 L	"	133	107	**77**	96
20	Affinity® 50 g + MCPA amine (50%) 0.5 L	"	87	88	87	**73**
21	Broadstrike® 25 g + Uptake oil 0.5%	"	111	128	119	103
22	MCPA amine (50%) 2 L	"	137	111	84	**77**
23	2 4-D amine 625 1.3 L	"	**51**	78	**68**	85
24	2 4-D ester (80%) 0.7 L	"	**33**	**53**	**37**	**49**
25	Kamba® (dicamba) 0.5 L	"	**31**	**47**	**24**	**57**
26	Logran® 10 g + Uptake® oil 1%	Z69+	145	122	93	80
27	Eclipse® 5 g + Uptake® oil 1%	"	77	95	107	114
lsd (0.05) Herbicides v/s Untreated control			49	24	20	21
lsd (0.05) Herbicides v/s Herbicides			65	31	26	27
CV (%)			44	22	21	21

Treatment 18 applied with Uptake® oil 0.5%v/v. * Registration is expected in 2008.
Figures in **bold** are significantly different from untreated control.

Nitrogen Decision Tools – choose your weapon

Jeremy Lemon, Department of Agriculture and Food, Western Australia

KEY MESSAGES

Several tools are available to help growers decide on rates of nitrogen to apply to crops. Most tools require some estimate of crop potential yield to scale the modelled nitrogen response. Updating yield estimates during the growing season is needed to review nitrogen requirements as seasonal conditions change. The use of any specific decision tool depends on the users preferences for ease of use, cost and availability. Different tools can give very different results so experience and user skill are still required.

AIMS

To investigate the use of several nitrogen decision tools for accuracy, ease of use and practicality. Recommended rates and modelled results were compared to actual crop performance during 2006 and previous seasons.

METHOD

Six sites were selected across the Esperance Port Zone in 2006 in consultation with SEPWA and host farmers. The sites were chosen to represent a normal situation of rotation and soil type. Soils were profile sampled by horizons to one metre (rocks prevented full sampling on some sites) to measure soil mineral nitrogen, organic carbon, pH, conductivity, initial soil moisture content, drained upper limit (DUL) and crop lower limit (CLL). Farmers contributed paddock crop history, daily rainfall data collection for the season and conducted a nitrogen experiment at four sites with their own machinery. These sites were at Mt Madden, Cascade, Neridup and Howick. Two further sites at Scaddan and Salmon Gums hosted small plot experiments.

The main tools compared were Select Your Nitrogen (SYN) – a spreadsheet tool developed by Bill Bowden and Art Diggle, Yield Prophet® - a subscription web based service using APSIM, Green Seeker® – a hand held spectral scanner and the Nitrogen Calculator – a card disc or PC based calculator. Potential Yield CALculator (PYCAL) was run for each site to estimate yield potential to adjust target yield as the season progressed. A SPAD meter was available late in the season and used for monitoring plant N status at booting at two sites (and one other) but no recommendations were generated.

Each grower had access to Yield Prophet® to check their crop development, yield probabilities and test proposed nitrogen strategies. The growers managed the bulk of their paddocks using their usual practices.

End of season yields and nitrogen responses were modelled using Yield Prophet and PYCAL/SYN to compare with measured plot yields. Yield Prophet® runs were generated using the soil, climate and crop management data collected during the season together with the rates and times of nitrogen applications applied to plots. For each site the best matched PYCAL yield generated from the range of parameters selected was used for the nitrogen unlimited yield in SYN runs.

RESULTS

Estimating yields

The first task in using most nitrogen decision tools is to select a potential yield to calibrate the response functions. The 2006 growing season was average to below average across the sites selected. There was good stored soil moisture on all sites after a wet autumn but rainfall was much lower than average during the growing season, with a very dry spring of decile 1-2 rainfall. The maximum yield harvested was not N limited and was close to modelled yield at most sites. There are several PYCAL yield estimates presented in Figure 1. The parameters used during the growing season were 110 mm intercept and 20 kg/ha/mm rainfall, based on many seasons of experience with

comparing PYCAL to actual paddock results in areas of lower than 400 mm annual rainfall where waterlogging is rare. In poor seasons actual yields are generally higher than modelled using a 110 mm intercept. However, with an intercept of 33 per cent of growing season rainfall, modelling yields are closer to the yield maximum for a site. Figure 1 shows the modelled and actual yields at each site with close agreement of Yield Prophet®, PYCAL (using 33 per cent GSR and 20 kg/ha/mm) and actual yields, except at Salmon Gums, where poor emergence and weeds reduced crop yield. There is no yield model which outperforms another in most situations.

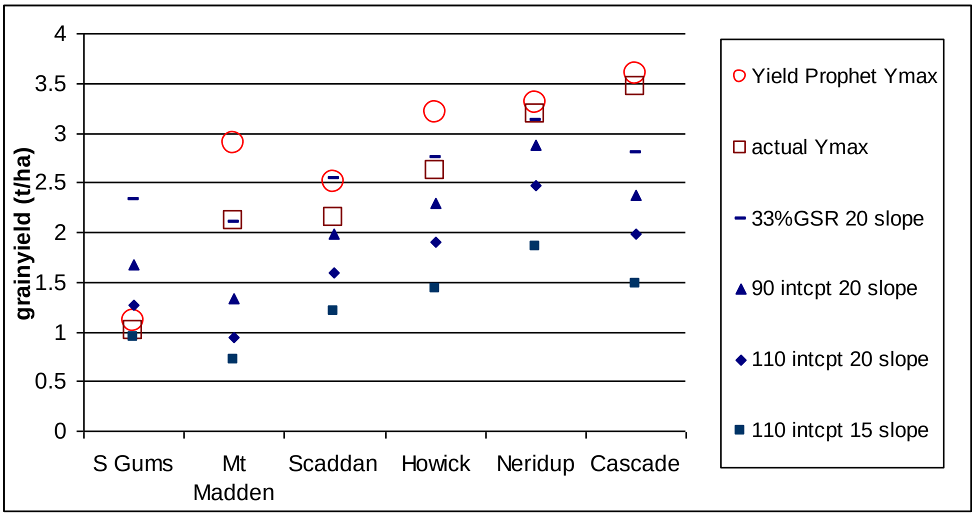

Figure 1. 2006 modelled and actual yield potential at six sites in the Esperance Port Zone.

Estimating nitrogen responses

Growing season nitrogen decisions based on a range of tools were compared as well as end of season field results with modelled results. At the beginning and during the growing season tools were run using the best available information at the time. The Nitrogen Calculator was used at all sites as it is easy and quick to use. Yield Prophet® was only used in-season as sampling was not done early enough to have the paddocks set up prior to the growing season. Some tools perform sensitivity analyses so the optimum rate of N was selected from each tool's output. Table 1 compares the nitrogen decisions for the sites based on a range of tools. Most decisions were comparable with some exceptions. At the Neridup site the actual yield with basal nitrogen at sowing was near maximum yield with a negative response to additional nitrogen. On other sites there was a small response to low rates of nitrogen.

Table 1. Maximum yield, protein and recommended nitrogen rates (kg/ha) for six sites generated from a range of decision tools before and during the 2006 growing season

Site	Pre-sow	End of season values derived from experiments				Rates selected pre-sowing		Rates selected in growing season.	
	Target yield t/ha	Max. yield t/ha	Ymax. protein %	kg N/ha at Y max	Economic optimum kg N/ha	Nitrogen calculator	SYN	Yield prophet	Green seeker
Cascade	3.0	3.4	11.0	34	34	40-60		75	na
Mt Madden	3.0	2.0	10.0	44	44	50-70		52 late	na
Neridup	4.0	3.2	10.6	24	24	80-120		0	9-30
Scaddan	4.0	2.1	10.5	43	0	60-85	40-60	86	49
Salmon Gums	2.0	1.0	11.5	63	63	30-40	33	55-80	18
Howick	4.0	2.6	11.4	47	47	65-90		105	70-90

The difficulty with modelling nitrogen responses and generating recommendations is selecting the responsiveness of the site/crop/season and calibrating the decision tool to reflect a positive, nil or negative response to nitrogen fertiliser. The response curves at any site differ as yield potential changes. Figure 2 illustrates two sites where two models and the actual response curves were all different.

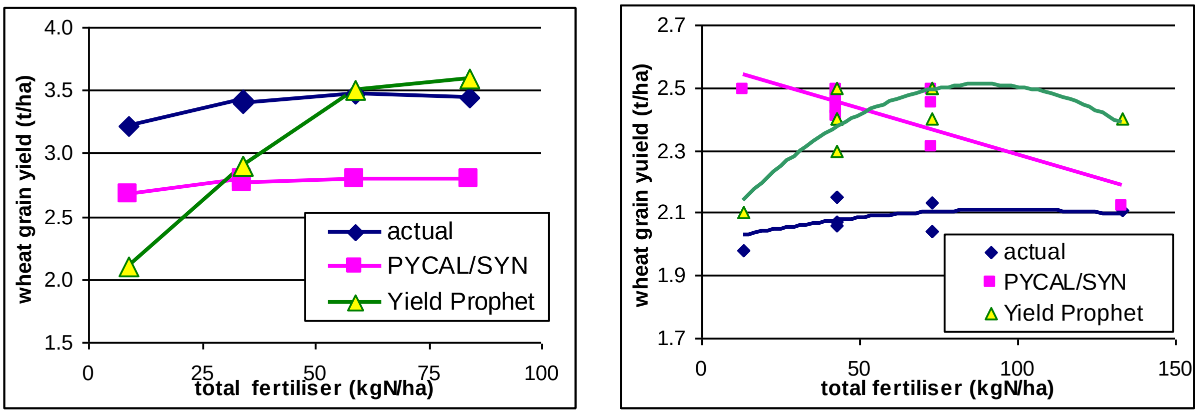

Figure 2. Comparison of 2006 actual and end of season modelled nitrogen yield responses at Cascade (left) and Scaddan (right).

At Cascade there was a small grain yield increase with rates of nitrogen above the basal 9 kg N/ha. PYCAL underestimated the potential yield so SYN based on PYCAL yield underestimated yields at all N rates, but the shape of the response curves is similar. Yield Prophet ® indicated a strong response to nitrogen fertiliser starting with a low yield at low N.

At Scaddan actual yields increased slightly to rates of nitrogen above the basal 13 kg N/ha. SYN modelled declining yield from the basal rate and Yield Prophet® modelled a strong yield increase.

In season tools

Most nitrogen decision tools can be used at any time before, during and after the growing season. In-season tools aim to measure the current nitrogen status of a crop (N supply to date) and match this with expected crop demand (yield from rainfall to come). There is increasing interest in rapid in-field assessment of crops nitrogen status and hence requirement. This would allow different application levels to zones within paddocks and a more timely application of additional nitrogen. Electronic scanning of crops for colour and/or reflectance offers promise but needs to be calibrated to likely fertiliser responses under local conditions. There are good relationships between measurements and nitrogen status of crops under ideal conditions but moisture stress and waterlogging confound results. With any method there is the problem of predicting what the season will do after fertiliser application.

The Green Seeker is a handheld spectral scanner which provides a Normalised Difference Vegetation Index (NDVI) averaged from many readings. Nitrogen recommendations are generated from comparative NDVI values from nitrogen rich strips and adjacent areas of standard paddock practice. A web based calculator is used for this but relationships need to be developed for WA conditions to have greater confidence in the tool. The system assumes that the optimum nitrogen status supports near maximum biomass at Z31 which is not the case for a dry spring which may occur after fertilising.

There was a good relationship between readings and nitrogen status at booting for the SPAD meter, a hand held ‘chlorophyll meter’, at EDRS (site not reported) but no relationship at Scaddan or Salmon Gums, probably due to moisture stress. Under the prevailing conditions of soil moisture stress at booting a response to additional fertiliser N was not likely. In season tools can help measure nitrogen status but users still need to know the soil moisture status and make an informed choice about prospects for the remainder of the season. This additional information can be derived from other tools and services or incorporated in the service as it is for Yield Prophet®.

Comparison of tools

Each nitrogen decision tool or system has characteristics that make it suitable for use and preferred by users. Table 2 summarises the features of different systems. None of the tools is 'accurate' in every situation. Some tools are easily accessible, others are still developmental. Some tools do not simulate yield reductions from excessive nitrogen and lead to economic penalties in poor seasons. The most useful tools are quick to run and readily present sensitivity analyses – especially economic analyses which include the effect of over-fertilising. N decision support systems also need to be able to operate during the growing season to take account of updated yield expectations.

Table 2. Attributes of six nitrogen decision tools and systems

	Soil test service	Nitrogen calculator	SYN	Yield prophet	Scanners (Green Seeker®)	Green meters (SPAD)
Accurate	Experienced use increases the accuracy of decisions based on any tool.					
Simple/easy to use	Pay for services	Yes – need to learn it	Need to learn it or consult	Yes and consultant access	Yes	Multiple readings
Accessible	Yes	Limited	Yes	Yes	Limited	Limited
Cost	Moderate	V low	Free	Annual subscription	High capital cost	Moderate capital cost
Responds to season	By yield range	By yield range	Yes – set Y max	Yes	No	No
Updates in season	Only by yield range	Any time	Any time	Any time	Narrow timing	Narrow timing
Take account of confounding influences	No	Limited – select uptake efficiency	Yes – e.g. leaching	Limited	No	No
Site or zone specific	Depends on sampling	No	No	Yes	Yes	Yes
Sensitivity analysis	Yes	No	Yes	Multiple reports	No	NO
Economic analysis	No	No	Yes	Yes	Yes – but weak	No

As each tool offers different features they can be used concurrently. The difficulty with this approach is when differing results (different shapes of yield response curves) are generated - causing confusion. Decisions based on experience and intuition are still required to select rates based on decision support tools.

CONCLUSION

Each nitrogen decision support tool gave credible rates for application in the context of current yield expectations when the tools were used. The rates varied but were generally higher than the final economic rate due to the poor seasonal conditions after decisions were implemented. Because of the large number of influences on crop nitrogen response, no decision tool will outperform another in every situation. Which tool you use depends on personal preference.

By delaying nitrogen fertiliser application for high yielding crops and taking account of seasonal and crop conditions, there is a greater chance of matching nitrogen fertiliser to crop requirements.

KEY WORDS

season, nitrogen, yield forecast, decision tool

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Barley agronomy highlights: Canopy management

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KEY MESSAGES

- Where powdery mildew and net blotch are the dominant diseases the suggested seeding rate for barley does not warrant reconsideration when the disease is controlled. Whilst increasing the seeding rate of barley did not increase disease levels in the canopy it did increase grain yield in most trials. The impact of seeding rate on grain quality (screenings, grain protein and grain brightness) was generally low.
- Where a foliar fungicide was used there were no increases in leaf disease levels as nitrogen supply increased. Where a foliar fungicide was not used, increases in leaf disease were more likely to be observed as nitrogen supply increased. Net blotch infection was much less sensitive to nitrogen application than powdery mildew over both 2005 and 2006 seasons.
- Screening levels in Baudin were more sensitive to increasing nitrogen rate than Vlamingh but both varieties were similarly sensitive to increasing seeding rate. Screenings were higher in Baudin than in Vlamingh. There was no interaction between seeding rate and rate of nitrogen applied on screening level measured or on the level of disease in the canopy, on grain yield or on grain protein.
- There was no impact of how the nitrogen was applied (single or split applications up to flag leaf emergence) on the level of disease recorded in the canopy in 2006, on grain yield or grain protein.
- Fungicides are more useful at reducing disease levels in the canopy than reducing the number of seeds sown, the amount of nitrogen applied or modifying the way in which the nitrogen is applied. Growers should manage their crops to maximise grain yield and grain quality bearing in mind the variety to be sown and the site yield potential; and use fungicides to minimise the invasion of the canopy with leaf disease.

AIMS

Powdery mildew and net blotch (net type and spot type) are two of the major leaf diseases of barley with yield reductions of up to 40 per cent recorded in barley grown in southern regions of Western Australia (Kith Jayasena, Crop Updates 2005). Powdery mildew damages the plant by reducing photosynthesis and increasing the rate of transpiration and respiration. Net blotches cause areas of the leaf to become brown, with adjacent areas becoming chlorotic. Yield losses are greatest when the plants are infected as seedlings, although plants may be infected at all stages of growth.

Powdery mildew development is optimal at air temperatures between 15°C and 22°C, but is severely retarded when the temperature rises above 25°C. Barley plants are most susceptible to mildew infection during periods of rapid growth, high nitrogen fertilisation, high humidity and low temperatures.

Net blotch development is optimal at air temperatures between 15°C and 25°C, although infection can occur between 8°C and 33°C. Like powdery mildew, barley plants are more susceptible with high nitrogen nutrition, high humidity and low temperatures. High humidity needs to persist for at least 10 hours for infection to occur.

The malting barley variety Baudin is noticeably susceptible to both forms of net blotch and powdery mildew. One of the current recommendations when growing Baudin in high disease risk situations is to reduce plant density (Farmnote 21/2004). Whilst not stated, this is to reduce canopy humidity. There is however no evidence that reducing plant density in Baudin will reduce disease incidence in the canopy and improve grain yield and grain quality.

This paper provides a snapshot of some of the disease and nitrogen research work undertaken by the barley agronomy group over the last two seasons (2005 and 2006). The research focused on managing Baudin barley better and examined whether or not the new malting barley showed similar responses. The influence of canopy management (through modifying plant density, nitrogen rate and/or nitrogen timing) on the level of disease in the canopy, grain yield, grain plumpness and grain protein is discussed. This research is on-going and will be continued in 2007.

METHOD

2005 canopy management trials – Statewide

Design – 2 varieties x 6 canopy treatments x 2 foliar fungicide treatments x 3 replicates.

Canopy management trials using Baudin and Vlamingh barley were sown at three target planting densities (75, 150 or 300 plants/m^2) at eight locations in 2005 (Meckering, Brookton, Wagin, Katanning, Gairdner River, Gibson and Scaddan). At each location 30 kg N/ha was applied at seeding. Four to six weeks after seeding, half the plots were top dressed with an additional 70 kg N/ha as urea. The seed used was treated with triadimenol as Zorro at 400 mL/100 kg seed. At both stem elongation (Z31) and flag leaf emergence (Z39) half the plots were sprayed with propiconazole at 500 mL/ha.

2006 canopy management trials – Central region

Design – 2 varieties x 22 canopy treatments x 2 foliar fungicide treatments x 3 replicates.

Canopy management trials were sown at three locations in the central wheatbelt – Calingiri, Morbinning and Katanning – in 2006. At each location Baudin and Vlamingh barley were sown with 22 different combinations canopy management (seeding rate, nitrogen applied and nitrogen timing). Seed was sown at 75, 150 or 300 plants/m^2. Nitrogen was applied at four different rates and for two rates the nitrogen was applied at different timings (single or multiple). The timings included at seeding, six weeks after sowing, Z31 and/or Z39. For the foliar fungicide treatments, half the plots were sprayed with propiconazole at 500 mL/ha at both Z31 and Z39. The other half of the plots were unsprayed.

Measurements

Plant establishment counts were taken at four weeks after seeding. Foliar leaf disease measurements were taken between flowering and early grain fill. The percentage of the flag-1, flag-2 and flag-3 leaf infected with disease was measured on 10 tillers per plot. Plots were harvested with a small plot harvester, weighed and sub-sampled. The grain sub-samples were cleaned over a 1.5 mm sieve and measured for average grain weight, hectolitre weight, screenings, grain brightness and grain protein.

RESULTS

Seasonal summary

In 2005 the main diseases present were powdery mildew, net type (NTNB) and spot type (STNB) net blotch with traces of scald. The main diseases present in the 2006 season were powdery mildew and net type net blotch, with traces of barley leaf rust. Spring rainfall levels were good across most trial sites in 2005 while in 2006, the central districts received spring rain after a late, very dry start and the south had a good start with a very dry spring finish.

Table 1. The average level of leaf area infected (% lai) with foliar disease (on flag-1 to flag-3) and the main diseases present at trial sites in 2005 and 2006

Year	Site	Date sown	Leaf area infected (%)	Diseases present	May-Oct. rainfall (mm)
2005	Brookton	18 May	4.4	Powdery mildew, NTNB	383
	Gairdner	25 May	11.0	Powdery mildew, STNB, scald	-
	Gibson	19 May	13.8	Powdery mildew	453
	Katanning	30 May	5.1	NTNB	383
	Meckering	11 May	2.0	NTNB, STNB	282
	Ravensthorpe	1 June	2.2	Powdery mildew, NTNB, STNB	219
	Scaddan	30 May	10.0	Powdery mildew, STNB, scald	278
	Wagin	13 June	4.1	Powdery mildew, NTNB	337
2006	Calingiri	24 May	8.8	Powdery mildew, NTNB	202
	Katanning	31 May	4.7	NTNB	188
	Morbinning	30 June	10.1	NTNB	186

Impact of disease on grain yield and quality

The level of disease recorded in Baudin barley was generally higher than that recorded in Vlamingh barley (Tables 2, 3, 5 and 6). Baudin generally had higher levels of both net type net blotch and powdery mildew than Vlamingh. At sites however where spot type net blotch (i.e. Gairdner, Meckering and Scaddan) was also present the two varieties had similar levels had similar levels of disease assessed as net blotch (Tables 1 and 3). The use of a two spray fungicide strategy to control leaf disease was effective in both 2005 and 2006 (Table 3).

Table 2. Average level of leaf area infected (% lai) with net blotch or powdery mildew during grain filling on the flag-1 to flag-3 leaves of Baudin and Vlamingh barley with and without foliar fungicide application across 8 sites in 2005 and 3 sites in 2006

Year		Leaf area infected (%)							
	Disease	Net blotch - net and/or spot				Powdery mildew			
	Fungicide	Nil		Plus		Nil		Plus	
	Variety	Baudin	Vlamingh	Baudin	Vlamingh	Baudin	Vlamingh	Baudin	Vlamingh
2005	Brookton	6.8	0.2	0.6	0.0	3.1	6.6	0.0	0.0
	Gairdner	0.1	0.1	0.1	0.1	22.8	11.6	9.4	1.3
	Gibson	1.6	1.6	1.5	1.6	0.0	0.0	0.0	0.0
	Katanning	2.6	1.9	0.4	0.2	10.6	2.8	1.6	0.2
	Meckering	1.8	2.4	1.6	2.2	0.0	0.0	0.0	0.0
	Ravensthorpe	0.3	0.0	0.3	0.0	5.7	0.2	2.9	0.0
	Scaddan	9.7	11.6	3.3	4.3	2.6	0.5	0.0	0.0
	Wagin	3.3	0.4	2.7	0.4	0.7	4.9	0.8	3.2
lsd(0.05)		1.8				4.0			
lsd (0.05) – site		2.2				3.9			
lsd (0.05) – site.foliar		0.8				2.4			
lsd (0.05) – site.variety		2.2				3.9			
2006	Calingiri	11.7	4.9	4.6	2.8	10.3	0.6	0.1	0.0
	Katanning	5.4	0.3	0.5	0.3	8.8	3.3	0.8	0.7
	Morbinning	20.1	7.7	7.7	4.8	0.0	0.0	0.0	0.0
lsd (0.05)		2.6				5.2			
lsd (0.05) – site		1.7				5.4			
lsd (0.05) – site.foliar		1.4				1.4			
lsd (0.05) – site.variety		1.7				5.4			

In Baudin, reducing moderate disease levels (10-15 per cent) with the use of fungicides gave a 6 per cent to 15 per cent gain in grain yield across trial sites (Figure 1) and improved screening levels. At low disease levels (< 5 per cent), there was no grain yield advantage in controlling the disease although at these sites screenings were reduced. For example, screenings were reduced by nearly 6 per cent at Wagin and 2.5 per cent at Meckering.

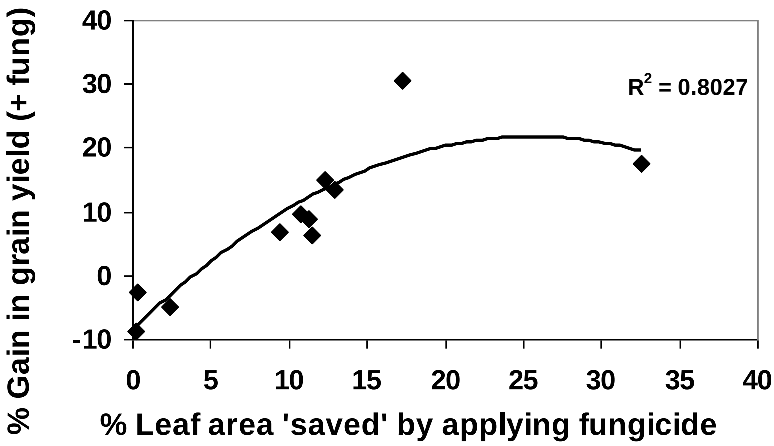

Figure 1. Effect of reducing barley leaf disease on grain yield (gain in yield from applying fungicide shown as a percentage of yield with nil fungicide) at 11 sites over 2005 and 2006.

Increasing seeding rate and crop performance

Table 3. Average level of leaf area infected (% lai) with disease during grain filling on the flag-1 to flag-3 leaves of Baudin and Vlamingh barley as seeding rate (plants/m^2) increased across 8 sites in 2005 and 3 sites in 2006

Year		Leaf area infected (%)					
	Variety	**Baudin**			**Vlamingh**		
	Seeding rate	**75**	**150**	**300**	**75**	**150**	**300**
2005	Brookton	6.4	4.3	5.2	6.0	2.4	1.9
	Gairdner	13.8	17.9	16.8	5.7	5.4	8.5
	Gibson	1.7	1.8	1.2	1.9	1.1	1.8
	Katanning	7.8	7.4	7.6	2.5	2.5	2.7
	Meckering	1.8	1.9	1.5	2.2	2.4	2.3
	Ravensthorpe	5.6	4.2	3.9	0.2	0.1	0.1
	Scaddan	8.2	6.9	8.4	9.7	7.6	7.3
	Wagin	3.6	3.6	4.0	4.4	5.3	3.7
	Average	**6.1**	**6.0**	**6.1**	**4.1**	**3.4**	**3.6**
2006	Calingiri	15.4	13.0	11.7	4.1	4.3	4.0
	Morbinning	7.9	6.3	6.9	2.0	2.1	2.8
	Katanning	14.2	13.9	13.7	6.0	6.7	6.0
	Average	**12.5**	**11.1**	**10.3**	**4.0**	**4.4**	**4.3**

In 2005, the average number of plants established at each seeding rate was 62, 102 and 153 plants/m^2, which was way below the target densities of 75, 150 and 300 plants/m^2. This low establishment was most likely due to a seedbed that was too wet. In 2006, the average number of barley plants established was 76, 132 and 215 plants/m^2 at Calingiri and Morbinning, and 106, 193 and 313 plants/m^2 at Katanning.

Increasing the number of barley plants established had little impact on the amount of leaf disease measured in the barley canopy during grain filling in both years (Table 3). The dominant diseases measured were powdery mildew and net blotch (Table 1). There was also no interaction between seeding rate and the level of disease scored in the canopy with either variety or site or foliar fungicides or the level of applied nitrogen in both 2005 and 2006.

Table 4. Grain yield (t/ha, average of Baudin and Vlamingh), screenings (% < 2.5 mm) in Baudin and screenings in Vlamingh (% < 2.5 mm) as seeding rate (plants/^{2}) increased across eight sites in 2005 and 3 sites in 2006

Year		Grain yield (t/ha)			Screenings (% < 2.5 mm)			Screenings (% < 2.5 mm)		
	Variety				**Baudin**			**Vlamingh**		
	Seeding rate	**75**	**150**	**300**	**75**	**150**	**300**	**75**	**150**	**300**
2005	Brookton	4.67	4.68	4.83	2	2	3	1	1	1
	Gairdner	3.57	3.94	4.13	2	3	3	1	1	1
	Gibson	4.11	4.41	4.43	11	13	14	7	8	10
	Katanning	2.72	2.98	3.14	3	3	6	3	3	3
	Meckering	2.66	2.75	3.01	8	6	8	7	6	6
	Ravensthorpe	3.41	3.38	3.22	2	3	4	1	1	2
	Scaddan	4.12	4.00	4.14	4	4	3	2	2	1
	Wagin	2.06	2.26	2.61	13	15	15	15	15	9
	Average	**3.42**	**3.55**	**3.69**	**6**	**6**	**7**	**5**	**5**	**4**
2006	Calingiri	3.24	3.28	3.36	25	20	17	7	7	8
	Morbinning	2.82	2.91	2.99	53	56	56	17	20	24
	Katanning	2.11	2.17	2.31	28	33	41	11	16	20
	Average	**2.72**	**2.79**	**2.89**	**35**	**36**	**38**	**12**	**14**	**17**

Increases in grain yield were observed at most sites (Table 4), but the impact of seeding rate on grain quality (screenings, grain protein and grain brightness) was generally low. In general increases in seeding rate were associated with increases in screenings, reductions in grain protein and reductions in grain brightness. The average reduction in grain protein was less than 0.5 per cent and the average reduction in grain brightness was less than 0.5 Minolta 'L' units.

At eight of the eleven sites increases in grain yield were observed as plant density increased (Table 4). In 2005, the average increase in grain yield at Gairdner, Gibson, Katanning, Meckering and Wagin was 439 kg/ha or a 16 per cent increase in yield from the lowest to the highest plant density. In 2006, the average increase in grain yield at Calingiri, Morbinning and Katanning was only 163 kg/ha or a 6 per cent increase. There was no interaction between variety and site in the response of Baudin and Vlamingh to increasing seeding rate.

Screening levels in Baudin were more sensitive to changes in site than Vlamingh, but similar in sensitivity to increases in seeding rate (Table 4). Screenings levels in Baudin were generally higher than those of Vlamingh and across all sites averaged nearly double those of Vlamingh. In 2006, the only site were there was a significant increase in screening levels with seeding rate was at Katanning, where the crop was sown at the end of June and received only 186 mm of growing season rainfall.

Previous work conducted by Dr Tanveer Khan and Kevin Young in the mid 1980s demonstrated that the optimum seeding rate (to maximise grain yield) increased in Stirling barley affected by the leaf disease scald when the disease was controlled (Technote 03/87). As there was no interaction between seeding rate and grain yield in 11 trials conducted over two contrasting seasons, this suggests that when powdery mildew and net blotch are the dominant diseases, the optimum seeding rate for barley is not modified when the disease is controlled. Baudin seed should also be treated with a full spectrum seed dressing to reduce disease infection in the first six weeks after emergence and minimise the impact of smut.

These results do not support an initial belief published in Farmnote 21/2004 that Baudin barley would benefit from sowing at lower plant densities in high disease risk environments. The results suggest that Baudin should be sown at the suggested establishment density of 120 to 150 plants/m^2 and fungicides, particularly applied at the beginning of stem elongation (Z31), should be used to minimise the impact of leaf diseases such as powdery mildew and net blotch.

Increasing nitrogen rate and crop performance

Disease levels in the canopy were slightly more sensitive to nitrogen application than seeding rate (Tables 3, 5 and 6). In general there were increases in total leaf area affected by disease as nitrogen supply increased, but this was dependant on seasonal conditions.

Table 5. Average level of leaf area infected (% lai) with disease during grain filling on the flag-1 to flag-3 leaves, grain yield (t/ha) and screenings (% < 2.5 mm) of Baudin and Vlamingh barley as nitrogen supply increased (kg N/ha applied at 6 WAS) at 8 sites in 2005

	Leaf area infected (%)				**Grain yield (t/ha)**				**Screenings (% < 2.5 mm)**			
Variety	**Baudin**		**Vlamingh**		**Baudin**		**Vlamingh**		**Baudin**		**Vlamingh**	
N applied	**30**	**100**	**30**	**100**	**30**	**100**	**30**	**100**	**30**	**100**	**30**	**100**
Brookton	3	8	1	6	4.43	5.02	4.39	5.08	1	4	1	1
Gairdner	12	20	3	10	3.61	4.38	3.36	4.17	1	4	1	1
Gibson	2	1	1	2	4.21	4.56	4.09	4.41	8	18	6	11
Katanning	4	11	2	4	2.89	3.48	2.54	2.87	3	5	3	3
Meckering	2	1	2	2	2.57	3.23	2.31	3.11	4	11	4	8
Ravensthorpe	3	7	0	0	3.21	3.44	3.17	3.53	2	3	1	1
Scaddan	7	8	8	8	4.05	4.12	3.99	4.18	3	4	2	2
Wagin	3	4	5	4	2.63	2.49	2.10	2.02	11	18	10	16
Average	**5**	**8**	**3**	**5**	**3.45**	**3.84**	**3.24**	**3.67**	**4**	**8**	**4**	**5**

In 2005, increasing the amount of nitrogen applied increased the amount of powdery mildew in the canopy, but only when no fungicide was applied. The level of net blotch in the canopy was not affected by nitrogen supply. At Brookton, Gairdner, Katanning and Ravensthorpe the level of powdery mildew increased from 4 per cent to just over 11 per cent when no foliar fungicide applied. In 2006, there were much smaller increases in leaf disease levels as nitrogen applied increased, with no interaction with foliar fungicides. At Calingiri and Morbinning, powdery mildew levels increased from 1 per cent to 2 per cent and net blotch levels from 8 per cent to 9 per cent.

Table 6. Average level of leaf area infected (%lai) with disease during grain filling on the flag-1 to flag-3 leaves, grain yield (t/ha) and screenings (% < 2.5 mm) of Baudin and Vlamingh barley as nitrogen supply increased (kg N/ha applied at 6 WAS) at 3 sites in 2006

Site	N applied	Leaf area infected (%)				Grain yield (t/ha)				Screenings (% < 2.5 mm)			
		0	20	40	60	0	20	40	60	0	20	40	60
Calingiri	Baudin	12	12	13	16	2.94	3.20	3.27	3.22	15	19	23	26
	Vlamingh	3	4	4	5	3.22	3.33	3.49	3.69	6	9	8	8
Katanning	Baudin	8	8	7	6	2.29	2.21	2.16	2.01	28	35	33	39
	Vlamingh	2	1	4	2	2.30	2.33	2.17	2.09	13	11	22	16
Morbinning	Baudin	13	14	14	15	2.69	2.83	2.76	2.64	40	50	61	69
	Vlamingh	6	6	7	6	2.99	3.19	3.12	3.04	10	16	24	31
Average	**Baudin**	**11**	**11**	**11**	**12**	**2.64**	**2.75**	**2.73**	**2.62**	**28**	**35**	**39**	**45**
	Vlamingh	**4**	**4**	**5**	**4**	**2.84**	**2.95**	**2.93**	**2.94**	**10**	**12**	**18**	**18**

In 2005, the overall impact of increasing nitrogen supply was to increase the grain yield by 408 kg/ha, screenings from 4 per cent to 7 per cent, grain protein from 10.4 per cent to 11.5 per cent and reduce grain brightness by 0.3 Minolta 'L' units (Table 5). Site by nitrogen applied interactions were observed for grain yield, screenings and grain protein. Only six of the eight sites were nitrogen responsive. At those six sites, increasing nitrogen supply from 30 kg N/ha to 100 kg N/ha increased grain yield by 541 kg/ha.

In 2006, grain yield increased as nitrogen supply increased only at Calingiri, was not affected at Morbinning and decreased at Katanning (Table 6). Increases in screenings were recorded at all three sites with larger increases at Morbinning than Calingiri and Katanning. Across sites, screening levels in Baudin were more sensitive to nitrogen application than Vlamingh. Grain protein responses to applied nitrogen were large at all sites and ranged from a 1.2 per cent increase at Calingiri with 60 kg N/ha applied at 6 WAS through to 3.1 per cent at Morbinning.

In the 2006 season trials, nitrogen was also applied at six different timings: All at seeding, all at 6 WAS, all at Z31, split evenly between 6 WAS and Z31, split evenly between 6 WAS and Z39 and split evenly between Z31 and Z39 (Table 7). There was no impact on how the nitrogen was applied (either as single or split applications) on the level of disease recorded in the canopy in the 2006 trials, on grain yield or grain protein. There was a small interaction with screenings with the level of screenings recorded highest with the 6 WAS + Z31 split and lowest with the Z31 + Z39 split.

Table 7. Average level of leaf area infected (% lai), grain yield (t/ha), screenings (% < 2.5 mm) and grain protein (%, db) when a set level of nitrogen applied in a single application or evenly split over two applications at 3 sites in 2006

Nitrogen timing method	0WAS	6WAS	Z31	6WAS+Z31	6WAS+Z39	Z31+Z39	lsd (0.05)
Leaf area infected (%)	8	9	8	9	8	8	ns
Grain yield (t/ha)	2.85	2.81	2.94	2.86	2.92	2.97	ns
Screenings (% < 2.5 mm)	30.5	31.1	29.5	32.8	29.4	27.4	3.2
Grain protein (%, db)	12.7	12.9	12.7	12.8	12.8	12.9	ns

KEY WORDS

barley, nitrogen, disease, seeding rate, nitrogen timing

ACKNOWLEDGMENTS

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Paper reviewed by: Steve Penny

Barley agronomy highlights: Leaf diseases and spots

Andrea Hills[1] and **Blakely Paynter**[2], Department of Agriculture and Food, Western Australia; Esperance[1] and Northam[2]

KEY MESSAGES

- No improvement in grain yield or level of disease in the canopy was found when four feed varieties (Barque, Keel, Dash and Molloy) were mixed in 2-way, 3-way and 4-way mixtures compared to monocultures (1-way) of those varieties.
- Small improvements in average grain weight and decreases in screenings were observed, but this is of little economic benefit for the production of feed barley.
- Growers are better off selecting the highest yielding feed barley variety which combines the levels of disease resistance required for their area of production, than combining varieties.
- Attempts to see if grain yield can be improved in Hamelin barley by reducing the level of physiological leaf spotting were not successful in 2006. Low levels of physiological leaf spotting occurred and the fungicides trialled did not reduce spotting levels or affect grain production in any way.

AIMS

This paper combines two research areas undertaken by the barley agronomy group at the DAFWA, which looked at ways of reducing leaf diseases without chemicals by mixing varieties and exploring chemical options to minimise the presence of physiological leaf spotting.

Mixing varieties to reduce leaf disease

The major leaf diseases of barley in Western Australia are scald, net type net blotch, spot type net blotch, powdery mildew and barley leaf rust. Yield reductions of up to 40 per cent have been recorded on barley grown in southern regions of Western Australia when leaf disease has not been controlled (Jayasena Crop Updates 2005). Yield losses are usually greatest when the plants are infected as seedlings, although plants may be infected at all stages of growth.

Over the last five years the use of in-furrow and foliar fungicides has increased significantly. The main reasons for this are the right environmental conditions, the lack of available varieties with some resistance to leaf disease, increased barley acreage, an increase in area sown to barley after barley and the availability of cheaper fungicide products. Whilst widespread use of fungicide to treat either fertiliser or the plant is helping to minimise the impact of leaf diseases, it is increasing the cost of growing barley. The other potential implication of the overuse of fungicides is the development of resistance. The most effective way to reduce input costs and avoid the development of resistance is to improve the resistance of varieties.

The barley industry in Australia is heavily focused on growing barley for the malting and brewing industries. The drawback from this focus is that the development of varieties that meet customer's needs, have good agronomic adaptation to large areas of Western Australia and have useful resistance to leaf diseases is a long and slow process due to the number of genes that need to be combined. Growers want to be able to defer some of their chemical costs from one part of their barley operations (i.e. feed) to their higher value malting barley crops.

They can do this if they grow feed varieties with intermediate resistance to leaf diseases. As with malting varieties, no feed barley variety combines adequate resistance to all leaf diseases and pathotypes present in Western Australia. A number of overseas studies show that mixtures of barley varieties can reduce disease incidence and increase grain yield relative to monocultures of the individual varieties. Research trials undertaken in 2005 examined the benefits (disease infection, grain yield and grain quality) from combining two or more high yielding feed barley varieties that differ in their resistance profile.

Physiological leaf spotting

Varieties such as Hamelin, Baudin and Fitzgerald regularly exhibit physiological leaf spotting. Many growers confuse the symptoms of physiological leaf spotting with boron toxicity and net blotch (see Farmnote 62/2005). The question is, does the presence of these physiological spots reduce yield potential and can the symptoms be reduced? Given that physiological leaf spotting appears to reduce green leaf area it is highly possible that it may limit grain yield potential in some seasons. Data from Syngenta in the United Kingdom suggests that the protectant fungicide Bravo® can reduce leaf spotting in barley and increase grain yield. Bravo® is a recommended fungicide that is often used in conjunction with strobilurin to reduce scald infection and leaf spotting in barley. Leaf spotting in the United Kingdom can be due to biotic (i.e. *Alternaria*, *Ramularia*) and abiotic (i.e. oxidative) stresses. It is most likely that in WA, physiological leaf spotting is due to abiotic rather than biotic stresses as *Ramularia* has yet to be reported.

In 2006 research trials were conducted to determine whether or not physiological leaf spotting could be reduced through the application of Bravo® Weatherstik (chlorothalonil). It should be noted that there are currently no registrations for the use of Bravo® on cereals in Australia.

METHOD

Mixing varieties to reduce leaf disease

Design: 4 varieties + 11 mixture combinations x 3 replicates

Treated seed of four feed barley varieties – Barque, Dash, Keel and Molloy – (differing in disease resistance profiles) were sown as a monoculture or as a mixture at eight locations in 2005. Before seeding, monocultures, 2-way, 3-way and 4-way mixtures of varieties were prepared to establish 150 plants/m^2. For the mixtures, equal numbers of seeds (based on seed weight and ratio of variety in mixture) were mixed. The seed used was treated with triadimenol as Zorro at 400 mL/100 kg seed. No in-furrow or in-crop fungicide was used. Trials were sown at Calingiri, Brookton, Wagin, Katanning, Gairdner River, Ravensthorpe, Gibson and Scaddan with a small plot seeder. Trials were sown as randomised blocks using a cyclic Latin square design.

Table 1. Disease resistance profiles of varieties sown in mixtures trials

Variety	Scald	Net type net blotch	Spot type net blotch	Powdery mildew	Barley leaf rust
Disease susceptible controls					
Baudin	**I**	S	S	S	S
Doolup	VS	S	MS	S	S
Vlamingh	**MR**	**I**	S	S	MS
Mixture cultivars					
Keel	**MR**	**R**	**MR**	S	VS
Barque	**MR**	MS	**I**	**R**	S
Dash	**R**	**I**	S	**R**	**R**
Molloy	S	MS	MS	**I**	**R**

Physiological leaf spotting

Design: 1 variety x 7 fungicide treatments x 3 replicates

Hamelin barley was sown at two locations – Merredin and Newdegate – to establish 150 plants/m^2. Products used to reduce the appearance of physiological leaf spotting in the United Kingdom – Bravo Weatherstik 720SC and Amistar Opti 600SC – were applied in this trial. These products are not registered in Australia. Bravo was applied at either Z31 or Z39 or at both Z31 and Z39. Amistar Opti was applied at either Z31 or Z39.

Measurements

Plots were sown with a small plot seeder sowing 6 to 8 rows of seed. Plant establishment counts were taken at four weeks after seeding. Physiological leaf spotting and foliar leaf disease measurements were taken between flowering and early grain fill. The percentage of the flag-1, flag-2 and flag-3 leaf

infected with disease was measured on ten tillers per plot. Plots were harvested with a small plot harvester, grain weighed and sub-sampled. The grain sub-samples was cleaned over a 1.5 mm sieve and measured for average grain weight, hectolitre weight, screenings, grain brightness and grain protein.

RESULTS

Mixing varieties to reduce leaf disease

Table 2. Average area of flag-1 to flag-3 leaves affected with disease (% lai) of four feed varieties when sown as a monoculture (1-way) or in 2-way, 3-way and 4-way mixtures and three control varieties at eight sites in 2005

Site and mixture	Leaf area infected (%)				
	1-way	2-way	3-way	4-way	Control
Brookton	4.1	4.1	4.1	3.3	9.6
Calingiri	0.0	0.0	0.0	0.0	0.3
Gairdner	11.9	5.3	5.3	5.3	31.6
Gibson	5.5	4.2	3.9	5.5	19.2
Katanning	7.7	6.5	5.5	5.2	10.7
Ravensthorpe	0.3	0.6	0.5	0.0	3.0
Scaddan	7.9	5.7	5.5	6.9	11.9
Wagin	3.8	3.3	4.5	3.3	2.7
Average	**5.1**	**3.7**	**3.7**	**3.7**	**11.1**
lsd (0.05) site	5.0				
lsd (0.05) site.mixture	4.3				

Disease levels above 5 per cent are likely to cause yield reductions in barley if not controlled with a foliar fungicide. Disease levels above 5 per cent during grain filling on the flag-1 to flag-3 leaves were recorded in the three control varieties (Baudin, Doolup and Vlamingh) at five of the eight sites (Brookton, Gairdner, Gibson, Katanning and Scaddan) (Table 2). The dominant diseases present at Brookton and Katanning were powdery mildew and net type net blotch. At Gairdner and Gibson the dominant disease was powdery mildew. At Scaddan the dominant leaf disease was spot type net blotch.

As the feed varieties sown had higher levels of resistance to powdery mildew and net blotch, the average level of disease recorded in the monocultures (1-way) was less than that of the control varieties. Whilst there was a trend towards a reduction in leaf area affected by disease when the feed varieties were mixed as 2-way, 3-way or 4-way mixtures, it was not significant.

Table 3. Average grain yield (t/ha) of four feed varieties when sown as a monoculture (1-way) or in 2-way, 3-way and 4-way mixtures and three control varieties at eight sites in 2005

Site and mixture	Grain yield (t/ha)				
	1-way	2-way	3-way	4-way	Control
Brookton	4.19	4.24	4.28	4.31	4.00
Calingiri	5.48	5.47	5.51	5.48	5.01
Gairdner	4.18	4.19	4.19	4.05	3.74
Gibson	3.54	3.38	3.58	3.25	3.69
Katanning	3.26	3.29	3.23	3.39	3.14
Ravensthorpe	3.43	3.35	3.33	3.47	3.29
Scaddan	3.97	4.05	4.10	4.31	4.08
Wagin	2.62	2.80	2.76	2.57	2.69
Average	**3.83**	**3.85**	**3.87**	**3.85**	**3.71**
lsd (0.05) site	0.29				
lsd (0.05) site.mixture	0.39				

Despite disease being present at most sites and a trend towards a reduction in leaf area affected with disease, there was no grain yield benefit observed from mixing varieties in either 2-way, 3-way and 4-way mixtures (Table 3). This is despite the literature suggesting that the more components in a mixture the greater the reduction in disease incidence and the higher grain yield potential (depending on the leaf disease present). In practical terms, the international literature suggests that 3-way mixtures often produce more stable and higher yields than 2-way mixtures and monocultures.

There was a trend towards increasing grain weight and reduced screenings (data not presented) once two or more varieties were mixed together, but the impact was low (Table 4). These observations concur with international literature that using variety mixtures can increase the homogeneity of grain samples. There was no effect of variety mixing on hectolitre weight, grain protein or grain brightness.

Table 4. Average grain weight (mg, db) of four feed varieties when sown as a monoculture (1-way) or in 2-way, 3-way and 4-way mixtures and three control varieties at eight sites in 2005

Site and mixture	Average grain weight (mg, db)				
	1-way	2-way	3-way	4-way	Control
Brookton	44.0	44.0	44.0	43.5	42.1
Calingiri	39.8	40.2	40.1	41.1	37.0
Gairdner	41.6	41.9	41.3	42.0	41.0
Gibson	39.7	39.9	39.3	38.9	37.3
Katanning	41.0	41.8	42.7	42.0	39.9
Ravensthorpe	41.7	43.0	42.7	44.7	43.4
Scaddan	39.8	40.8	40.9	41.3	38.5
Wagin	39.5	40.0	40.1	39.1	37.7
Average	**40.9**	**41.5**	**41.4**	**41.6**	**39.6**
lsd (0.05) site	0.9				
lsd (0.05) site.mixture	1.6				

Physiological leaf spotting

The level of physiological leaf spotting observed at Merredin and Newdegate was low (Table 5). At Merredin it averaged 3.9 per cent of the flag-1 to flag-3 leaf area during grain filling and only 2.8 per cent at Newdegate. Neither of the fungicides used (Bravo Weatherstik 720SC and Amistar Opti 600SC) reduced the level of physiological leaf spotting, or increased grain yield. Due to the low levels of physiological leaf spotting observed, it was impossible to determine if the products often used in the United Kingdom to reduce leaf spotting are effective in Western Australia.

Table 5. Effect of fungicidal treatment on flag-1 to flag-3 leaf area affected by physiological leaf spotting (%lai) and grain yield (t/ha) at two sites in 2006

Fungicide product and timing	Rate at each timing (L/ha)	Physiological leaf spotting (%)	Grain yield (t/ha)
Control #1	-	4.0	1.83
Control #2	-	3.1	1.75
Bravo @ Z31	1.4	2.8	1.88
Bravo @ Z39	1.4	3.5	1.91
Bravo @ Z31 + Z39	0.7	3.8	1.82
Amistar Opti @ Z31	2.0	2.5	1.77
Amistar Opti @ Z39	2.0	3.8	1.84

KEY WORDS

barley, variety mixtures, physiological leaf spotting, disease

ACKNOWLEDGMENTS

Technical support for this research was provided by Sue Cartledge and David Dodge. Research trials were sown, sprayed and harvested by the Research Support Units of the Department at Merredin and Newdegate. The research is supported by the Department and the GRDC.

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Paper reviewed by: Steve Penny

Fungicide applications for stripe rust management in adult plant resistant (APR) wheat varieties

Geoff Thomas, Rob Loughman, Ian Hartley and Andrew Taylor; Department of Agriculture and Food, Western Australia

KEY MESSAGES

- Fungicide application can reduce both incidence and severity of stripe rust infection and reduce yield loss.
- Sapphire wheat has APR and this can limit the development of stripe rust.
- Early application of fungicide is most effective at reducing yield loss.
- Yield response to fungicide application is possible in APR varieties in high yielding crops.

AIMS

To determine the extent to which fungicide protection is required to manage stripe rust in an APR wheat variety (e.g. Sapphire).

METHOD

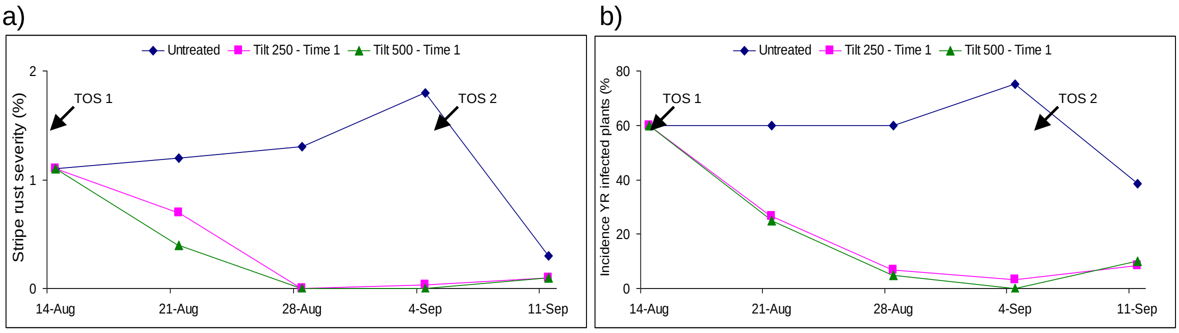
Two trial sites were set up in farm paddocks at Gibson (DAFWA Esperance Downs RSU) and at Cascades. At both sites Sapphire wheat was grown under normal crop management and without seeding fungicide protection. Stripe rust became evident in both paddocks around stem elongation and experimental fungicide application occurred at a similar time to in-paddock spraying, reflecting local disease management practises. At two times, growth stage Z31/33 (mid stem elongation stage) and three weeks later, different rates of fungicide, propiconazole 62 g a.i./ha or 125 g a.i./ha (e.g. Tilt 250 or 500 mL/ha) were applied as a single application in a randomised replicated design. A multiple spray treatment (125 g a.i./ha at both times) provided full protection as a reference control. Disease and yield measurements were carried out at both sites.

RESULTS

Site 1, Cascades: Time of spraying 1 (TOS 1) – 14 August (Z32/33), TOS 2 – 5 September (Z59/65)

At the time of first application 60 per cent of plants were infected with average severity of 1 per cent (Figure 1). Over the next three weeks, rust incidence on untreated plots rose to 75 per cent and severity 1.7 per cent (top three leaves). Incidence and severity of infection in fungicide treated plots fell to almost zero in that same period. At the time of the second application, infection severity (sporulating pustules) and incidence were beginning to fall in untreated plots. No differences in rust severity were noted from the second application. The first fungicide applications slightly reduced leaf necrosis, however by six weeks after spraying all leaves were 100 per cent necrotic. Untreated plots recorded 32 per cent incidence of some head infection, both fungicide spray times eradicated head infection.

Average yield across treatments was 1.9 t/ha, fungicide application did not impact on yield (Figure 3).



Site 2, Gibson (EDRS): TOS 1 – 21 August (Z31/32), TOS 2 – 11 September (Z55)

Figure 1. Effect of fungicide application on a) severity of stripe rust infection (top 3 leaves) and b) incidence of stripe rust infection in Sapphire wheat at Cascades in 2006 (Tilt 250EC applied 14 August and 5 September, only TOS1 shown as TOS2 had no significant effect).

Baseline infection at the time of spraying in this trial was 10 per cent incidence at 0.1 per cent severity (Figure 2). In the following two weeks incidence of infection in untreated plots rose to 80 per cent at 3 per cent severity (top 3 leaves). This level was maintained for one week before reducing over the next 3 weeks to almost zero. Applications of fungicide at TOS2 hastened the decline in infection. Plots sprayed at TOS1 had an increase in disease incidence at four and five weeks after TOS1, with Tilt 250 mL/ha providing a shorter period of protection than Tilt 500 mL/ha.

At three to five weeks after TOS1, necrotic leaf area (average top 3 leaves) was significantly lower in fungicide sprayed plots than in untreated plots. Stripe rust and low levels of septoria nodorum contributed to leaf necrosis. TOS2 did not significantly reduce necrotic leaf area. Seven weeks after TOS1 necrotic leaf area was approximately 60 per cent in all plots.

Average yield across treatments was 4.5 t/ha, all fungicide applications resulted in higher yield (Figure 3). The greatest response was evident from two applications. Of the single application treatments early application resulted in greater yield increase, response to higher rate was minimal.

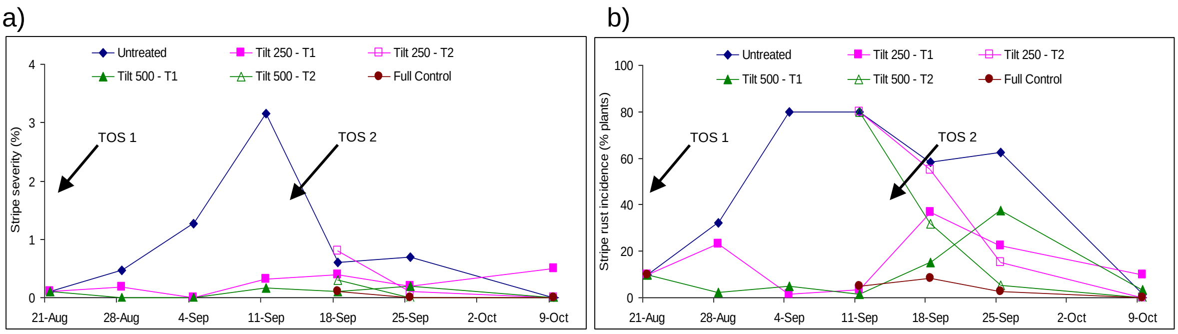


Figure 2. Effect of fungicide application on a) severity of stripe rust infection (top 3 leaves) and b) incidence of stripe rust infection in Sapphire wheat at Gibson in 2006 (Tilt 250EC applied 21 August and 11 September).

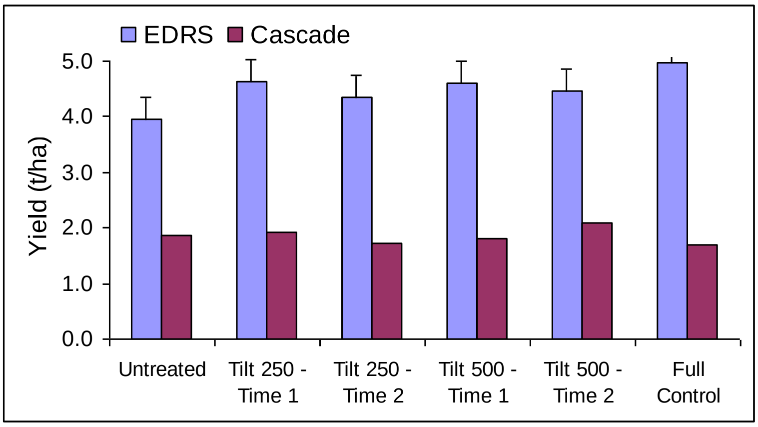


Figure 3. Effect of fungicide application on yield of stripe rust infected Sapphire wheat at Gibson (EDRS) and Cascades in 2006. Bar = lsd ($p < 0.05$), EDRS lsd = 0.4, Cascades lsd = ns.

CONCLUSION

At Cascades, at the time of fungicide application, rust was evident on over half of all plants at a low severity. This was a later stage in epidemic development than at Gibson where only 10 per cent of plants were infected. Fungicide application rapidly reduced rust infection at Cascades, however at the same time rust infection in untreated plots rose only slightly. At this site APR began to inhibit infection at Z33-39.8888

At Gibson fungicide application stopped the development of rust infection. Incidence and severity of infection in untreated plots rose to 80 per cent infection and 3 per cent severity by the time of the second fungicide application. At this time infection incidence and severity began to fall in untreated plots, however fungicide application hastened this decline. APR expression was delayed at this site and occurred around Z49/55.

No yield response occurred at Cascades, due in part to lower yield potential, earlier onset of APR and fungicide application later in epidemic development. At Gibson, yield potential was far greater, fungicide application occurred earlier in the epidemic, APR was delayed and there were low levels of septoria infection, possibly resulting in an additive fungicide response.

KEY WORDS

stripe rust, fungicide, adult plant resistance

ACKNOWLEDGMENTS

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Paper reviewed by: Ciara Beard and Kith Jayasena

Effect of seed treatment with Jockey on time of onset and disease severity of stripe rust in wheat

Manisha Shankar, John Majewski and **Rob Loughman**, Department of Agriculture and Food, Western Australia

KEY MESSAGES

Disease onset and progress was significantly delayed and reduced overall in all varieties with Jockey (Fluquinconazole) seed treatment even at a quarter (112 mL/100 kg seed) of the recommended rate.

Prevention of early exposure to stripe rust with seed treatment enhances disease control and reduces yield impact in fully susceptible varieties and is also valuable for varieties with adult plant resistance.

AIM

To determine the effect of seed treatment with varying concentrations of Jockey (Fluquinconazole) on disease development in wheat genotypes with varying levels of resistance to stripe rust.

BACKGROUND

Managing risk from stripe rust, which can have early onset in crops exposed to local carryover infections, depends on the susceptibility of the variety sown and the amount of localised green bridge present in autumn. Experience in previous years has indicated the need for a better understanding of delayed infection from fungicide use at seeding on varieties with varying levels of resistance.

METHOD

Six wheat varieties ranging in levels of resistance to stripe rust but similar in time of heading were used in this study: EGA Bonnie Rock and H45 (susceptible), Carnamah (moderately susceptible), EGA Castle Rock, Wyalkatchem (intermediate) and Mira (resistant). Seed of each variety was treated with varying rates of Fluquinconazole and the experiment sown as a randomised split-plot design with four replications at Medina Research Station on 22 June 2006. Main plots comprised of the following seed treatments:

1. Nil seed treatment.
2. Fluquinconazole 112 mL/100 kg seed.
3. Fluquinconazole 225 mL/100 kg seed.
4. Fluquinconazole 450 mL/100 kg seed.
5. Fluquinconazole 450 mL/100 kg seed + foliar sprays with Folicur (1 mL/L) four weeks after sowing and then at four weekly intervals.

Sub-plots constituted the varieties each sown in four 3 m long rows spaced 22 cm apart and surrounded by four rows of barley buffer. Seeding rate was 2 g/m. Six infected seedlings of susceptible variety Harrismith were transplanted on 13 July (three weeks after sowing (WAS)) into the two central rows, spaced 30 cm apart.

Severity of stripe rust was assessed on upper canopy leaves from all tillers in one central row. Measurements were made five weeks after introduction of infected transplants and then approximately at fortnightly intervals till maximum disease had reached flag leaves of very susceptible varieties. Severity of head infection was measured at 16 WAS. The two central rows were hand harvested at maturity and grain yields, percentage screenings and hectolitre weights determined.

RESULTS

Leaf infection. With nil seed treatment disease was well established by 18 August (8 WAS) (Figure 1a) in most varieties as compared to no disease till 5 September (10 WAS) with various rates of Fluquinconazole treated seed (Figure 1b). Variety Mira exhibited resistance at all stages of development and remained almost free of disease with all treatments.

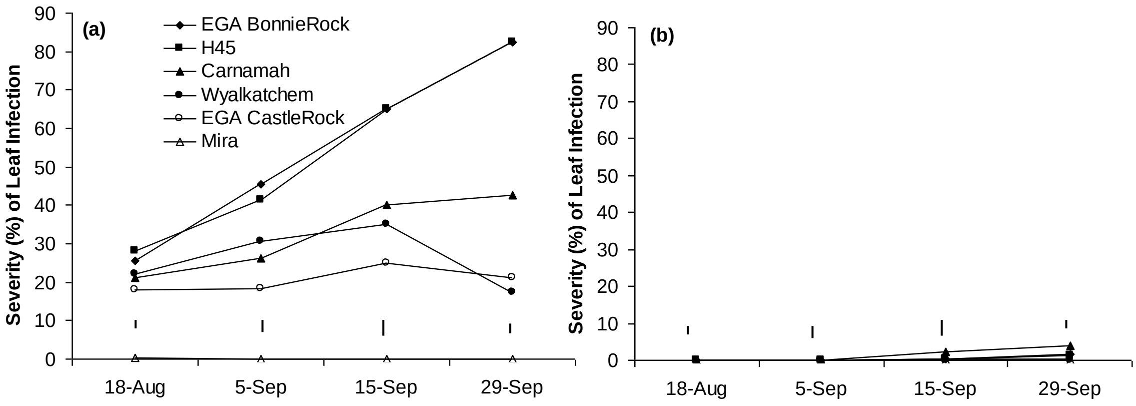

Figure 1. Progress of leaf infection in wheat varieties with (a) nil seed treatment and with (b) seed treatment with Jockey (Fluquinconazole) @ 112 mL/100 kg seed. Bars denote lsd ($p < 0.05$).

With nil seed treatment disease progressed rapidly in EGA Bonnie Rock and H45 showing very high disease severity (> 80 per cent) by 29 September (14 WAS) (Figure 1a). Disease severity in varieties Carnamah, Wyalkatchem and Castle Rock was significantly less than Bonnie Rock and H45 at all developmental stages. In Wyalkatchem and EGA Castle Rock disease severity diminished with enhanced expression of adult plant resistance at 14 WAS.

With the lowest rate of Fluquinconazole (112 mL/100 kg seed) treated seed, traces of the disease (1 to 2 per cent severity) was observed in EGA Bonnie Rock, H45 and Carnamah on 15 September (12 WAS) (Figure 1b). Disease in these three varieties showed very slight progress (up to 4 per cent in Carnamah) in the next two weeks. Trace amounts (< 1 per cent severity) of disease were observed at 12 and 14 WAS with higher rates of Fluquinconazole (225 mL/100 kg seed and 450 mL/100 kg seed) treated seed. No disease was observed with the treatment of Fluquinconazole 450 mL/100 kg seed + foliar sprays with Folicur.

Head and grain responses

With nil seed treatment H45 and EGA Bonnie Rock developed severe head infection by 13 October (16 WAS) (Figure 2). Head infection of Wyalkatchem, Carnamah and EGA Castle Rock was significantly less than H45 or EGA Bonnie Rock while Mira showed no head infection. No head infection was observed with all Fluquinconazole seed treatments.

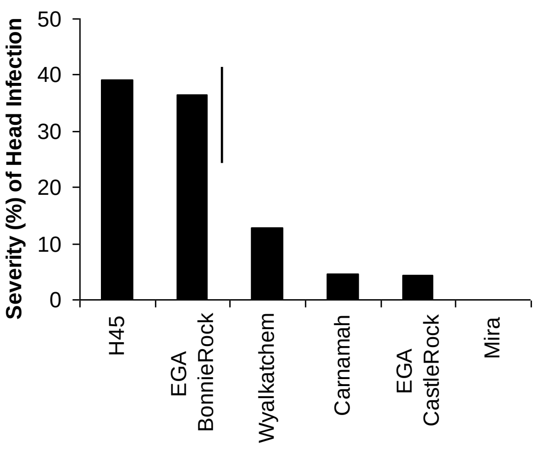

Figure 2. Severity (%) of head infection in wheat varieties with nil seed treatment. Bar denotes lsd ($p < 0.05$).

Grain yields were significantly affected in all varieties except Mira with nil seed treatment as compared to various Fluquinconazole seed treatments (Figure 3a). Stripe rust effects on yield were greatest for EGA Bonnie Rock and H45, then Carnamah, Wyalkatchem and EGA Castle Rock. There was a strong correlation ($R^2 = 0.9$) between grain yield and severity of leaf infection at 14 WAS.

Screenings were affected in EGA Bonnie Rock, H45 and Carnamah (Figure 3b) while hectolitre weights were affected in EGA Bonnie Rock and H45 (Figure 3c).

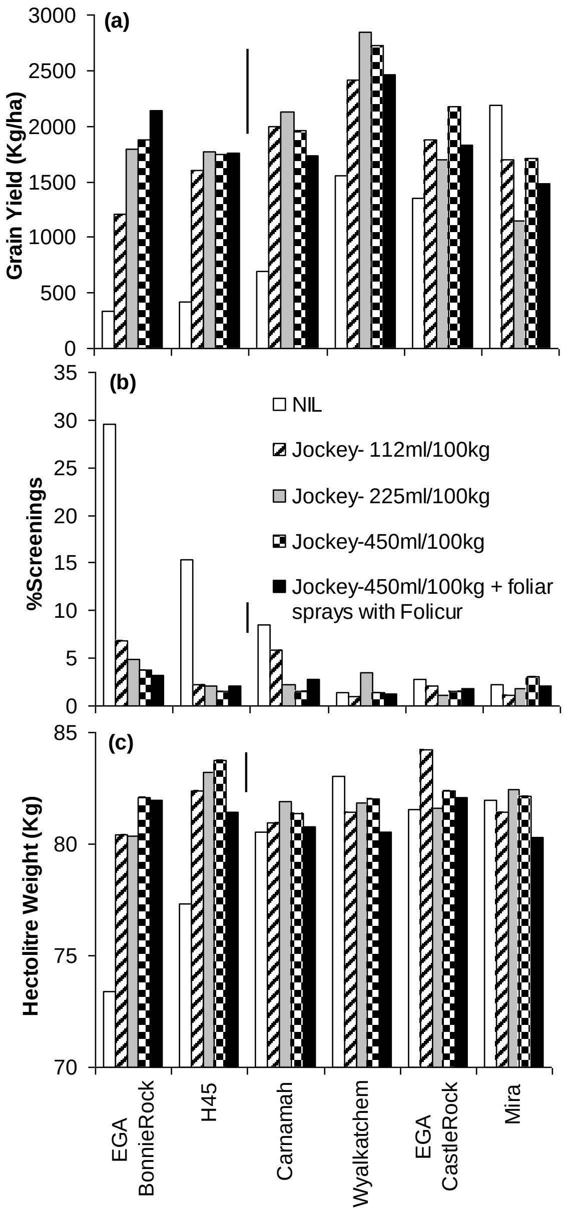

Figure 3. Effect of seed treatment with various rates of Jockey (Fluquinconazole) on (a) grain yield (kg/ha), (b) percentage screenings and (c) hectolitre weight (kg). Bars denote lsd ($p < 0.05$).

CONCLUSIONS

Seed treatment with Jockey significantly delayed time of onset and disease development in all varieties other than when fully resistant.

Under these seasonal and environmental conditions no rate response in Jockey was observed.

KEY WORDS

fluquinconazole, disease onset and development, partial resistance, adult plant resistance

ACKNOWLEDGMENTS

Support of staff at Medina Research Station is gratefully acknowledged.

Project No.: DAW120

Paper reviewed by: Robert Loughman

Rotations for management of Cereal Cyst Nematode

Vivien Vanstone, Department of Agriculture and Food, Western Australia, South Perth

KEY MESSAGES

- Susceptible cereal cultivars encourage increased levels of CCN in the soil.
- CCN should be monitored where symptoms are observed in-crop.
- CCN is readily managed by rotations that include resistant cereal cultivars and non-host crops.
- In trials conducted in 2005 resistant cereal and non-host crops, respectively, reduced number of CCN eggs in the soil by 84 per cent and 96 per cent compared to susceptible cereal.
- Non-host crops are more effective than resistant cereals in reducing levels of CCN.

BACKGROUND

Cereal Cyst Nematode (CCN, *Heterodera avenae*) is a damaging pest of cereals capable of causing significant yield loss. These nematodes are detected frequently on the roots of crops in the Northern and Central Agricultural Regions, but are not restricted to these areas (Table 1).

CCN infects only cereals and other grasses (particularly wild oat). Intensive cropping of susceptible cereal cultivars will lead to the build-up of CCN in paddocks where the nematode is already present.

The cysts produced on the roots are the swollen body of the female nematode. During spring, 'white cysts' about the size of a pin-head can be seen attached to the roots. These turn brown and remain in the soil over summer. Eggs hatch in autumn, allowing the juvenile nematodes to emerge and penetrate seedling roots. Once the nematode has established a feeding site, it remains in this position for the remainder of its life.

CCN reproduce only once during the growing season. Each cyst contains several hundred eggs. However, only 70-80 per cent of these hatch each season, regardless of the crop host. For this reason, it can take several years for high CCN levels to be reduced by rotation with resistant or non-host crops.

The symptoms of CCN infection are readily recognised. Above-ground, patches of yellowed and stunted plants can be observed. Planting a susceptible crop in successive years will result in these patches becoming larger with time. Below-ground, wheat and barley roots will be 'knotted', and oat roots appear 'ropey' and swollen. Development of root systems is retarded and shallow. In spring, the characteristic 'white cysts' can be seen with the naked eye if roots are carefully dug and washed free of soil.

Table 1. Identifications of Cereal Cyst Nematode from samples sent to *AGWEST* Plant Laboratories for disease diagnosis, 1988-2005

Location	No. of times identified
Northern Ag Region	
Calingiri	1
Coorow	3
Dongara	1
Geraldton	26
Northampton	8
Walkaway	6
Wongan Hills	9
Piawaning	1
Yerecoin	7
Central Ag Region	
Bolgart	1
Goomalling	4
Merredin	3
Northam	4
York	11
Southern Ag Region	
Albany	3
Kojonup	9

AIMS

- To demonstrate the effect of crop rotation on levels of CCN at infested sites.
- To compare the reactions of CCN populations from SA and WA to a standard set of cultivars to ensure that results reported from SA CCN screening and breeding activities are valid for WA.

METHODS

Field trials

In 2005, three trials were sown in the Northern Agricultural Region: Two at Mt Rennie near Geraldton, and a third on the Irwin River flats near Dongara. The number of CCN eggs in the soil was determined by the South Australian Research and Development Institute (SARDI) using the CCN component of the PreDicta-B™ DNA test.

In March 2005, CCN populations were high at the Mt Rennie 'Wrigglesworth' trial site (17 eggs/g soil) and at the Dongara site (29 eggs/g soil). Levels at the second Mt Rennie site ('River') were extreme (74 eggs/g soil). Both Mt Rennie sites were previously sown to Calingiri wheat and the Dongara site to Massif oat.

Plots (40 x 1.8 m) of wheat, barley and oat with differing levels of susceptibility to CCN were sown in May 2005 to manipulate the levels of nematodes in the soil in preparation for over-sowing with intolerant cereal in 2006. Non-hosts were included in each trial (field pea and/or lupin). Each treatment was replicated six times.

In November 2005, 40 soil cores (4 cm diameter) were taken from each plot to a depth of 15 cm. Soil was dried, sub-sampled and sent to SARDI for analysis to detect CCN DNA. Square root transformed data for number of CCN eggs per gram of soil in each plot was subjected to analysis of variance.

WA/SA CCN comparative testing

Organic matter was extracted from soil collected from CCN infested paddocks at Dongara and Geraldton. The SARDI CCN Screening Service hatched juvenile nematodes from the cysts contained in the organic matter extract. Ten replicates of cultivars with known reaction to CCN were grown in sandy loam, and each plant inoculated with 500 nematodes.

After 10 weeks, number of cysts per plant was assessed and natural log transformed values for these data analysed by the Tukey HSD pair-wise comparison test.

RESULTS

Field trials

At the end of the season, soil under susceptible cereal cultivars (Carrolup, Mundah and Janz) contained significantly more CCN eggs than that under resistant cereal cultivars (Potoroo, Doolup and Yitpi) and non-hosts (Helena, Kaspa and Tanjil).

Compared to susceptible cereal, resistant cultivars produced 84 per cent fewer eggs and non-host crops 96 per cent fewer eggs (Table 2). The non-host crops resulted in 75 per cent fewer eggs than the resistant cereal cultivars.

Table 2. Number of Cereal Cyst Nematode eggs per gram of soil for 6 replicate plots sown to each cultivar at 3 sites, 2005

Cultivar	Reaction to CCN	CCN eggs / g soil (November 2005)		
		Mt Rennie 'Wrigglesworth'	Mt Rennie 'River'	Dongara
Carrolup oat	Susceptible	88	65	15
Potoroo oat	Resistant	11	18	3
Mundah barley	Susceptible	33	64	25
Doolup barley	Resistant	3	6	3
Janz wheat	Susceptible	23	34	36
Yitpi wheat	Resistant	4	7	3
Helena field pea	Non-host	3	2	4
Kaspa field pea	Non-host	-	-	3
Tanjil lupin	Non-host	< 1	3	-

- Not sown at this site.

WA/SA CCN comparative testing

Cereal cultivars performed similarly in terms of resistance or susceptibility to CCN whether the nematodes had been sourced from SA or WA (Table 3). Cultivars performed as expected according to their known levels of resistance or susceptibility to CCN.

Table 3. Number of cysts per plant for 10 replicates of each cultivar inoculated with Cereal Cyst Nematode juveniles sourced from South Australia and two Western Australian sites

Cultivar	Reaction to CCN	CCN cysts / plant		
		SA	Geraldton WA	Dongara WA
Chebec barley	Resistant	1	0.6	1
Annuello wheat	Resistant	4.1	5.9	3.9
Galleon barley	Resistant	4.8	5.7	1.6
WAWHT2631 wheat	Resistant	6.9	4.3	4.6
Wallaroo oat	Resistant	9.1	5.7	5.7
Frame wheat	Moderately resistant	16.5	17.7	14
Molineux wheat	Moderately resistant	18.5	19.1	19.6
Schooner barley	Susceptible	42.9	63.1	52.3
Spear wheat	Susceptible	52.1	61.6	81.2
Gairdner barley	Susceptible	53.9	62.7	54.9
Dalyup oat	Susceptible	67.4	84.3	54.1
Egret wheat	Susceptible	88.5	70.4	64.3

CONCLUSION

Field trials

Non-host crops significantly reduced CCN levels in only one season, even at sites that had initially high nematode levels. The non-hosts were more effective than the resistant cereals. While resistant cereals will still allow some feeding and multiplication of CCN, non-host crops will not allow CCN to feed, develop or multiply. However, vigilance is required in paddocks where CCN has been identified. After only one or two seasons of a susceptible crop, levels can quickly increase and become damaging.

The trials were designed to be over sown with wheat in 2006, but this was not undertaken due to the drought conditions, and the plots were left fallow. Plots were sampled in spring 2006, and soil again submitted to SARDI for CCN enumeration by DNA test. The CCN levels indicated by these tests (< 5 eggs/g soil) were below the number likely to cause consistent and measurable yield loss to intolerant cereal cultivars. Furthermore, the significant differences between plots where susceptible, resistant and non-host crops had been grown in 2005 had diminished. Eggs would have hatched in response to rain events in late July, and the juveniles then died as they were unable to feed.

Just two CCN eggs per gram of soil can cause significant economic loss to intolerant cereal crops. Levels of 1-5 eggs per gram of soil can reduce yield of wheat and oat by up to 20 per cent.

If seasonal conditions in 2006 had allowed the planned over-sowing of the trials with intolerant cereal, significant yield loss could have been expected in the plots where high CCN levels occurred in response to the susceptible crop that had been sown in 2005.

WA/SA CCN comparative testing

Cereal cultivars developed in SA for resistance to CCN could be utilised in WA, where appropriate, for management of this nematode. Besides Doolup barley, no current WA cereal cultivars are resistant to CCN.

WA cereal breeders could utilise the SARDI screening service with confidence that results would be applicable to cultivars bred for WA.

KEY WORDS

nematode, cereal, management, rotation

ACKNOWLEDGMENTS

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Paper reviewed by: Bill MacLeod

Occurrence of Wheat Streak Mosaic Virus in the Western Australian grainbelt during the 2006 growing season

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KEY MESSAGES

- In August 2006, in the Merredin district, WSMV was detected at an incidence of > 95 per cent in a severely stunted wheat crop. In the same paddock annual ryegrass, barley grass, windmill grass and wild oats were also infected.
- A survey of wheat crops and trials throughout the grainbelt, found WSMV in wheat crops and trials at sites over a very wide area. Infected crops were located in all rainfall zones, and ranged from Esperance in the south to Dongara in the north.
- The distribution of WSMV-infected sites during 2006, with infection concentrated in eastern grainbelt districts that received considerable summer and autumn rains, indicates that a substantial 'green bridge' surviving up until sowing favoured higher infection incidences in subsequent wheat crops.
- Farmers sowing cereal crops in high risk situations during 2007 need to ensure early removal of 'green bridge' prior to sowing and that their crop is sown with seed that is unlikely to be infected.

AIM

To determine the occurrence of WSMV in the WA grainbelt by testing leaf samples from diverse locations from wheat crops and trials during the 2006 growing season.

BACKGROUND

Wheat streak mosaic virus (WSMV) is seed- and mite-borne and causes a disease that reduces the yield of wheat and damages grain quality. Wheat plants infected with the virus are severely stunted, and show pale streaking and mottling of leaves. The virus is spread from infected wheat plants to healthy ones by the wheat leaf curl mite (*Aceria tosichella*). It is also carried from one season to the next via infected wheat seed. WSMV occurs in most wheat growing regions of the world including North and South America, Europe, North Africa, and West, East and Southeast Asia. When conditions favour widespread infection early in the life of wheat crops, crop failure sometimes occurs. In the Great Plains region of North America, annual WSMV-induced yield losses are about 5 per cent overall, but localised outbreaks can be much more destructive, causing losses approaching 100 per cent.

The first definitive report of WSMV detection into Australia was in 2002 in wheat breeding facilities in Canberra. Soon afterwards it was detected at wheat breeding sites in SA, QLD, VIC and NSW. It also severely damaged a few irrigated wheat crops in NSW in 2003. In 2004, symptoms were noticed at low incidences in some high rainfall wheat crops in NSW, but it apparently caused little damage. In 2005, widespread WSMV infection, often associated with crop failure, occurred in high rainfall zone wheat in NSW with over 5,000 hectares severely affected. In 2006, the area badly affected in NSW increased to 20,000 hectares. In WA, between 2003 and summer 2006, more than 35,000 samples of wheat and grasses were collected in targeted surveillance, but WSMV was not detected. A different approach was then used in autumn 2006, when a survey of volunteer wheat collected 4,203 samples from 28 paddocks on 24 farms in 6 grainbelt districts. For the first time, WSMV was detected: The infected samples came from eight paddocks on three farms, one farm in the Kondinin district and two in the Esperance region. In a follow up survey in May, these initial detections at the three farms were confirmed. Additionally, WSMV was detected in self-sown wheat on two and four additional farms near Kondinin and Esperance respectively. Infection incidences within infected paddocks ranged from 1-8 per cent at Kondinin and 1-2 per cent at Esperance. No infection was detected in any grass samples collected. This article describes the results of a large-scale survey to determine the occurrence of WSMV in the grainbelt done in the growing season of 2006.

METHOD

The growing season survey started in late August and continued until early October. Sampling started with a severely WSMV-infected crop near Merredin. Potentially symptomatic and/or random samples were collected from wheat plantings. Random samples were collected from grass weeds in or near infected crops at some highly-infected sites. The survey included wheat trials and commercial wheat crops in most grainbelt districts, except in some south coastal and northern areas. In the growing season survey, at most sites a few potentially symptomatic plant samples were collected, at some sites there were also random samples (normally 100 leaves each), and, where no potentially symptomatic plants were found, only random samples were obtained. All leaf samples were tested in the laboratory by ELISA using antiserum specific for WSMV.

RESULTS

In August 2006 in the Merredin district, WSMV was detected at an incidence of > 95 per cent in a severely stunted wheat crop. This was the only paddock on the farm where the green bridge of volunteer cereals was not well controlled before sowing. In the same paddock annual ryegrass, barley grass, windmill grass and wild oats were also infected. The virus had also spread to wheat crops in neighbouring paddocks on the same farm and on two adjacent farms. WSMV incidences in neighbouring paddocks declined with increasing distance from the heavily-infected paddock. A range of wheat varieties were infected.

In the survey of wheat trials, WSMV was detected on 9/23 farms and in 13/44 trials with infection incidences of up to 7 per cent (4,016 samples tested). In the survey of commercial crops, 7,630 random samples were tested and infection was found on 19/27 (70 per cent) farms and in 27/75 (36 per cent) crops at infection incidences of up to 100 per cent. There were 465 potentially symptomatic samples from commercial crops and in these, WSMV was detected on 48/82 (58 per cent) farms and in 50/93 (54 per cent) crops. Many different wheat varieties were WSMV-infected. The virus was found at sites over a very wide area including all rainfall zones, and in districts ranging from Esperance and Katanning districts in the south to Dongara in the north. The distribution of WSMV-infected sites, showed that infection was concentrated particularly in eastern grainbelt districts that received substantial summer and autumn rains and had an extensive 'green bridge' in autumn before sowing.

CONCLUSIONS

WSMV was found in much of the grainbelt, including all rainfall zones. However, infected sites were concentrated particularly in the eastern grainbelt districts that received considerable summer and autumn rains. This distribution of WSMV-infected sites indicates that a substantial 'green bridge' before the growing season favoured high infection incidences in subsequent wheat crops. Examples particularly from the Merredin district indicated that, where this 'green bridge' was not adequately controlled, major crop loss could result. The virus was detected in alternative hosts consisting of volunteer wheat, barley, annual ryegrass, barley grass, windmill grass and wild oats. Seed-infected plants of wheat are likely to be the primary source of infection for subsequent spread by vector mites. Currently, destroying the 'green bridge' at least four weeks before sowing so that no grass plants are still surviving is the most effective means of limiting the impact of the disease. In addition, growers should not sow seed that has been saved from conspicuously infected crops and, in high risk situations. Growers in high risk situations should also consider delayed sowing to avoid seedlings emerging in warm autumn conditions that favour greater vector mite activity. A seed testing service for seed samples sent in by growers will be available from AGWEST Plant Laboratories from February 2007. This service will test a 1000 seed sample as a bulk by PCR and provide a positive or negative result for WSMV presence. Where a positive result is obtained, growers should consider sourcing healthy seed for sowing. Applying pesticides to kill the mite vector has not proven effective in the USA where WSMV has been endemic for more than 50 years. WSMV resistance genes can be used to breed WSMV-resistant wheat, but this breeding is in its infancy in Australia.

KEY WORDS

wheat, virus, disease, survey, incidence, prevalence, seed, losses, 'green bridge'

ACKNOWLEDGMENTS

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Paper reviewed by: Bill MacLeod

Development of a seed test for Wheat Streak Mosaic Virus in bulk samples of wheat

Geoffrey Dwyer, Belinda Welsh, Cuiping Wang and **Roger Jones**, Department of Agriculture and Food, Western Australia, South Perth

KEY MESSAGES

- Movement of WSMV through infected wheat seed is likely to have been the major route by which the virus has spread.
- A seed testing service for seed samples sent in by growers is now available from AGWEST Plant Laboratories.

BACKGROUND

Wheat streak mosaic virus (WSMV) was found for the first time in Australia at wheat breeding facilities in Canberra in 2002 and subsequently at wheat breeding sites in SA, QLD, VIC and NSW. In 2004, WSMV was discovered to be seed-borne in wheat seed, a finding that has significant implications for the movement of wheat seed nationally and internationally.

WSMV was detected for the first time in Western Australia at Esperance in the autumn of 2006. Further testing of wheat crops in spring of 2006 showed that WSMV was widely distributed across the wheat belt. The full extent of the distribution of the virus in WA and the varieties of wheat which are infected is yet to be determined.

AIMS

The aim of this research was to develop a robust diagnostic test for detecting WSMV in bulk samples of wheat seed.

METHOD

Seed from a range of different wheat varieties with and without WSMV infection were obtained from various sources at DAFWA. Seeds for positive controls came from a heavily WSMV infected crop of the wheat variety Wedgetail, sourced through NSW DPI. WSMV-infected leaf tissue was provided by Brenda Coutts, Plant Pathology, DAFWA.

Statistical models to provide an indication of the expected limits of detection of the WSMV test were generated separately by DAFWA biometricians, Mario D'Antuono and Jane Speijers. These were based on published batch testing formulae and a novel model to illustrate the sampling procedure.

Extraction of viral RNA from seed was done using several commercial kits and published methods (e.g. phenol-chloroform, Qiagen columns, Trizol, etc.). RT-PCR reagents, positive and negative controls and thermal cycling parameters were empirically optimised to achieve best results.

Sequence analysis

The coat protein gene of 14 new WSMV isolates were sequenced. The isolates were obtained from infected leaves and seed collected from various sources in WA and the Eastern States. Sequence analysis was done using standard methods. Finished sequences were submitted to the Genbank database.

RESULTS

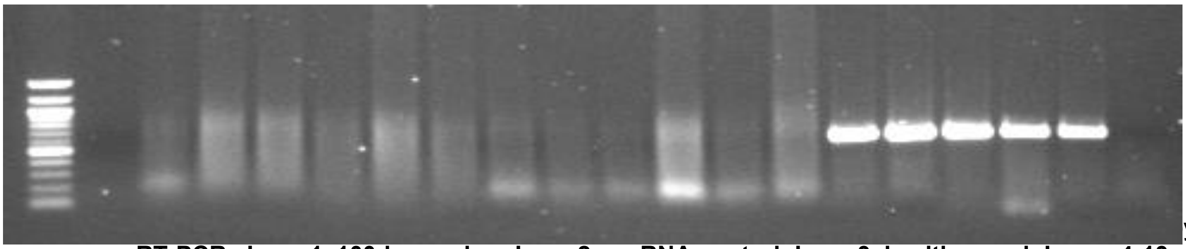
Statistical parameters

Simulation and batch testing statistical models generated very similar statistical outputs. The actual level of WSMV contamination in wheat seed is unknown. Assuming a 'true rate' of one contaminated seed in 1000 healthy seeds, three replicates of 1000 seeds would need to be tested to achieve a

probability value of ≥ 95 per cent, 4 replicates for ≥ 98 per cent and 5 replicates for ≥ 99 per cent. This would equate to a bulk seed test with a level of detection of at least one infected seed in 3000 healthy seeds (95 per cent), 1:4000 (98 per cent) and 1:5000 (99 per cent).

RNA extraction and RT-PCR

Most RNA extraction methods examined produced RNA. However, RNA quality and presence of substances that co-purify with the RNA proved to be inhibitory to the RT-PCR. Initial work examined a standard acid phenol:chloroform:isoamyl alcohol extraction method, commonly used to extract viral RNA from leaf tissue and less often from seed. This method was effective for extracting viral RNA from small amounts of seed flour (≤ 100 mg) but was not suitable for larger amounts due to RT-PCR inhibitors. A similar result was encountered when using a range of commercial column and non-column based RNA extraction kits.



y RT-PCR. Lane 1, 100-bp marker; Lane 2, no RNA control; Lane 3, healthy seed; Lanes 4-13, undiluted infected seed extracts Lane 14, positive control; Lanes 15-19, five-fold dilutions of RNA extracts in lanes 4-8.

Serial dilutions of the RNA extract showed that the inhibitor(s) could often be diluted to a level that allowed the RT-PCR to work (Figure 1). However, because the level of dilution required for individual extracts varied, it was not a considered a reliable method. A combination of two commercial kits was found to provide a method suitable for extracting RNA of satisfactory quality for RT-PCR. This method utilises a proprietary RNA extraction solution to lyse cells and the lysate is then put through a spin column to purify RNA prior to elution. Inhibitor molecules are still co-purified with the RNA but at concentrations which are sufficiently low that they are not normally inhibitory to the RT-PCR.

Sequences analysis

The coat protein gene of 14 WSMV isolates was sequenced to determine the relationship of WSMV isolates and if more than one incursion into WA had occurred. The results clearly show that all isolates (including an additional eight previously sequenced Australian isolates on Genbank) share very high sequence identity (> 99.3 per cent) demonstrating that there has probably only been a single incursion into Australia.

CONCLUSION

A diagnostic test for detecting WSMV in bulk samples of wheat seed has been developed. The test is highly specific for WSMV and currently has a sensitivity of detection of one infected seed in 1000. The current test is labour intensive and expensive to conduct, however, further modification of the test in 2007 will enable the sensitivity increase to 1:5000, a level required to achieve statistical confidence of 99 per cent.

The coat protein sequences of WSMV isolates in Australia are greater than 99 per cent identical, which clearly points to a single introduction. Movement of WSMV through contaminated wheat seed is likely to have been the major route by which the virus has been disseminated so widely.

A seed testing service for seed samples sent in by growers is now available from AGWEST Plant Laboratories. The test only determines whether or not a harvested crop has been exposed to the WSMV disease and does not test directly for seed transmission. Where a positive result is obtained, growers should consider replacing seed with seed that is free of WSMV. The results from seed testing in 2007 will add significantly to our knowledge of the distribution of WSMV in the WA wheat belt.

KEY WORDS

Wheat Streak Mosaic Virus, seed test, diagnostics, RT-PCR

ACKNOWLEDGMENTS

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Project No.: DAWA00141 'Developing a sensitive dry seed test to detect seed-borne viruses in bulk seed samples of wheat'

Paper reviewed by: Bill MacLeod, Mark Holland, Shashi Sharma

Developing the Australian barley value chain

Linda Price, Barley Australia

KEY MESSAGES

- Australia's barley industry has undergone a transformation in the past two years including the formation of national bodies and national alliances for the generic promotion of Australian barley in breeding new varieties and in researching quality.
- The Australian barley industry has responded to increasing international competitive marketing pressures through a national focus on quality which has resulted in the release of a suite of improved malting barley varieties.
- Quality of malting barley is of increasing importance as competition increases in international markets and the Australian industry is improving its position with the latest suite of barley varieties bred in Australia.
- Maintaining the integrity of product coming through the supply chain is of paramount importance and Barley Australia is working towards a national quality brand (much like a Woolmark® for wool) to fulfil emerging customer needs and support the marketing of the national barley crop, as well as Australian processed malt.

QUALITY BARLEY FOR AUSTRALIA AND THE WORLD

The Australian barley industry has undergone a transformation over the past 24 months with the development of various national barley industry bodies to deliver whole of industry outcomes in respect of promotion and development of new barley varieties which possess superior quality and agronomic traits. One of these bodies is Barley Australia, established in February 2005 out of the former Malting Barley Development Council (MBDC), as decided by the then-MBDC members to take the goals of the council and facilitate them through a new company – Barley Australia (BA) which would be resourced to execute these goals.

Barley Australia is a truly national body comprising seven founding members representing the industry in all the major barley growing States in Australia – QLD and NSW-based grain marketer GrainCorp, Victorian maltsters International Malting Company Australia and Barrett Burston; South Australian and Victorian marketer ABB Grain and maltster Joe White Maltings, WA-based maltsters Kirin Australia and the WA coarse grains marketer Grain Pool.

Among Barley Australia's goals is the task of nationally coordinating the way Australian barley is approved, branded and promoted to international and domestic markets.

Another body, Barley Breeding Australia, is the industry's nationally coordinated barley breeding program. It was created in mid 2006 by GRDC and the owners of the State-based barley breeding programs to create a single nationally focussed breeding program that would be able to create efficiencies and synergies in the use of limited breeding investment funds. Barley breeding now operates as a single national breeding program (Barley Breeding Australia) with integration of the national germplasm pool and three collaborative breeding nodes at Warwick, Adelaide and Perth. Supporting germplasm development, regional evaluation, and disease and quality screening programs operate at Toowoomba, Wagga Wagga, Horsham and Launceston.

Barley Breeding Australia's objective is to meet the needs of growers and end users (malt, feed and food) through world best practice in cereal breeding. Improving the quality reputation of Australian barley and malt is increasingly important in the competitive global grain marketing environment. The instigation of the national barley breeding program, the development of a Barley Australia-created national variety accreditation program and the introduction of a national product quality trademark will stand to improve the recognition and customer confidence in the purchasing of an Australian accredited malting variety that meets a specific quality standard.

Varietal accreditation

The process of varietal accreditation has been established to highlight, and to articulate to the marketplace the formal evaluation process through which all new varieties must pass before they can supersede existing varieties. It means that new varieties can be more easily launched into the market place as there is industry-reviewed performance data of the variety. If the customer is purchasing a variety of barley for the first time it makes the task easier with formal information on the variety available for review.

BA works closely with Barley Breeding Australia to ensure that only elite new varieties with superior qualities (agronomic and processing) enter the accreditation process. As an organisation representing the interests of maltsters and marketers BA is able to ensure that only varieties that possess a sensible balance between agronomic performance and processing performance enter the accreditation pathway.

The national accreditation system defines the performance parameters of a variety in the malt house and brew house. The Malting and Brewing Industry Barley Technical Committee (MBIBTC) is the body that determines the protocols by which testing for suitability to be a malting barley variety is carried out; it evaluates varieties on a commercial malt scale, and ensures that these are consistent with international testing methodology benchmarks. The variety is then pilot brewed at the GRDC/industry co-funded Pilot Brewing Australia facility located in Abbotsford, Melbourne. Pilot Brewing Australia analysis allows the MBIBTC to analyse the lines of malt under a range of brewing processes which simulate brewing styles in countries to which Australia is selling product.

Other important factors are overlaid on varietal accreditation such as determining if and where marketers will establish malting segregations, whether a domestic market exists, and agronomic performance of a variety relative to other cropping alternatives. In this context the regional advisory councils (Northern, Southern, South East and Western Barley Councils) play an important role and complement the evaluation undertaken by the three barley breeding nodes in Barley Breeding Australia.

After the evaluation of malting and brewing capability, BA provides formal endorsement of MBIBTC evaluation results for the international market. BA also collates quality information from commercial scale malting trials and pilot brewing trials together with agronomic information to provide a national data base and consistent pre-competitive promotional information resource, variety by variety.

It is important to note here that varietal accreditation provides a brand to be used **in conjunction with** the individual marketing or malting company's own branding. BA **does not market any barley** but does help improve all commercial industry stakeholders' status in the eyes of their own individual customers, and in the international marketing arena.

Going forward, new varieties will be released with a *Barley Australia Variety Accredited*™ stamp to demonstrate to end users and producers that the variety is equal to, or better than, existing varieties from an agronomic and/or processing perspective. In the future, BA will have the capability to accredit barley varieties for a range of end uses working in conjunction with the relevant commercial sectors' evaluation methodologies to determine the varieties' suitability to that particular end use – be it feed, food or pharmaceutical.

Trade-marking

A quality trademark or brand is a key strategy to protect the reputation of our industry. The introduction of a trademark for Australian barley is the next progression from delivering Variety Accredited barley and malt to the world. BA is now at an advanced stage in developing a national trademark for the barley industry to provide customers confidence that the product they are receiving conforms with (internationally congruent) national standards in respect to varieties which have been developed, tested and released, as well as a product that has arrived in their factory from an auditable, traceable supply chain.

The BA *Assured Quality* trademark will ultimately operate at two levels and at the higher level will encompass the quality assurance of the grain from varietal integrity and performance, farm production processing and delivery through to the end-user.

A trademark which incorporates a series of HACCP compliant QA systems will satisfy emerging market needs in respect of traceability and identity preservation. Although delivery of a whole-chain, HACCP-compliant quality assured system is still some distance away for our industry, in the first instance the trademark will relate to the QA programs utilised by all other businesses in the supply chain post farm gate. It will also pertain to the marketing of malting barley varieties which are accredited by Barley Australia.

While the BA *Assured Quality* trademark is owned by BA it is envisaged that it can be licensed to other grain exporters who are not members of BA, and such an arrangement will be beneficial for the industry ensuring a minimum quality standard for exported product.

The importance of the BA *Assured Quality* trademark is driven by a number of factors. Key Asian malt markets will not only continue to expand but will become more sophisticated and demanding in quality preferences and requirements. This is already evident in Japan where at least one major Brewer, Sapporo, has given a public commitment to its beer customers that it will be able to trace the malt content back to the farm. Competitors in the malt industry have seen the development of UK Assured Malt which has delivered significant inroads into these markets in the past two years. In addition industry consolidation could realistically see the major European and/or US brewers expand operations in Asia and insist on greater regulatory standards with respect to QA and traceability. It is important that the Australian industry take heed of these developments and respond accordingly.

Communication and information

Besides variety accreditation and trade mark development, a further role of BA is in the area of communication and industry information. BA provides the structure and resources to access the intellectual capital residing in major barley marketing and malting companies and it ensures that barley breeders receive the best market intelligence on the ever evolving and changing quality preferences of end-users. BA also facilitates an annual forum for the purpose of information exchange between the breeding and research sectors and the commercial market sectors which is positively viewed by industry.

BA is a contact point or ‘front door’ for the Australian industry and is increasingly seen to be so by recognition from international equivalent organisations such as the Canadian Malt Barley Technical Committee and the Canadian Wheat Board.

R&D project management

There are two GRDC funded projects for which BA provides administration; one the Pilot Brewing Australia project and the second the ‘Understanding market requirements’ project. BA is the logical place to house the administration services for these projects as they are for whole-of-industry pre-commercial benefit.

CONCLUSION

The industry map for the Australian barley industry has undergone substantive change which has resulted in stronger and more efficient linkages between all sectors of the supply chain, through breeders, farmers, seed commercialisation agents, grain marketers, maltsters, brewers on a domestic basis as well as important links to the export market through Barley Australia Ltd. Built into the structure is the capacity to evaluate barley on a national basis, inform customers of new Australian varieties in the marketplace and inform growers of new varieties the market desires. Equally, the structure ensures feedback to inform breeders of trait requirements from the marketplace to allow development of varieties for the future.

BA sits in an ideal position within the barley industry to inform other stakeholders in the supply chain on market requirements and create strategies on a national basis to ensure these are met and that Australian barley remains competitive with, and preferred over, product from other sources.

It is apparent that the demand from customers and countries to ‘backing up’ quality with internationally-recognised QA protocols is steadily increasing. It is a process driven by both governments and business, and ultimately by consumers in those countries. For the majority of

markets the ability to provide a quality assured supply chain which enables traceability back to the farm level will not mean opportunity to secure increased prices for product – but simply an opportunity to buy a 'ticket to the game'.

The future for the Australian barley industry is about future access to markets **not market premiums**. This will be a difficult and unpalatable message for many primary producers but it is one already faced by marketers and maltsters. It is a message that BA will be vigorously pursuing in the future.

KEY WORDS

Barley Australia, Barley Breeding Australia, varietal accreditation, trademark, national body, research, breeding

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