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Crop Updates 2004 - Cereals

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2004 CEREALS

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Compiled and edited by Renaye Horne

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ACKNOWLEDGEMENTS

The Agribusiness Crop Updates is a world class event and its contribution to Australian Agriculture is invaluable. Behind every great event, there is a fantastic team and I would like to acknowledge this year's team to ensure they receive the recognition they deserve:

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RE Horne

Renaye Horne
CEREALS CONVENOR

Declining profitability in continuous cropping systems. Is more wheat the answer on Duplex soil?

Dr Wal Anderson, Department of Agriculture; Albany

It is assumed that this discussion is taking place for the following scenario:

- Duplex soils in the medium to low rainfall cropping zones.
- The pasture seed bank is at very low levels as a result of poor seasons and frequency of cropping.
- Field peas grow well on this soil type, but have not been widely adopted.
- Fungicides are applied to wheat.
- Both liquid and solid N fertilisers are applied.
- Monitoring of pests, weeds and diseases is rigorously practised.
- Growers are more confident than previously of seasonal forecasts.
- Lupins are grown on an opportunistic basis depending on their price relativity with wheat.

It is further assumed that the reported trend towards a greater number of wheat crops in the cropping sequence is driven by the need to maintain cash flow, at least in the short to medium term, and that this trend will continue until the system proves uneconomic. The current price and yield relativities that favour wheat are clearly driving this apparent trend towards a flexible cropping sequence on this soil type, rather than a fixed crop rotation system. However, there is a need to examine the possible pitfalls of such a system and to offer some suggestions about how to manage it to minimise the risks in the longer term.

POSSIBLE PITFALLS

1. *Variable N response on duplex soils*
   Experiments over several years have shown that although average grain yield responses to N fertilisers on duplex soils are often greater than on other soils, the reliability of obtaining an economic response has been less. This is reflected in the probability of obtaining a grain protein percentage in wheat grown after legumes in the range acceptable for noodles - 80% on duplex soils compared to 100% on sandplain soils. This probability drops to 60% compared to 85% when the wheat was grown after non-legume. The relatively less reliable yield responses to applied N on the duplex soils can be related to poorer uptake efficiency (Table 1) which implies that the economics of N application to second and subsequent wheat crops will not compare favourably with other soil types. Table 1 details net N uptake efficiency and utilisation efficiency in experiments on duplex compared to 'other' soils [data from 15 sites in WA].

Table 1. Efficiency of nitrogen uptake by wheat in experiments on duplex and other soils

	Uptake efficiency (kg N/kg N applied)	Utilisation efficiency (kg grain/kg N uptake)
Duplex soils	**0.35**	21
'Other' soils	**0.62**	21

Source: Anderson *et al*. (1992) AJEA 32, 963.

2. *Transient waterlogging*
   The poor uptake efficiency of many duplex soils is possibly related in turn to transient waterlogging. Most duplex soils have a bleached sand or a gravel layer overlying the clay subsoil. This is often associated with transient waterlogging, even in dry seasons and in low rainfall areas. The impact of waterlogging at depth can be to destroy roots and impair nutrient uptake (Table 2). It may also cause leaching of soluble nutrients out of the rootzone. Although transient waterlogging may not affect wheat more than other crops or pastures it suggests that solutions other than simply changing the crop sequence may be appropriate.

Table 2. Nitrogen taken up (kg/ha) by the wheat crop on duplex and 'other' soils under transient waterlogged and well drained conditions

N uptake (kg N/ha)	Duplex soils			'Other' soils	
	Cunderdin			Northam	Wongan Hills
	1986	1987	1988	1986	1987
Waterlogged	**52**		**56**		
Well drained		**80**		**71**	**79**

Source: Anderson *et al*. AJEA 32, 963.

3. *Potassium deficiency*
   It is now quite widely recognised that K deficiency can be the cause of reduced wheat yields in these soils (Table 3). Most non-cereals are more susceptible to K deficiency than wheat, but if K is not added to legumes in a K-responsive situation reduced N fixation can result, with negative implications for the following wheat crop.

Table 3. Grain yield responses of wheat to applied N and K at Nyabing in 1990 [initial soil test, 0-10 cm - 57 mg/kg P, 34 mg/kg K, pH 4.6, OC 0.9%. 1 t/ha lime applied as basal]

Fertiliser treatment (kg/ha)	Grain yield (t/ha)
Nil	**2.27**
40 N	**1.49**
60 K	**2.93**
40 N + 60 K	**3.59**

Source: Anderson *et al*. (1992) AJEA 32, 963.

4. *Organic carbon is often low*
   Soils in the wheat belt that are cropped frequently often have organic carbon contents below 1%. The ratio of carbon to nitrogen can be changed in favour of carbon in soils where a large proportion of the crop residues that are returned to the soil is cereal stubble. This will have the effect of reducing the power of the organic matter to supply nitrogen to the crop and will increase the amount of N that is required from fertiliser. In the longer term reduced organic matter in the soil will reduce the ability of the soil to hold and provide plant nutrients (Table 4).

Table 4. Selected chemical properties of duplex and red-brown earth soils at Merredin (0-5 cm depth)

Soil	pH (Ca Cl_2)	Organic carbon (%)	C:N ratio	Cation exchange capacity (me/100 g)
Duplex	4.9	0.64	**223**	2
Red-brown earth	6.2	0.88	**22**	7

Source: The Wheat Book (1991).

5. *Root diseases*
   A higher frequency of cereal crops will imply a greater chance of building up root disease organisms such as Take-All and Crown Rot. So far there are no effective treatments for these diseases except through rotation with non-susceptible or 'break' crops such as pulses, grain and pasture legumes and canola. Since the widespread use of no till systems the crowns of cereal plants do not decompose as quickly as in cultivated systems. This provides the opportunity for the organism that causes crown rot to build-up. Root diseases reduce grain quality as well as grain yield. Any budget for an extra wheat crop should include a discounted yield and quality factor.

6. *Weed management*
   A higher frequency of wheat in the system may favour grass weeds (e.g. brome grass, wild oats). This is not inevitable but will depend on the species present and the choices of chemicals used. Grass weeds not controlled before the wheat crop is sown will reduce both yield and protein.

POSSIBLE REMEDIES

1. *Better N management*
   Placement of N fertiliser in a band in the soil below and to the side of the seed row has long been known to improve uptake efficiency. It may also be possible to detect waterlogging at depth (using dipwells) and apply N fertilisers (solid or liquid) to overcome losses due to this cause.

   There is a better return to N applied to early-sown crops than to late sown crops - don't waste your N fertiliser investment on late sown crops (Table 5).

Table 5. Grain yield response to applied N fertiliser related to sowing time [data from 15 experiments in the central wheat belt]

Sowing month	N rate (kg/ha)		Agronomic efficiency (kg grain/unit of applied N)*
	0	40	
May	1.92	2.46	**13.5**
June	1.74	1.88	**3.3**

* Economic breakeven for N application is about 5:1. Source: W. Anderson, unpublished.

2. *Soil test*
   If the value of monitoring pests, weeds and diseases can be justified, the same logic should be more widely applied to soil testing for K and P in particular. Testing for pH and K in the subsoil can pay dividends. Testing for organic carbon and total N in the soil may also be used to assist in N management (see Nitrogen Calculator).

3. *Occasional cultivation doesn't hurt, even for passionate no-tillers*
   This will assist breakdown of crop residues and have an effect on reducing soil compaction. Deep cultivation or ripping and gypsum application may also be applicable in some cases. Cultivation on an 'as needs' basis is not incompatible with no till or tramline practices and can assist in maintaining a viable system.

4. *Green/brown manure can pull you out of a mess in some circumstances*
   There is strong evidence that the occasional green manure crop can reduce seed set of resistant weeds, increase soil water infiltration and the yield and/or protein of the subsequent wheat crop, even in duplex soils (Table 6).

Table 6. Impact of field peas and oats as green mulch on soil properties, wheat yield and gross margin at Gnowangerup

Treatment	2001			2002		
	Ryegrass (% of total biomass)	Nitrate + ammonium - N (mg/kg)	Organic carbon (%)	Grain yield (t/ha)	Grain protein (%)	Gross margin over 2 years ($/ha)
Peas - harvested	15	19.0	0.86	1.36	11.8	255
Peas mulched	15	27.7	0.88	2.42	12.3	416
Oats mulched	2	34.7	1.00	2.42	11.0	417

Source: F. Hoyle, unpublished.

5. *Manage differently for higher yields*
There does not appear to be any reason why duplex soils should deliver lower yields than 'better' soils. The pathway to higher yields however, appears to be more dependent on early sowing and higher seed rates than on sandplain and clay loam soils where responses to improved varieties and N fertilisers play a greater role in yield improvement (Table 7).

Table 7. Grain yields and yield increases due to management practices on duplex and 'other' soils [data are from 3 sites on each soil group]

Treatment	Yield (t/ha)	
	Duplex	**Other**
Package yield	3.60	3.22
Control yield	2.54	2.13
Management	**Yield increase (t/ha)**	
Early Sowing (ES)	**0.41**	**-**
ES + high-yielding variety (HYV)	0.17	**0.39**
ES + HYV + 40N	0.15	**0.56**
ES + HYV + 40N + high seed rate	**0.33**	0.14

Source: Anderson *et al*. (1992) AJEA 32, 963.

6. *Address soil constraints, regardless of crop sequence*
Many duplex soils have constraints such as acidity, poor drainage, soil compaction, and non wetting. Some of these will likely be exacerbated by continuous cropping and by a narrow range of crops in the sequence. The problem of poor or declining productivity of these soils can be addressed by considering some or all of the following amelioration treatments; liming, deep ripping and gypsum, claying, tramline farming, green manuring or raised beds (e.g. Table 8).

Table 8. Grain yield of wheat (t/ha) on two soil types in 1999, two years after deep ripping and gypsum application at two sites in the central wheat belt

	Merredin - red-brown earth	**Tammin - duplex**
Control	3.15	3.40
Gypsum (2.5 t/ha)	**3.69**	**3.93**
Deep ripping (40 cm)	3.01	3.52
Deep ripping + gypsum	**3.95**	**4.10**
LSD (5%)	0.43	0.29

Source: Hamza and Anderson (2003) AJAR 54, 273.

7. *Match quality type to soil type*
The probability of obtaining the quality appropriate to various grades of wheat is affected by the soil type as well as the rotation. For example the probability of obtaining the protein level that draws a bonus for the Noodle grade is greater on sandplain soils, then duplex soils and lower on heavier soils. Similarly the probability of obtaining protein appropriate to the Australian Hard grade is greater on the heavy soils and sandplain than on duplexes (Table 9). The data in Table 9 are for wheat after legumes and illustrate that lower protein grades such as Noodles and APW are probably more appropriate on duplex soils, regardless of the rotation.

Table 9. Success rate (%) of achieving Noodle and A. Hard grades of wheat in experiments on various soil types following grain or pasture legumes*

Soil type	Noodle experiments 1994-1997	Hard wheat experiments 1993-1995
	Protein 9.5-11.5%	**Protein > 11.5%**
Clay loams	50	85
Duplex soils	80	50
Sandplain soils	100	90

* Source: Anderson, unpublished data 1997; Kerr, unpublished data 1996.

8. *Consider the yield penalty of choosing a resistant variety*
   Most highly disease resistant varieties do not have the yield potential of susceptible varieties (Table 10). The cost of fungicide application and the probability of attack by the disease(s) for which each variety is susceptible should be taken into account when planning a strategy for an extra year of wheat.

Table 10. Mean yields in variety experiments of wheat varieties in Agzones 2 and 3 according to their level of disease resistance* [diseases considered were: *Septoria nodorum*, *S. tritici*, Yellow spot, leaf rust, stem rust and stripe rust, varieties in bold are suggested for both Agzones]

	Resistant[1]	**Moderately resistant[2]**	**Susceptible[3]**
Varieties	Clearfield Janz Perenjori Castle rock **Datatine**	**EGA Jitarning** **Calingiri** **Carnamah** **Wyalkatchem**	**Arrino** EGA Bonnie Rock Westonia Tincurrin
Mean yield (t/ha) Agzone 2 Agzone 3 Mean	 2.29 2.97 2.63	 2.49 3.19 2.84	 2.46 3.13 2.80
Loss of yield (Moderately resistant + Susceptible/2) - Resistant = 0.19 t/ha.			

1. Rated 4 or more for all leaf diseases.
2. Only one leaf disease rated less than score 4.
3. Rated < 4 for more than one leaf disease.

* Source: Crop Variety Sowing Guide 2004.

9. *If all else fails, try field peas*
   New, semi-leafless types may overcome some of the objections to growing field peas, the rotation benefits can be significant (yield and protein) and many of the problems discussed above can be avoided.

KEY WORDS

wheat, rotation, duplex soil

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Disease implications of extending the wheat phase in low-medium rainfall areas

Dr Vivian Vanstone and **Dr Robert Loughman**, Department of Agriculture; South Perth

KEY MESSAGES

- Stubble management and seasonal rainfall will be chief factors in determining risk from leaf disease. Foliar fungicide sprays can be used to offset increased leaf disease threat under a high spring seasonal rainfall scenario.
- Greatest risk comes from root disease, particularly nematodes, where inoculum build up may not be recognised and risk management options are limited.
- Leaf disease risks usually revert to low levels after a one-year break. The risks of root disease may persist into subsequent phases.
- Monitor crop performance and disease levels in current as well as future crops.

INTRODUCTION

Seasonal variability demands that grain growers capture opportunities in grain production by tactically varying cropping phases optimised to 'average seasonal conditions'. In 2003, the need for the WA grains industry to rebound strongly after extreme drought in 2002 resulted in many paddocks being re-cropped to wheat, thus capturing residual fertiliser in circumstances of low disease carryover. One of the main limiting factors to growing wheat on wheat is the carry-over or build-up of disease. If sowing wheat on wheat, disease management in the current and subsequent seasons needs to be carefully considered and the risk of yield loss assessed. If it worked in 2003, can it be made to work in 2004?

LEAF DISEASES

While leaf disease may arise from air-borne spores from neighbouring areas, wheat following wheat always represents a higher disease risk compared to wheat in rotation. The proximity of the young crop to stubble-borne inoculum from pathogens can result in the establishment of early yellow spot and septoria in crops, providing a disease base capable of rapid development in spring. This risk is greatest on high biomass stubbles, likely to have carried disease in the previous year. Destroying stubble, where soil types permit, will reduce disease risk.

A major factor in determining risk is growing season spring rainfall. Leaf moisture availability (as rainfall, extended dews and high humidity) will determine whether disease progresses rapidly prior to grain fill, thus impacting on yield. This risk is comparatively low in low rainfall areas or years of low rainfall. In medium rainfall areas the risk is manageable (with fungicides if necessary) except in years of exceptional rainfall. The risk is less acceptable in high rainfall areas.

Knowledge of the disease status of the previous crop will assist in assessing this risk. Previous crops with a burden of yellow spot or septoria nodorum blotch can carry more infestation through the stubble phase than crops that carried healthy foliage late into the previous season.

Keep paddock reports, photographic and crop diagnostic records and refer back to information relevant from the past season. Consider this in paddock selection and avoid using varieties that are most susceptible to yellow spot and septoria diseases when extending a wheat phase.

If leaf disease does establish early there may be a need to spray a broad spectrum foliar fungicide at early to late stem elongation. A follow up spray after 3-4 weeks could be required if the spring is suitably wet.

ROOT DISEASES

An extended wheat phase defers the most important basis for managing cereal root disease, *crop rotation*, which is the over-riding influence on inoculum levels in the soil. Apart from fungicide treatments at seeding for take-all (a rare disease in low-medium rainfall areas), chemical control is not an option for fungal root diseases and nematode parasites. In low-medium rainfall areas, root lesion nematodes (RLN) (*Pratylenchus* spp.) are more likely to influence outcomes than fungal root diseases. A survey of cropping soils of WA (Riley and Kelly 2002) indicated that *Pratylenchus* occurs throughout the field cropping areas of WA and that inappropriate rotations will result in population build up and

eventual yield loss in intolerant crops. These diseases can affect the current crop **and also subsequent crops** when disease levels in the soil increase substantially.

Prioritise root disease management issues according to the perceived risk of yield loss from each identified disease. Ways to assess risk include:

- Paddock history, performance and observations from previous seasons. Assays of the diseases present and their levels (e.g. AGWEST Plant Laboratories) can be reconciled with paddock knowledge and records. Was the crop uniform, did it yield well, was it checked for root disease? It is also strongly advisable for growers and agronomists to become familiar with the above-ground and below-ground symptoms of different root diseases. Where nematodes are suspected, identify to species.
- Determine identity and levels of disease-causing organisms in the soil. Predictive soil assays are available as a guide (e.g. PreDicta-B from Bayer CropScience) including common (but not all) species of RLNs. Test results must be interpreted in concert with local knowledge of seasonal and paddock conditions, including crop performance in previous seasons. Adherence to recommended sampling methods for any test is critical for valid results.
- Root disease risks can vary with each paddock. As management options for different diseases can vary, prioritisation of diseases (and paddocks) may be necessary.

Managing risk from root disease in low-medium rainfall areas

If sowing wheat on wheat, it is possible to devise management strategies to reduce potential yield loss. Sow early but with at least a six week fallow break for control of weeds and volunteers. Ensure adequate nutrition of major and trace elements. With a known history of take-all use an appropriate fungicide at seeding (e.g. Jockey, Impact in-furrow). For *Pratylenchus* spp., some tolerant wheat cultivars are available, although these may still suffer yield reduction if disease levels at sowing are high. For some diseases (e.g. take-all), all wheat cultivars are susceptible. Cultivate deep, sow shallow to diminsh risk from rhizoctonia bare patch. Do not grow durum after wheat (crown rot). If Fusarium (crown rot) is present consider options to destroy infected residues.

The majority of management issues represent sound cropping practices, regardless of disease (e.g. timely sowing, control of weeds and volunteers, adequate nutrition). If any of the root diseases are present at moderate-high levels, sow a good rotation break crop (i.e. non or poor-host). It is also critical to consider the impact on subsequent crops if disease levels increase. Poor or non-host crops will reduce RLN levels, but this may take several seasons if these levels become high. Continued monitoring of crop performance and disease levels is crucial.

Soils suppressive to take-all or rhizoctonia bare patch have been known to develop after cropping with cereals for at least 4 years (usually longer). Yields are likely to suffer before suppression develops.

CONCLUSIONS

Stubble management and seasonal rainfall will be chief factors in determining risk from leaf disease in an extended wheat phase. Fungicide sprays provide a means of managing risk of yield loss if diseases threaten crops. The future consequences of an extended wheat crop on leaf diseases are minimal as leaf disease risks usually revert to low levels after a one-year break.

In contrast, previous cropping sequence will be the chief factor in determining risk from root diseases. Determining the risk of root diseases and monitoring paddock outcomes, together with good agronomic management, will help to minimise risks. However the consequences of root disease management failure have the potential to persist into subsequent crop phases.

KEY WORDS

pathogen, nematode, fungicide, risk

REFERENCES

Riley, I.T. and Kelly, S.J. (2002). 'Endoparasitic nematodes in cropping soils of Western Australia', *Australian Journal of Experimental Agriculture*, vol. 42, no. 1, pp. 49-56.

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Paper reviewed by: David Bowran

Prolonged wheat phases on duplex soils - where do weeds set the boundary?

Vanessa Stewart, Department of Agriculture; Merredin

The success of continuous wheat phases is dependent on many factors, good weed management being just one of them. The aim of this paper is to outline the threat weeds pose to prolonged wheat phases on duplex soils and to define some critical weed management factors that must be achieved in order for these rotations to succeed.

KEY WEED THREATS

In defining key weed threats for continuous wheat it is important to:

1. identify the likely problem species;
2. define the resistance status of those weed species; and
3. understand why weeds are important to the success of a continuous wheat phase.

Key weed species

Given the scenario of extending the traditional length of the cereal phase in rotations on duplex soils what are the key weed species likely to present problems?

The usual suspects come immediately to mind - wild radish and annual ryegrass. In addition to these species silver grass, capeweed, barley grass, brome grass and doublegees are weeds that will cause problems on duplex soils. Summer weeds are also an important consideration.

Herbicide resistance

Of concern to prolonged wheat phases are the levels of resistance in the key weed species, annual ryegrass and wild radish in terms of both distribution and to different modes of action (MOA) (Table 1).

Going back for another year of wheat limits the range of weed management tools and herbicides that can be used. In paddocks where resistance has been detected at low levels (resistance test results indicate - developing resistance) continued use of that herbicide MOA is likely to see the susceptibility removed from the population.

Too often our focus is just on resistance in wild radish and annual ryegrass. Farmers in the Western Australian wheatbelt should be paying particular attention to the risk of developing resistance in grass weeds - barley grass, brome grass and wild oats. Each of these grass weeds has a restricted range of available selective post-emergent herbicide options for use in wheat.

Table 1. Known resistances in Australian annual ryegrass and wild radish populations

Weed species	Herbicide group	Example herbicide
Annual ryegrass	A - 'fops'	e.g. diclofop
	A - 'dims' e.g. sethoxydim	e.g. sethoxydim
	B - sulphonyl ureas	e.g. chlorsulfuron
	B - imidazolinones	e.g. imazapic, imazapyr
	C - triazines	e.g. simazine, atrazine
	D - dinitroanilines	e.g. trifluralin
	M - glycines	e.g. glyphosate
	K - amides*	e.g. metolachlor*
	E - thiocarbamates*	e.g. triallate*
Wild radish	B - sulfonyl ureas	e.g. chlorsulfuron
	B - sulfonamides	e.g. metosulam
	B - imidazolinones	e.g. imazapic, imazapyr
	C - triazines	e.g. simazine, atrazine
	F - nicotinanalides	e.g. diflufenican
	I - Phenoxys	e.g. 2,4-D

* The resistance to these herbicides has been identified in populations of ryegrass that have multiple resistance.

Knockdown resistance

The current state of play in WA is that we now have four confirmed populations of glyphosate resistant annual ryegrass (Hashem, pers. comm. 2003). Two of these populations are from broadacre cropping environments. Across Australia more than 50 glyphosate resistant annual ryegrass populations have been confirmed.

In addition to this there is confirmed resistance to paraquat/diquat in populations of barley grass, silvergrass and capeweed in other Australian States. While there has not been any populations of annual ryegrass identified as resistant to paraquat in Australia, there is a population with this resistance in South Africa.

If people persist with growing continuous wheat on duplex soils, establishing crops with one knockdown application and minimal soil disturbance they are setting themselves up for resistance to the knockdown herbicides, particularly in scenarios where they also have resistance to post-emergent selective herbicides.

Importance of weeds in prolonged wheat phases

Weeds have the ability to significantly reduce wheat yields through competition for light, nutrients, water and space. Weed competition can influence wheat (protein) and contaminate harvested grain.

Competition and quality

Research by Sally Peltzer, Department of Agriculture found that the greater the weed competition, either in number and size, the greater the loss in grain protein. A ryegrass:wheat dry matter ratio of 1:2 was sufficient to decrease both grain yield and grain protein. Grain yield was more sensitive than grain protein to the presence of weeds; a ryegrass:wheat dry matter ratio of 1:4 decreased yield but had no effect of grain protein (Peltzer and Bowran, 1996).

Research conducted on wild radish in wheat lupin rotations found that the presence of 10-75 radish plants/m^2 at the reproductive stage of crops could reduce wheat yield by 7-56% (Hashem *et al*. 2001). In addition it was also found that radish increased the level of wheat screenings.

Disease host

Grass weeds are acknowledged as important hosts for a number of wheat diseases including take all, rhizoctonia and crown rot.

CRITICAL WEED MANAGEMENT FACTORS FOR SUCCESS OF PROLONGED WEED MANAGEMENT PHASES

Summer weed control

Summer weeds must be controlled to ensure success of an extra year of wheat. Given that many weeds will be crop volunteers their control is essential to remove the pest and disease green bridge.

Early control of summer weeds also minimises crop establishment delays due to vines entangling seeding equipment and cloddy seedbeds and allows time for the breakdown of allelotoxins produced by weed species such as goosefoot.

Know your potential problem - weed density

Planning for this season's crop should have started last year. Paddock inspections (and harvest) will have left you with a reasonable idea of weeds in paddocks last year and the amount of seed set.

Equally important, but harder to assess is an estimation of the residual weed seedbank from previous seasons in the soil. The net result of weed management efforts in the season just finished may have left few weeds in the paddock. Yet those weeds that germinated and were subsequently controlled will have represented only a proportion of the existing seedbank. It is important to bear in mind the 'hangover' effect of previous weed management failures.

Know your problem weed - weed biology/emergence pattern

The seed biology and emergence pattern of different weed species varies considerably. Understanding seed bank life (how many years can it remain viable), emergence pattern (i.e. staggered or majority early) and response to cultural management (e.g. tillage and nutrient placement) provides the opportunity to manipulate these traits to the advantage of good weed control.

Know your potential problem - herbicide resistance

Testing for herbicide resistance so you know which herbicide options you have available before you go back for another year of wheat will also improve you weed management. There is little benefit in discovering after the fact that your post emergent herbicides won't control the weeds. These in crop weeds have the potential to drastically reduce yields.

Conversely assuming that you have herbicide resistance without testing can mean that you rule out extremely cost-effective weed management tools for no good reason.

Control weeds early

Early emerging weeds are more competitive, produce more seed and that seed in the case of radish tends to be more dormant.

In addition to this leaving weeds until later emergences occur may mean that the weeds are large enough to survive herbicide application. The impact of later germinating weeds will be minimised by the fact that the crop should have a competitive advantage over them.

Management of blow outs

Small areas where weed control methods have failed cannot be ignored. They have the potential to set vast numbers of seed, potentially resistant.

Farmers who have been managing highly resistant ryegrass populations report that adopting a policy of wiping out 'blowout' areas by cutting hay or brown manuring has kept paddocks in production.

Integrated weed management

The ability to keep growing wheat will be dependent on the incorporation of as many different weed management tools as possible into the weed management strategy. This will reduce the selection pressure for herbicide resistance and also provide backup management strategies to limit the number of in-crop weeds and control survivors of herbicide treatments.

There are a range of weed management tools that can be used in wheat, these include healthy crops, burning, autumn tickle, delayed sowing, high crop seeding rate, seed carts and agronomic manipulation.

To effectively use herbicide and non-herbicide weed management tools you should:

- be aware of the effectiveness of each tool in its own right;
- be aware of the limitations of each different tool as well as their non-weed benefits;
- appreciate how different tools can 'fit' together in an IWM system and how they can complement other aspects of farm management.

When selecting weed control tools to use make sure that options are selected that target the weeds at all stages of the life cycle. This includes:

1. aiming to deplete weed seed reserves;
2. managing young weeds (through control and competitive manipulation);
3. preventing viable seed set;
4. preventing fresh viable seed inputs to the seed bank.

Ensuring competitive crops (or good crop agronomy)

Don't lose the race before it has started! In order to maximise the competitive ability of wheat crops (and for that matter all other crops) it is essential that they are healthy. This means get the agronomy right!

Crops need to be sown at the correct depth, attention paid to avoiding herbicide damage and insects need to be controlled. Failure to address these issues can result in reduced competitive ability of the crop and therefore an environment that favours weeds.

Crop establishment practice

There are many different methods of crop establishment. Some utilise cultivation while others aim for minimal soil disturbance. Each system will have some advantages for weed management.

Cultivation itself can be effective at killing germinated weeds while at the same time it buries weed seed. Minimal disturbance systems leave many of the weed seeds on the soil surface.

Don't add to the problem

Use clean seed no need to plant the problem.

Monitor your paddocks/keep records

Make sure you know what weeds are issues in your crop this year - after all you may want to grow wheat again next year (and you should know what your potential weed problems are going into any phase of a rotation).

Keeping records of your weed management actions for each paddock will help ensure that you keep varying the things that you do and help identify what works under certain conditions. In particular keeping track of herbicides used and the mode of action (MOA) groups that they belonged to will help remind you of the need to consider using herbicides from the full range of MOA available.

CONCLUSION

It is possible to continue growing wheat if you understand the nature of your weed problems and you adequately manage your weed populations.

The success of continuous wheat will be depend on your ability to prevent seed being added to the seedbank and preventing seed germinating as in-crop weeds. This will be especially important where you have high levels of herbicide resistance. Use of weed management strategies like seed collection/destruction at harvest, judicious burning and manipulation of the seedbank to encourage germination (and control) prior to crop establishment will become increasingly essential for successful continuous wheat.

The weed management critical success factors have been developed from the perspective of increasing the length of the wheat phase once you are already in it. There are additional factors that can increase your ability to have prolonged wheat phases if the rotation is planned in advance. They all rely on good planning and good weed control in the years leading into the commencement of a prolonged wheat phase.

To avoid weeds being the factor that prevents you successfully prolonging a wheat phase it is important to follow the Professor Stephen Powles' adage of 'when on a good thing **don't** stick to it'.

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Paper reviewed by: Peter Newman

NB: There is an extended version of this paper on the Crop Update 2004 CD.

Management of small grain screenings in wheat

Dr Wal Anderson and **Dr Darshan Sharma**, Department of Agriculture; Albany and Northam

BACKGROUND

Many of the factors influencing the production of small grains in wheat crops can be managed so that the risks of downgrading and loss of income can be reduced. The following is a summary of recent and earlier research findings in Western Australia.

KEY MESSAGES

- Use less nitrogen (N) for sowings after early June where soil N supply is likely to be higher (good legume rotation, clay soils). Reduce N and seed rates if sowing susceptible varieties after early June
- Choose more tolerant varieties (e.g. Wyalkatchem, Carnamah, Calingiri). Short season varieties are not immune to high screenings. Varieties differ in their sensitivity to management factors such as N rate, sowing time and seed rate.
- Use a soil and/or a tissue test to diagnose and correct nutrient deficiencies. Problems can be especially severe in relation to screenings on sands and after canola.
- Manage for minimum root diseases (break crops and grass weed control) and leaf diseases (resistant varieties, fungicides).
- Match variety to sowing time and avoid cropping valley floors to reduce frost risk.

AIM

To provide guidelines for managing the risk of small grain screenings in wheat in Western Australia. [Data on which the guidelines are based will be presented in the oral concurrent session.]

METHOD

Available research data have been summarised and the more robust information used to suggest practical management guidelines.

RESULTS

Many experiments have shown that increasing N fertiliser rates can be associated with high levels of screenings. This is probably worst in crops that have extremely good early growth, receive extra N fertiliser before the end of tillering, and then suffer water stress during grain filling. Varieties do differ in their susceptibility with the club head soft wheats being worst and varieties like Carnamah being least susceptible at high N rates.

Potassium deficiency, especially when normal N rates are applied, can result in severe screenings problems. Soil tests for potassium (K) are relatively reliable and both top (0-10 cm) and subsoil (at visible change of colour or texture) samples should be tested. Often it will pay to substitute some K fertiliser for N without spending any more in total.

High plant populations (seed rates) are not usually associated with increased screenings ***unless*** used in combination with one or more risk factors such as late sowing (water stress during grain filling), K deficiency, high N rates or susceptible varieties.

Sowing after early June has often been associated with higher screenings, especially when longer season varieties are used. However, if late rains provide adequate moisture for grain filling, or if stress early in the season is relieved towards flowering, screenings are less likely, even for late sowing.

Research in the northern area of the grain belt has found that screenings were worse on sandy compared to loamy soils and that crops following canola were worse than those following lupins. These findings were probably associated with poorer nutrition on the sands and after canola.

Varieties do differ in their inherent grain size and shape, and in the distribution of grains across the tillers and within the ears, and hence in their susceptibility to screenings. They also differ in their tendency to produce small grains in response to management factors so that a variety may produce screenings in one paddock but not in another. The most recent data are summarised below.

Sensitivity group	Cultivar	Management factor
Highly sensitive	Harrismith	All
Sensitive	H45	N rate
Moderately tolerant	Brookton	N rate
	Westonia	Time of sowing, plant population
Tolerant	Wyalkatchem	All
	Carnamah	Time of sowing, N rate
	Calingiri	N rate

It should be emphasised that variety sensitivities to management are second order factors as causes of small grain screenings in wheat.

It can be safely concluded that controlling root and leaf diseases will maintain average grain size and reduce small grain screenings.

Preliminary data from the south coast show that more screenings are likely in crops sown on wider rows than on the conventional spacing of 180 mm (7 inches) – see data of M. Amjad elsewhere in the Updates Proceedings.

CONCLUSION

Fertiliser and seed rates, sowing times, rotations (including weed control), fungicide applications and choice of variety can be managed by growers to reduce the risks of downgrading and improve the profitability of wheat crops in Western Australia.

KEY WORDS

Screenings, small grain, sievings, wheat

ACKNOWLEDGMENTS

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Project No.: Various

Paper reviewed by: Brenda Shackley, Narelle Hill

Agronomic responses of new wheat varieties

Christine Zaicou-Kunesch, Dr Darshan Sharma, Brenda Shackley, Dr Mohammad Amjad, Dr Wal Anderson and **Steve Penny**, Department of Agriculture; Geraldton, Northam, Katanning, Esperance, Albany and Merredin

KEY MESSAGES

Wyalkatchem was a consistently good performer across the State, however there are a number of potential new varieties which growers might adopt in the future. Varieties and lines discussed include GBA Shenton, GBA Ruby, GBA Sapphire, EGA Castle Rock, EGA Jitarning, EGA 2248, WAWHT 2525A and WAWHT 2499.

AIMS

Growers recognise that there are appropriate management conditions required for any wheat variety to obtain optimal performance. The impact of sowing time, optimum nitrogen and seed rates will have a big impact on the yield and quality of a variety. Access to this information close to the time of release will improve the performance and adoption of superior varieties. This paper aims to provide a guide for the management of current and newly released varieties from Western Australia and elsewhere.

METHOD

Field based agronomy trials were located on eight locations across the state from Mullewa and Mingenew in the north to Salmon Gums and Gibson on the south-coast. (NB: Please refer to additional papers in this publication for trial details.) For current information on disease ratings, please refer to the papers in this publication on Flag smut resistance in major WA varieties (John Majewski and Manisha Shankar) and an update on Rust resistance for wheat varieties in WA (Manisha Shankar, John Majewski and Jamie Piotrowski).

RESULTS

Time of sowing

At all locations except Mingenew and Gibson, maximum yield of all varieties was achieved in the later half of May. This was the first sowing opportunity at Nungarin, Quairading, Katanning, Nyabing and Salmon Gums. At Mingenew, maximum yield occurred in early May, which was the first sowing opportunity. However at Gibson (on the south coast) and Mullewa (in the north) yields with the first sowing time (28 May and 9 May respectively) were significantly less than for the second time of sowing (13 June and 26 June respectively). At these two locations, conditions at seeding were marginal. Establishment on the red loam at Mullewa was reduced by about 15% to 111 plants/m^2. The lack of summer rain and low rainfall throughout the season had a big impact on grain quality (Table 1). Grain protein averaged about 16**%** and screening levels in the trials exceeded 10% for many of the varieties.

Table 1. Annual rainfall (mm), rainfall in the growing season and decile rating at the trial sites in 2003

Site	Annual rain	Decile	Total (May-Oct.)	Decile (May-Oct.)
Mullewa	297	4	209	3
Mingenew	405	5	345	6
Nungarin	356	8	238	8
Salmon Gums	519	10	342	Highest
EDRS	609	10	449	10
Quairading	351	5	234	3
Nyabing	451	8	311	6
Katanning	416	3	332	4

Soft wheats (AS)

The new soft wheat EGA 2248 performed exceptionally well in the Great Southern at Katanning and Nyabing. It outyielded Datatine and EGA Jitarning at each time of sowing in 2003 (Figure 1). EGA2248 is the earliest maturing soft wheat variety, slightly later than Westonia. It yielded exceptionally well being suited to the major sowing opportunities. It does not, replace EGA Jitarning, which is suited to early sowing opportunities and longer season environments; it is complimentary rather. Both EGA2248 and EGA Jitarning have less small grain screenings than Datatine but EGA2248 may have a problem with high protein levels (Shackley 2004).

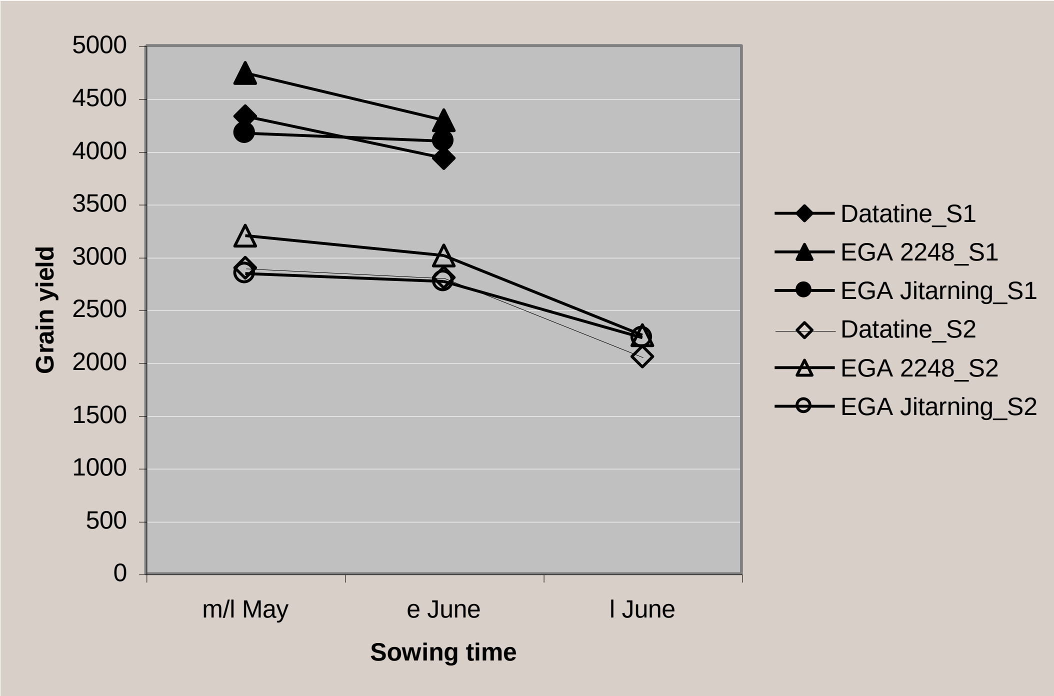

Figure 1. Effect of time of sowing on grain yield (kg/ha) of soft wheat varieties at Nyabing (S1) and Katanning (S2). [LSD (var. TOS) at Nyabing = 340 and LSD (var. TOS) at Katanning = 312].

Hard wheats (AH)

WAWHT2525A has Sunelg/Blade parentage and is a potential AH variety. The 'A' in its name denotes that this is an awnless variety. It has metribuzin tolerance that is useful for controlling weeds such as Brome grass (Dhammu 2004). It performed reasonably well in the north with mid May sowings, but did not perform exceptionally well in other regions in 2003 (Figure 2). Protein levels for WAWHT2525A were 1.5 to 2% better than the majority of other varieties with similar yields. The optimum plant density tended to be at the higher end of the scale, similar to Calingiri and Carnamah at 121 plants/m^2 (Table 2).

EGA Castle Rock did not perform exceptionally well throughout the state. It is a Cascades type wheat with triple rust resistance. May sowings were shown to be best for this variety (Figure 2). Growers who currently include Cascades in their seeding program may want to consider this variety in 2005 when the seed is available. However, EGA Castle Rock leaf disease resistance and Black Point resistance were not quite as good as for Cascades at Mingenew. The optimum plant population for EGA Castle Rock tended to be between Wylkatchem and Carnamah at 99 plants/m^2 (Table 2).

Yitpi, a recently classified AH wheat variety, performed well in the southern districts but not at other locations in 2004. In addition its leaf disease resistances are not quite as good as for other hard wheat varieties.

WAWHT2499, a potential AH wheat, is a shorter season variety and with an early June sowing was the second ranked AH variety at Mullewa. Across the state it preformed reasonably well with a June sowing but its Black Point (fungal staining) levels do not make it a choice for growers in the high

rainfall areas (Figure 2). It is only suggested for Agzones 4, 5 and 2. It is expected to have slightly better stripe rust resistance than EGA Bonnie Rock. The optimum plant population for WAWHT 2249 tended to be similar to Wylkatchem at 94 plants/m^2. The optimum plant population for EGA Castle Rock tended to be between Wylkatchem and Carnamah at 99 plants/m^2 (Table 2).

Australian premium white (APW)

Across most agronomy trials, Wyalkatchem was the highest yielding APW variety with May and early June sowings. Westonia also performed very well with June sowings. However there are a number of other varieties that have potential in WA.

GBA Shenton with triple rust resistance is provisionally an APW. It reached 50% anthesis within the timing of EGA Bonnie Rock and Carnamah. It yielded reasonably well with late May sowings in the north and mid June plantings in the south coast.

GBA Ruby is also provisionally an APW and was quite a tall variety in some trials, but has good straw strength. It did not perform as well as Wyalkatchem however it has triple rust resistance which might be useful.

GBA Sapphire is a longer season variety with APW classification (pending 2003 data) that struggled in the central region to be among the top varieties. In contrast, on the south coast and great southern this variety performed exceptionally well with a late May and early June sowing. Limited seed supplies resulted in the exclusion of this variety from agronomy trials in the northern agricultural region. Similar to GBA Shenton, GBA Sapphire has triple rust resistance that would be useful in the southern districts.

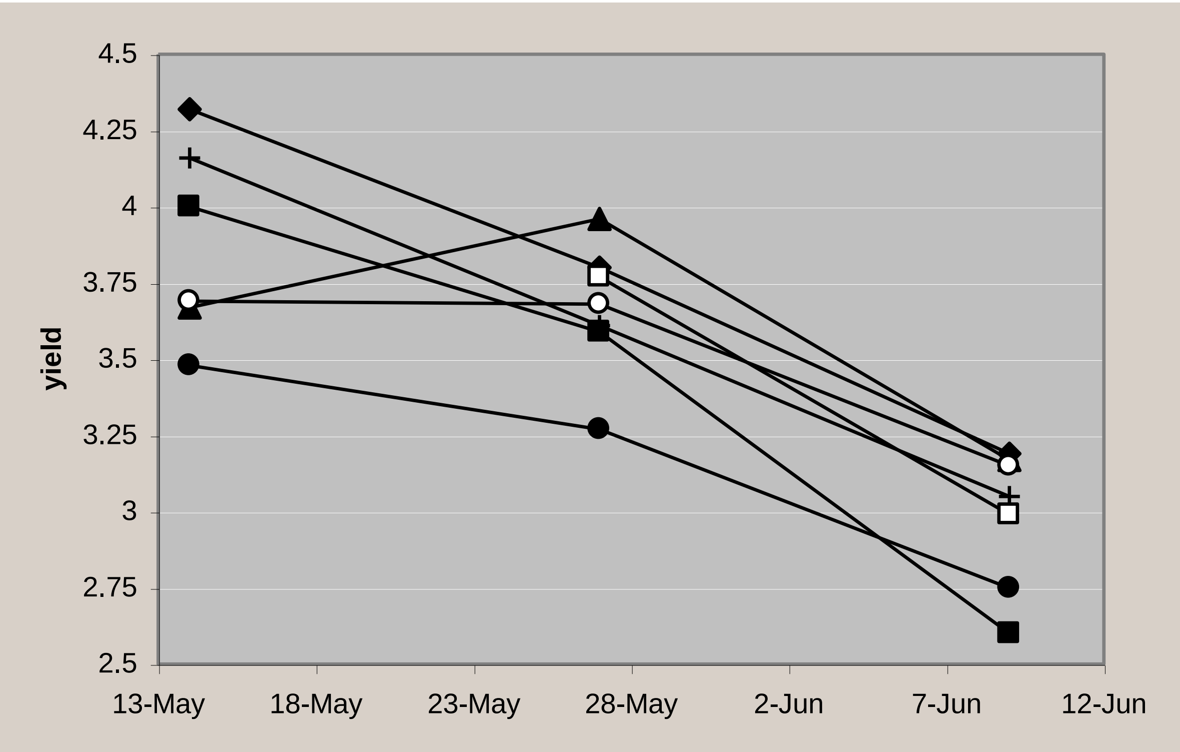

Figure 2. Effect of time of sowing on grain yield (t/ha) of Australian Hard wheat varieties at Mingenew. [LSD (var. TOS) = 0.30] (O: WAWHT2499; □: Yitpi; ■ : Cascades; ◆: Carnamah; ▲ EGA Bonnie Rock; +: WAWHT2525A; ●: EGA Castle Rock).

Noodle wheats

The noodle wheat Calingiri was sown across all sites. Similar to previous seasons, it had a restricted range of sowing within May. In the north, Calingiri outyielded Arrino across all times of sowing at Mingenew, and met protein standards for noodles. In the low rainfall of Mullewa, Arrino outperformed Calingiri by over 300 kg/ha with an early June sowing, however protein levels exceeded 17%. A

similar result occurred at Nungarin in the central region. High protein levels due to the clay loam soil type and legume rotation caused down grading although both noodle varieties performed equally up to mid June at both sites in 2003.

Table 2. Average optimum plant density (minimum number of plants necessary to avoid making plant population a limiting factor) and seed rate of six wheat varieties. (Data are an average of trials at Salmon Gums, Mingenew and Katanning where the average grain yield exceeded 2.7 t/ha.)

Variety	Optimum plant density (plants/m^2)	Seed rate (kg/ha)
Calingiri	115	56
Carnamah	106	48
EGA Castle Rock	99	47
WAWHT2499	94	48
WAWHT2525A	121	56
Wyalkatchem	91	46

KEY WORDS

wheat, varieties, agronomy, yield

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Paper reviewed by: Dr Wal Anderson

Managing wheat yield reduction from wide rows

Dr Mohammad Amjad and **Dr Wal Anderson**, Department of Agriculture;
Esperance and Albany

KEY MESSAGES

Wide row spacing (360 mm) in wheat is often associated with lower grain yield, and higher small grain screenings, particularly in drier years. These problems can be managed by adopting the following six wide row agronomy options:

1. Select slow maturing, longer season wheat varieties.
2. Maintain the target plant population density at 150 plants/m^2.
3. Increase nitrogen (N) rate for greater grain yield for long season wheat.
4. Early sowing (May) improves yield and weed competition in wide rows.
5. Deep place both N and phosphorus (P) fertiliser away from seed.
6. Increase the lateral spread of seed within the rows to 50 to 75 mm on wide rows that will improve yield and retain benefits of wide rows for stubble management.

AIMS

The first aim of this work was to establish the effect of row spacing on optimum seeding rate (plant population density) for some of the newer wheat cultivars of different maturities (early, medium and late) when grown in the south east of Western Australia.

The second aim was to test the hypothesis that increasing the lateral seed row width (wider seed spread within the row) will improve yield particularly at wider row spacing compared to normal row width as conventionally used at wider row spacings.

METHOD

Three experiments were conducted in 2000, 2001 and 2002 on an alkaline, grey sandy duplex soil (Mallee soil) at Salmon Gums (Latitude 32°58'S, Longitude 121°38'E). In 2000, 3 cultivars (Camm - long season, Cascades - mid season and Westonia - short season), 5 plant populations (50, 100, 150, 200 and 250 plants/m^2) and 2 N rates (23 kg N/ha and 46 kg N/ha) were completely randomised within the main plots of 3 row spacings (180 mm, 240 mm and 360 mm). In 2001, similar experiments were repeated but sown twice, 4 weeks apart with 3 target plant populations (100, 150, 200 plants/m^2). In 2002, row spacing effects were further investigated by varying the row width (seed lateral spread) from the conventional 25 mm to 50 mm and 75 mm and using 6 fertiliser placement methods.

RESULTS

The seasonal rainfall varied widely over the three years. 2000 was an average year for annual rainfall but the growing season rainfall (May to October) was less than 50% of the long-term average (204 mm) at Salmon Gums. There was 324 mm of summer rainfall in that year. 2002 was the driest year with annual rainfall of 198 mm and growing season rainfall of 78 mm. Only 2001 had rainfall close to the average of 346 mm annual rainfall and 167 mm seasonal rainfall for the Mallee environment.

Crop establishment and weed competition

The effect of row spacing (RS) on plant establishment was significant in all three experiments. In 2000, there were more plants in the narrow row spacing of 180 mm compared to wider row spacings of 240 mm and 360 but the differences were significant only at populations of 150, 200 and 250 plants/m^2. Treatment differences for weed competitions were also observed in 2000. The highest biomass of ryegrass (the major weed species present) was found at the wide row spacing of 360 mm. Cultivars also competed differently with weeds (data not shown). The dry weed biomass was significantly lower in Camm (5.48 g/m^2) compared to Cascades (8.44 g/m^2) and Westonia (9.90 g/m^2).

Grain yield

Average grain yields were 1.49 t/ha, 2.47 t/ha and 1.0 t/ha in 2000, 2001 and 2002 respectively. Narrow row spacing of 180 mm consistently produced higher yield compared to the wide row spacing

of 360 mm in 2000 and 2001. There was no difference in grain yield between narrow and wider row spacing when row width was increased from 25 mm to 75 mm in 2002 but there was an interaction between row spacing, variety and N rate. The yield decline in wider rows was greater (up to 15%) for cv Westonia and cv Cascades than cv Camm (up to 9%). The response of cv Camm at wider row spacings can be partially explained by its higher green leaf area and dry matter production as measured in 2000 (data not shown). This may also help to explain the observed advantage for cv Camm in competing with weeds at all row spacings.

Grain protein, screenings and seed size

Increasing the row spacing from 180 mm to 360 mm increased the grain protein from 10.8% to 11.1% and small grain screenings from 8.5% to 10.5% respectively in 2000 at Salmon Gums. In 2001, there was no effect of row spacing on both grain protein and screenings. At 360 mm row spacing, the protein was decreased by 1.0% and the screenings were increased by 6% with increasing the row width from 25 mm to 75 mm. In the dry year of 2002, grain protein and small grain screenings were generally high. It was also found in this study that the wider row spacing generally changed grain size distribution with more small grain (< 2.0 mm) and less large grain (> 2.6 mm) in harvest grain samples.

CONCLUSION

Our results indicate that the narrow row spacing (180 mm) consistently resulted in higher yield, lower protein and lower small grain screenings over three years at Salmon Gums. There were no negative interactions observed with 180 mm row spacing with cultivars, sowing rate, N rate, sowing date, fertiliser placement or row width.

If the lower impact of wide rows on the long season variety Camm also applies to other long season varieties, this can be used to reduce the negative impact on grain yield.

As demonstrated in this research, the yield reduction at wide row spacing (360 mm) could also be managed by increasing the row width (spread) up to 75 mm. Presumably a greater spread of seed within the row would also assist competition of the wheat crop with weeds.

Farmers may have to carefully consider both pros and cons of wider row spacing in their farming environment. There is a range of issues related to placement of seed and fertiliser, weed competition, herbicide resistance, soil disturbance, cost of machinery components, yield penalties, ease of operations, timeliness and saving in operational labor and fuel energy on wide row spacing. Yield reduction in cereals is highly likely at wide row spacings at the row width of 25 mm (conventional row width for current no till seeding). The possible factors causing yield reduction at wider row spacing in drier environments might be high concentration of seed and fertiliser in a narrow band in the soil (physical problem), causing fertiliser toxicity (chemical problem) and resulting in reduced plant germination (establishment problem) reduced competition with weeds (biological problem) and ultimately result in more small grain screenings and yield reduction (economical problem).

New technological developments in farming systems including ribbon seeding, paired rows (with shielded spray for inter row weeds), skip rows, separate placement of fertiliser from seed, variable rate control, controlled traffic, claying, liming, deep ripping, liquid fertiliser and herbicide application, may also help to improve operational efficiency and reduce costs at wider row spacings. Our three years of investigations on wide rows provide agronomic management options that could be adopted both in existing and new farming systems for improving grain yield and quality on wide rows.

KEY WORDS

row spacing, row width, cultivar, seeding rate

ACKNOWLEDGMENTS

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Paper reviewed by: Glen Riethmuller

Row spacing and stubble effect on wheat yield and ryegrass seed set

Glen Riethmuller, Department of Agriculture; Merredin

KEY MESSAGES

- Over five years of no-till, retaining stubble averaged 10% higher wheat yields than burning.
- Wheat yield reduced around 0.4% for every centimetre row spacing increased from 18 cm, with or without stubble.
- In 2003, around five times more ryegrass seed was produced from retaining stubble compared to burning but the wheat yielded 20% better with stubble retained.
- About twice as much ryegrass seed was produced with 27 cm row spacing than all other spacings with stubble retained.

AIMS

To assess the effect of wheat row spacing and stubble retention on the wheat yield and on ryegrass seed set.

METHOD

This trial is a continuing experiment at the Merredin Research Station that was setup in 1987 by Steve Porritt to look at stubble and row spacing interactions in wheat. Each year the same treatment is applied to the same plot. Treatments are burnt and stubble retained, with row spacings of 9, 18, 27 and 36 cm with six replications and a plot width of 5 m. The soil is a red-brown sandy clay loam (salmon gum, gimlet). The experiment was initially sown with all tines kept on the six row combine seeder and just the seed tubes changed but in 1995 it was changed to a no-till system where non-sowing tines were removed and 40 mm wide points used. Stubble was cut to 20 cm long at harvest each year to allow stubble handling. A pulse rotation was also started in 1992. In 2003, this effectively gave five wheat years with full cultivation and 5 wheat years under no-till.

In 2003 the experiment was sown to Wyalkatchem wheat at 100 kg/ha (pickled with Real®) on 4 June with 80 kg/ha of Agras No. 1 banded 3 cm below the seed and 1.0 L/ha trifluralin. The 9 cm spacing was sown in two passes and levelled with a Phoenix rotary harrow. All other spacings had 76 mm wide press wheels and a chain with a ring behind. Ryegrass was noticed to be increasing so a Rytec seed collection system was used on the KEW plot header, which allowed ryegrass seed yield to be measured. Crop lifters were used at 23 cm spacing to improve the ryegrass capture and the header front height was controlled with a hydraulic cylinder stop.

RESULTS

The stubble had little effect on the average wheat yield in the full cultivation years but increased the yield by an average of 10% with the no-till system (Table 1).

The average wheat yield reduced with increasing row spacing in both tillage systems (Table 1.). The interesting aspect is the yield loss was around 1% for every inch (2.5 cm) that the row spacing increased from 18 cm (7 inches) with or without stubble. Burning stubble in the no-till system showed an average of 10% less yield than stubble retained. This shows the benefit of stubble retention in a no-till system and the highest yields were obtained from the narrow rows with stubble retention in a no-till system on this site.

The ryegrass samples were collected from the header and cleaned to get the weight and number of seeds. The ryegrass numbers were much higher with stubble retained than burnt and was much worse with the 27 cm row spacing (Table 2). Some ryegrass was seen above the crop in all plots.

Burning is known to reduce ryegrass numbers, however the 27 cm row spacing results are interesting. The plots were examined after harvest and very little ryegrass stems were found so the collection efficiency of the header was assumed to be the same for each row spacing. The 27 cm spacing plots did appear to have most of the ryegrass growing within a 15 cm band width across the row. The 36 cm row spacing plots had a similar appearance within the row but there appeared to be less ryegrass between the rows. Perhaps the trifluralin was more effective within the 36 cm rows than the 27 cm spacings. Also the 27 cm appeared to have a larger mound of soil between the rows than the

other spacings, even more than the 36 cm spacing. Perhaps the ryegrass in the stubble retained 27 cm rows caused the slightly more than expected yield reduction in that spacing.

Table 1. Average wheat yield (t/ha) with stubble, row spacing and tillage system

Treatments	Yield (full cultivation) '88, '89, '90, '91, '93	% Yield loss of 18 cm stubble (full cultivation)	Yield (no-till) '95, '97, '98, '01, '03	% Yield loss of 18 cm stubble (no-till)
Stubble burnt				
1. 9 cm rows	2.06	-1.6	2.71	7.3
2. 18 cm rows	1.99	1.9	2.61	10.7
3. 27 cm rows	1.99	1.9	2.54	13.4
4. 36 cm rows	1.92	5.4	2.37	19.1
Burnt mean	1.99	1.9	2.56	12.7
Stubble retained				
5. 9 cm rows	2.02	0.4	2.93	0.0
6. 18 cm rows	2.03	0.0	2.93	0.0
7. 27 cm rows	1.90	6.5	2.74	6.4
8. 36 cm rows	1.89	6.8	2.70	7.7
Stubble mean	1.96	3.4	2.82	3.6

Table 2. Collected ryegrass seed and wheat yield with row spacing and stubble in 2003

Treatments	Seed number/m^2	Percentage of 18 cm stubble	Wyalkatchem yield (t/ha)	Percentage of 18 cm stubble
Stubble burnt				
1. 9 cm rows	36	19	2.98	82
2. 18 cm rows	58	31	3.01	82
3. 27 cm rows	80	42	2.86	78
4. 36 cm rows	60	32	2.76	76
Burnt mean	59	31	2.90	79
Stubble retained				
5. 9 cm rows	213	113	3.54	97
6. 18 cm rows	189	100	3.65	100
7. 27 cm rows	451	239	3.34	92
8. 36 cm rows	239	126	3.34	92
Stubble mean	273	144	3.47	95
LSD (P < 0.05) Stubble, F pr	61	< 0.001	0.0933	< 0.001
LSD (P < 0.05) Spacing, F pr	86	0.005	0.132	< 0.001
LSD (P < 0.05) Stub x Spac,F pr	122	0.038	n.s.	0.646
C. of V. (%)	62.7		5.0	

CONCLUSIONS

Retaining stubble averaged 10% higher wheat yields than burning with no-till over five years. Wheat yield reduced around 0.4% for every centimetre row spacing increased from 18 cm, with or without stubble. This is about a 1% reduction for every inch row spacing is increased from 7 inches. Retaining stubble produced around fives times more ryegrass than burning. About twice as much ryegrass seed was produced with 27 cm row spacing with stubble retained than all other spacings. It is planned to sow barley in 2004 and ryegrass may again be collected at harvest.

KEY WORDS

wheat, stubble, row spacing, ryegrass

ACKNOWLEDGMENTS

The author would like to thank Kevin Boyd and the staff at the Merredin Research Station for their patience in looking after this experiment over the years.

Project No.: Grains Soil Management

Paper reviewed by: Dr Mohammad Amjad

Grain protein management - lessons learnt on the south coast

Jeremy Lemon, Department of Agriculture; Esperance

KEY MESSAGES

Potential yield is the largest determinant of nitrogen fertiliser rates to manage grain protein. PYCAL® and the Nitrogen Calculator can be used to estimate nitrogen requirements as the season progresses. Additional nitrogen can be applied to a crop up to the boot stage under favourable seasonal conditions to manage grain protein. The nitrogen model SYN needs further evaluation in the South Coast environment before it can be used as a decision tool for protein managment.

AIMS

This GRDC funded project is a joint effort between the South East Premium Wheatgrowers Association, Department of Agriculture and local grower groups in the Esperance port zone. Declining wheat protein levels in the port zone has prompted grower interest in more active management of grain protein. The project aims to idenitify current local nitrogen management practices, test nitrogen decision support tools, evaluate nitrogen fertiliser management strategies and develop farmer confidence in using these tools to manage grain protein levels in the face of uncertain seasonal conditions.

METHOD

Three core sites were established with grower groups, representing the main environments in the area. An additional 13 farmer demonstration sites were established to support these main sites. The demonstrations also provided a good range of investigations that the farmers in each area considered priorites. All sites were sown by cooperating farmers. There are limitations to the number of plots that can be sown and the detail of investigation, but the involvement of farmers in the sites ensures interest and confidence in the results.

Sites were characterised by soil profile analysis and daily rainfall recording. The results of yield and protein were compared to the decision tools PYCAL, the Nitrogen Calculator and Select Your Nitrogen.

RESULTS

In 2003 the Esperance area received well above average (decile 9) rainfall for the growing season with many centres recording decile 9 rainfall in summer/autumn as well. Ravensthorpe experienced average rainfall which allowed results to be compared in different seasonal conditions. Additional nitrogen increased protein at all sites, while yields were also increased at less fertile sites, which generated greater returns than just protein increases.

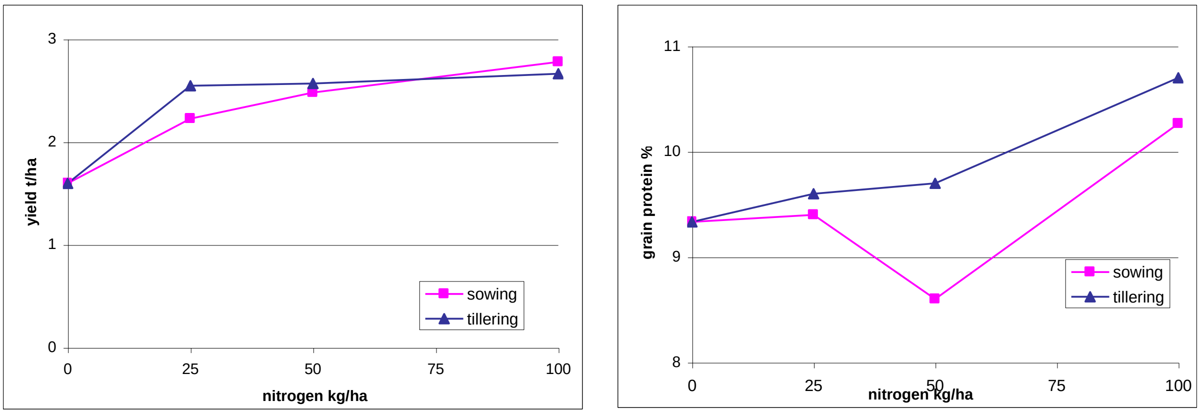

Figure 1. Yield and protein responses to sowing and late tillering applications of nitrogen as Calcium Ammonium Nitrate at West River 2003.

The experimental results presented in Figure 1 show typical results from the 2003 set of trials for a responsive site with readily visible differences seen in spring. In this experiment, nitrogen applied at tillering appears to be more effective than at sowing. The site had high soil moisture at sowing but seasonal rainfall was average without any large events to cause leaching. Other sites also showed effective application of late nitrogen.

As seen in Table 1, higher protein was generally achieved in the field than Select Your Nitrogen (SYN) simulations, up to 3.5% better. In most cases, SYN yields are lower than actuals even at unrealistic potential yields in the model. There is higher nitrogen uptake than SYN indicates. The nitrogen calculator is still a useful tool for quick assessments of nitrogen supply and demand at a given yield.

Table 1. Comparison of actual results and SYN output for a selection of 2003 sites

Location	Field results			SYN output			Comment
	Yield	Protein	@ N/ha	Yield	Protein	@ N/ha	
Neridup A	4.2	10.5	70	3.8	8.3	70	Higher protein than SYN.
Neridup dG	3.4	11.1	34	3.1	8.1	34	Limited yield from waterlogging.
Ravensthorpe E	2.8	10.3	100	2.79	8.5	100	Summer rain no leaching.
Salmon Gums G	3	8.6	25	3.33	8.5	24	Reasonable SYN match.
Grass Patch L	4.4	9.5	30	3.85	9.1	60	Using PYCAL yield for Ymax.
Cascade B	3.7	11.5	50	3.5	8.8	60	Range of times of application.
Mt Madden B	3.6	12.4	55	3.35	8.9	60	Much higher protein than SYN.

CONCLUSION

Crop yield potential remains the most important determinant of nitrogen requirement. Nitrogen decisions based on pre-season estimates of expected yield need to be reviewed as the season develops. In the absence of limitations to crop growth, PYCAL gives a reasonable estimate of progressive potential yield. This can be used in conjunction with nitrogen models to adjust fertiliser applications as the season progesses with later applications up to booting effective if followup rain is received.

The nitrogen simulation model SYN needs further evaluation in a range of seasonnal conditions before it can be confidently used for estimating nitrogen fertiliser for protein management on the South Coast.

A suggested nitrogen fertiliser strategy is to apply nitrogen at sowing for the expected yield of a decile 3 season at your target protein level. The yield potential can be reviewed at mid tillering for additional nitrogen if required. The potential yield can be further reviewed during stem elongation and more nitrogen applied if required. Later applications need soil moisture both at the time of application and followup rainfall to ensure nitrogen is washed into the root zone which is likely in above average seasons.

KEY WORDS

cereal protein, nitrogen, south coast WA

ACKNOWLEDGMENTS

Terina Burnett, Veronica Reck, Ben Curtis and many participating farmers.

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Paper reviewed by: John Simons

Unravelling the mysteries of optimum seed rates

Dr Wal Anderson, Dr Darshan Sharma, Brenda Shackley and **Mario D'Antuono**,
Department of Agriculture; Albany, Northam, Katanning and South Perth

KEY MESSAGES

- Minimum plant populations required to maximise grain yield of wheat increase by about 40-50 plants/m^2 for each tonne of potential yield.
- More pre-sowing rainfall, more rainfall in the growing season and earlier sowing time all increased the minimum population required to maximise yield. Clay loam soils needed fewer plants/m^2 (but higher seed rates) than sandy soils to reach the maximum yield.
- Differences between varieties were not apparent unless yields were above about 3 t/ha.
- 150 plants/m^2, sufficient for a 3 t/ha crop, would require 80 kg/ha of seed on a clay soil or 70 kg/ha on a sand.

BACKGROUND

Using a seed rate that is sufficient for an average season may turn out to be one of the main factors limiting yield in a good season. Conversely, using the seed rate for an average season is unlikely to be detrimental to yield or grain quality in a poor season. Better decisions can be made if the seed rate is adjusted according to the expectation of wheat grain yield. Plant population (or seed rate) may limit yield in many situations where other limitations to production have been overcome. Season, soil type, sowing time and sometimes variety are factors that affect the optimum plant population and corresponding minimum seed rate required to maximise yield.

AIMS

The aim of this research was to provide guidelines for assessing the minimum plant populations, and hence seed rates, to maximise wheat grain yield in Western Australia.

METHOD

Data from over 30 experiments containing four or five target plant populations and a range of relevant varieties were used. The experiments were conducted during 1996-2001 at locations ranging from Yuna to Lake King. The optimum plant population (based on the point at which each extra 1 plant/m^2 yielded 2.5 kg/ha of grain) was calculated for each data set (1 variety x 4-5 plant populations). The optima were grouped initially according to pre and post-sowing rainfall, sowing time and soil type. Later, the effect of applied N and variety were used as additional grouping criteria. All calculations were based on actual plant numbers counted in each experiment. Yield components were used to assist interpretation of the results.

RESULTS

Where rainfall in the growing season was less than 205 mm, the optimum plant population increased from 35 plants/m^2 (20 kg/ha of seed) to 124 plants/m^2 (65 kg/ha) with the increase in rainfall (pre-sowing and growing season) and earlier sowing. Yields at the optimum population in this set increased from 1.39 t/ha to over 2.85 t/ha. Where rainfall in the growing season was greater than 205 mm, the trend to increased optimum population with increased yield was also evident with some major exceptions. The exceptional cases were where the yields were limited by something other than seasonal rainfall (i.e. they were less than the rainfall-limited potential). Yields in this group ranged from about 2.5 to about 3.5 t/ha.

In general, crops on clay loam soils required higher seed rates, but fewer plants, to maximise grain yield than on sandy soils. This apparent anomaly was due to the lower establishment percentages that are common on the heavier soil types (e.g. about 75% on clays cf. about 85% on sands at

150 plants/m^2 target population). N fertiliser did not affect the optimum seed rate in the experiments. Calculated seed rates for a range of target populations, are shown in Table 1.

Differences between varieties in the optimum plant population were only evident in the group where rainfall exceeded 205 mm and grain yield exceeded about 3 t/ha. Varieties that had larger ear size (weight per ear) had lower optimum plant populations.

Table 1. Viable seeds required to achieve various target populations. Corresponding seed rates in kg/ha are in brackets (based on 38 mg seed size and establishment percentages for the amounts of seed sown and the different soil types)

Target plants/m^2	Viable seeds/m^2 required	
	Clay loams	Sands and sandy loams
50	59 (25)	53 (20)
100	128 (50)	111 (45)
150	200 (80)	176 (70)
200	286 (115)	256 (100)
300	536 (215)	461 (185)

CONCLUSION

- Better estimates of the minimum seed rate (plant population) for wheat can be made if pre-sowing rainfall, rainfall zone, sowing date, soil type and variety are taken into account.
- Optimum seed rates (and associated populations) should be viewed as the *minimum* requirement to avoid limitations to grain yield caused by too few plants under weed-free conditions. Higher rates should be used to provide competition in weedy situations.
- The 'rule of thumb' is that a minimum of 40-50 plants/m^2 are required for every tonne of anticipated yield.

KEY WORDS

plant population, seed rate, wheat

ACKNOWLEDGMENTS

Melaine Kupsch, Mechelle Owen, Anne Smith, Bindi Webb, Ray Tugwell, James Bee, Sheena Lyon assisted with the experiments. Department of Agriculture and GRDC provided the funds.

Project No.: Several

Paper reviewed by: Steve Penny

Agronomic features for growing better wheat - south east agricultural region 2003

Dr Mohammad Amjad, Veronika Reck and **Ben Curtis**, Department of Agriculture; Esperance

KEY MESSAGES

- A good start of the 2003 season followed by consistently good conditions around grain filling has generally resulted in higher grain yield averaging over 3.0 and 4.0 t/ha in the Mallee and Sandplain environments respectively.
- May sowing on the opening rains in the Mallee resulted in 40% greater yield than the late June sowing. On the Sandplain the May sowing (in marginal conditions) yielded similar to late June sowing (3.5 t/ha), and the early June sowing out-yielded both May and late June sowing by 0.5 t/ha. New crossbreds WAWHT2524 and WAWHT2661 yielded the highest followed by Wyalkatchem, GBA Sapphire and Mitre.
- Differences between varieties in response to increasing seed rate that were evident at 30 kg/ha of applied N were much less evident at 60 kg/ha of N. All varieties responded positively to the combination of high seed rate (200 plants/m^2) and 60 kg/ha of N.
- Growing two or more varieties with better disease resistance, tolerance to weather damage and grain quality characteristics should help to reduce risks in the south coastal environments in 2004.

AIMS

South coastal growers are faced with a choice of new wheat varieties both from WA and the Eastern states, about which there is often little relevant information available in the local environment. Agronomic investigations were carried out with the following aims:

1. To investigate how new wheat varieties respond to sowing times on the coastal Sandplain and inland Mallee environments.
2. To investigate how seed rate (plant population) and fertiliser nitrogen response differs between new wheat varieties and coastal environments.

METHOD

During 2003, 25 wheat varieties were tested for sowing date responses on Sandplain at Gibson and Mallee soils at Salmon Gums. There were 10 core varieties (EGA Bonnie Rock, Calingiri, Carnamah, Cascades, Kukri, Mitre, Spear, Westonia, Wyalkatchem, Yitpi), nine new varieties (Annuello, Babbler, Bowerbird, Braewood, GBA Combat, Pugsley, GBA Ruby, GBA Sapphire, GBA Shenton) and six crossbreds (WAWHT2394-EGA Blanco, WAWHT2499, WAWHT2473-EGA Castle Rock, WAWHT2524, WAWHT2525A, WAWHT2661). Experiments were sown in late May, early June and late June.

A subset of six wheat varieties was also tested for seed rate and nitrogen rate responses at Cascade after non-legume rotation and at Gibson after lupins. Varieties were sown at four seed rates (target plant populations of 50, 100, 200, 300 plants/m^2) and four nitrogen rates (nil, 30, 60, 120 kg N/ha) in both Sandplain and Mallee environments. A basal phosphate fertiliser of 15 kg P/ha was deep banded at seeding and all four nitrogen rates were topdressed four weeks after seeding. Varieties and nitrogen rate plots were grouped together in a complete factorial design. Wheat varieties included in investigations were three core varieties (Calingiri, Carnamah, and Wyalkatchem) and three crossbreds (WAWHT2473 -EGA Castle Rock, WAWHT2499 and WAWHT2525A). Disease pressure in the plots in 2003 was not severe but one fungicide spray was applied to control septoria diseases and stem rust (Westonia and Yitpi only were affected).

RESULTS

The 2003 season started well with greater than average follow-up rains during the growing season both on coastal Sandplain (annual rainfall 490 mm and May-Oct 342 mm) and inland Mallee (annual rainfall 342 mm and May-October 209 mm) environments.

Variety response to sowing date

The yield losses due to sowing after the optimum time (late may in the Mallee site, mid-June at the Sandplain site) were unusually high for the south coast region at over 30 kg/ha/day. The varieties and sowing date interactions were significant for grain yield on both Mallee soils at Salmon Gums and Sandplain soils at Gibson. On Mallee soils, varieties yielded the highest at 26 May sowing (averaged 3.55 t/ha) compared to 3.11 t/ha and 2.57 t/ha at 10 June and 24 June sowing respectively. On Sandplain soils, the average yields were 3.59 t/ha, 4.01t/ha and 3.48 t/ha for 28 May, 13 June and 25 June respectively.

The highest yielding of the named varieties at the early sowing at Salmon Gums were Wyalkatchem, GBA Ruby and Westonia; at the mid sowing GBA Sapphire yielded most and at the late sowing Wyalkatchem and Westonia were again high yielding. At the early sowing at Gibson; Westonia, Spear, Pugsley, GBA Sapphire and EGA Bonnie Rock were in front, while the mid-sowing saw EGA Blanco, GBA Sapphire, GBA Shenton, Westonia and Wyalkatchem lead the way with Carnamah being outstanding at the late sowing.

Variety response to seed rate and nitrogen rate

The Sandplain trial was severely water logged during the growing season and abandoned. At the Mallee site, all varieties responded to increased plant population and nitrogen rate, and averaged 2.86 t/ha. The increase in grain yield was not significant at lower plant population of 50 plants/m^2 at all N rates. Grain yield was significantly increased at combinations of 100, 200 and 300 plants/m^2 with 60 and 120 kg N/ha only but not at lower N and seed rates.

The interaction of Varieties, N rate and plant population was significant for grain yield. Wyalkatchem appeared to have a higher optimum plant population at the 30kg/ha N rate, as did EGA Castle Rock. However, at the 60kg/ha N rate all varieties responded similarly to increasing plant population. The responses of the crossbreds need to be clarified through further testing in 2004. All six varieties yielded similarly at the higher inputs of N (120 kg N/ha) and plant population (300 plants/m^2). Grain quality data was not available at the time of reporting due to the late harvest in 2003/04.

CONCLUSION

High yield potential and high grain quality attributes are the key parameters in variety selection on the coast. Based on the results of 2003 and previous experience there appears to be a trade-off between yield, disease resistance and susceptibility to weather damage. The highest yielders have been Wyalkatchem and Westonia. Based on limited testing in 2003; GBA Sapphire, WAWHT2524 and WAWHT2661 have also shown promise. The best tolerance to weather damage is probably found in Sun type (Braewood) and Sunelg type (WAWHT25252A), and the disease situation is best addressed with Janz and it's derivatives (Annuello, Mitre and Babbler). The key consideration appears to be choosing the appropriate mix of varieties depending on risk factors, yield, and likely sowing times. A cropping programme based on one, or a limited number of varieties, is less likely to succeed in the long term. Growing two or more varieties with better resistance to disease, weather damage staining, sprouting and falling numbers) and grain quality parameters should help to reduce risks in the south coastal environments in 2004.

KEY WORDS

cultivar, varieties, plant population, seeding rate

ACKNOWLEDGMENTS

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Project No.: DAW12 - South Coast

Paper reviewed by: Dr Wal Anderson

NB: There is an extended version of this paper on the Crop Update 2004 CD.

Agronomic responses of new wheat varieties - great southern agricultural region 2003

Brenda Shackley and **Judith Devenish**, Department of Agriculture; Katanning and Jerrumungup

KEY MESSAGES

- The limited release Australian Soft (AS) variety EGA2248 was the highest yielding variety in the Great Southern. Other high yielding varieties were Calingiri, Carnamah, Wyalkatchem and Yitpi. The GBA lines, Ruby, Sapphire and Shenton were variable in their performance over the two sites.
- EGA2248 is superior compared to other AS varieties EGA Jitarning and Datatine for screenings but it may have problems with high protein levels.
- Wyalkatchem had the highest response to nitrogen (N) at Katanning. EGA Castle Rock had the lowest. All varieties responded significantly to increasing plant density between 50, 80 and 145 plants/m^2. WAWHT2525A had the highest minimum plant population.

AIMS

To maximise varietal performance in the Great Southern and Lakes region by providing variety specific agronomic information on new and potential wheat varieties (local, interstate and private companies).

METHOD

Field based agronomy trials were located at Katanning (duplex) and Nyabing (shallow loam) for the time of sowing trials, and at Katanning (duplex following canola) and Newdegate (duplex following lupins) for the variety/nitrogen/plant density trials in 2003. Low levels of leaf rust and stem rust were present in the trials late in the season. No fungicide treatments were applied at any stage.

Sowing times at Nyabing were 22 May and 3 June, while Katanning sites were sown on 23 May, 6 June and 23 June. Twenty-four varieties from WA and elsewhere were sown at each date.

A subset of six varieties (Carnamah, Calingiri, Wyalkatchem, EGA Castle Rock, WAWHT2499 and WAWHT2525A) were examined at four N rates (0, 30, 60 and 120 kg N/ha) and four targeted plant densities (50, 100, 200 and 300 plants/m^2). N response as used here is the change in yield between nil and the first N rate used (30 kg/ha of N) in responsive situations. Optimum plant population is estimated as the point on the yield repsonse curve where yield increases 2.5 kg/ha for each additional 1 plant/m^2. It is the minimum population (or seed rate) required under good conditions in a weed-free environment.

RESULTS

Time of sowing

Mid/late May sowing of the wheat varieties in the Great Southern was the most productive 'window' for all but two of the varieties. Westonia and Wyalkatchem in contast, were as, or more productive when sown in early June. Their performance at the earlier sowing time was limited by frost damage at both sites. Performance of the varieties at an earlier sowing opportunity was not evaluated.

The highest yielding released variety at 3.2t/ha and 4.7t/ha at Katanning and Nyabing respectively, was EGA2248; the limited release standard head soft wheat. Other varieties that performed well in terms of grain yield were Calingiri, Carnamah, Westonia, Wyalkatchem, Yitpi, Datatine, EGA Jitarning, EGA Blanco and Mitre (Table 1). Not all the GBA lines were fully evaluated due to the lack of seed. GBA Shenton and GBA Ruby performed well but they also varied between the two sites. Grain quality results are not available at this stage.

Table 1. Grain yield (t/ha) response of wheat varieties to sowing time in the Great Southern (2003)

Variety	Nyabing 22-May	Nyabing 3-Jun	*Average*	Katanning 23-May	Katanning 6-Jun	Katanning 23-Jun	*Average*
Calingiri	***4.5***	3.9	*4.2*	***3.1***	2.6	***2.3***	*2.7*
Carnamah	***4.4***	***4.2***	*4.3*	***2.9***	***2.8***	***2.4***	*2.7*
Wyalkatchem	4.0	***4.5***	*4.2*	2.5	2.6	***2.4***	*2.5*
Westonia	***4.5***	***4.4***	*4.4*	2.7	***2.8***	2.0	*2.5*
EGABlanco	4.1	3.8	*4.0*	2.7	2.5	***2.2***	*2.5*
EGACastle Rock	4.0	3.6	*3.8*	2.5	2.4	1.8	*2.2*
Cascades	3.9	3.5	*3.7*	2.7	2.4	1.9	*2.3*
EGABonnieRock	4.3	4.0	*4.2*	2.6	2.4	2.0	*2.4*
GBARuby	***4.4***	4.0	*4.2*	2.4	2.6	***2.1***	*2.4*
GBASapphire	***4.7***	3.9	*4.3*	***3.1***			*
GBAShenton	4.1	3.4	*3.7*	2.8	***2.7***	1.8	*2.4*
Annuello	4.1	3.6	*3.9*	2.6	2.5	1.9	*2.4*
Kukri	4.3	3.9	*4.1*	2.5	2.5	2.0	*2.3*
Mitre	***4.4***	3.9	*4.2*	2.8	2.3	***2.1***	*2.4*
Yitpi	***4.6***	3.9	*4.2*	***3.1***	2.6	***2.4***	*2.7*
Pugsley	***4.4***	3.8	*4.1*	2.7	2.4	***2.1***	*2.4*
Spear	4.3	3.5	*3.9*	2.7	2.5	***2.2***	*2.5*
EGA2248	***4.7***	***4.3***	*4.5*	***3.2***	***3.0***	***2.3***	*2.8*
EGAJitarning	4.2	4.1	*4.1*	2.8	***2.8***	***2.2***	*2.6*
Datatine	4.3	3.9	*4.1*	***2.9***	***2.8***	***2.1***	*2.6*
WAWHT2499				2.0	2.4	2.0	*2.1*
WAWHT2524	***4.9***	***4.5***	*4.7*	***3.0***	***2.9***	***2.5***	*2.8*
WAWHT2525A	4.0	3.7	*3.9*	2.7	2.2	2.1	*2.3*
Average	4.3	3.9	*4.1*	2.7	2.6	2.1	*2.5*
	Fpr	lsd		Fpr	lsd		
TOS	0.336	2.7		0.093	0.6		
Variety	<.001	0.2		<.001	0.2		
TOS*Var	0.001	0.9 (0.3)		<.001	0.6 (0.3)		
CV (%)	4.1			7.8			

Highest yielding released variety highlighted. Varieties in bold and italitics are not significantly different from the highest yielding released variety.

EGA2248 is the earliest maturing soft wheat variety, slightly later than Westonia. It yielded exceptionally well being suited to the major sowing opportunities. However, it is complimentary to EGA Jitarning, which is suited to early sowing opportunities and longer season environments. Both EGA2248 and EGA Jitarning have less small grain screenings than Datatine but EGA2248 may have a problem with high protein levels (Table 2).

Response to nitrogen rates and plant density

Overall the N rates were not significant at the Katanning or Newdegate sites, although at Katanning grain yields were increased for all varieties up to 30 kg N/ha. At this site, Wyalkatchem achieved the highest agronomic efficiency of N use at nine compared to EGA Castle Rock the lowest at four. The efficiency of N use values were higher than in 2002 but still lower than values obtained 1999-2001 (Shackley *et al*. 2003). Interestingly WAWHT2525A was the only variety to respond to 30 kg N/ha at Newdegate.

A significant plant density and a variety by plant density response were found at both sites in the Great Southern and Lakes region. By increasing plant densities from 80 to 145 per m^2, grain yields on average were increased between 140 and 200 kg/ha at Newdegate and Katanning respectively. Targeted plant densities were 100 and 200 plants/m^2 or 50 and 106 kg/ha of seed.

Based on the 2.5:1 ratio (see method) Wyalkatchem and Carnamah's optimum plant populations of 100 plants/m^2 (50 kg/ha seed rate) were found to be similar to 2002. EGA Castle Rock is similar to Carnamah at an optimum population of 100 plants/m^2. WAWHT2525A achieved an optimum population above 130 plants/m^2 (> 60 kg/ha of seed), suggesting it is similar to Calingiri in it's requirement of a high plant population to achieve maximum yield.

Table 2. Screenings and grain protein levels of soft wheat varieties over three sowing times, Katanning 2003

Grain quality	Variety	Time of sowing			Average
		23 May	6 June	23 June	
Screenings[1] (whole + broken, %)	Datatine	***12***	***15***	***30***	19
	EGA Jitarning	5	***15***	***24***	15
	EGA 2248	5	4	5	5
	Average	7	11	20	13
Grain protein (%)	Datatine	8.5	8.8	9.2	8.8
	EGA Jitarning	8.7	9.2	***9.7***	9.2
	EGA 2248	9.4	***9.6***	***10.1***	9.7
	Average	8.8	9.2	9.7	9.2

[1] Prelimary results, broken to be excluded from sample.

CONCLUSION

This paper forms one part of a project with four components looking at variety specific responses statewide. Please refer to the other project components (North, Central and South Coast) for a more complete summary.

In 2004, growers will need to match variety choice with grain yield, grain quality (i.e. screenings) and disease risk. Only EGA Castle Rock, EGA Jitarning and the GBA lines have the triple rust resistance, but seed is limited. The alternative varieties such as Calingiri, Carnamah, Wyalkatchem, EGA2248 and Yitpi trade disease resistance with yield. Good disease management and agronomy will be essential because of the range of characteristics of the different varieties.

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KEY WORDS

varieties, time of sowing, nitrogen, seed rate

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Paper reviewed by: Dr Wal Anderson

Variety specific responses of new wheat varieties - central agricultural region 2003

Dr Darshan Sharma and **Dr Wal Anderson**, Department of Agriculture; Northam and Albany

KEY MESSAGES

- In experiments at Nungarin and Quairading in 2003, Wyalkatchem and Westonia were adapted to a wider range of sowing times. The response of Shenton needs further testing. Ruby was better adapted to later sowing. EGA Castle Rock, Kukri, Pugsley, Annuello and Mitre were not well adapted for yield in the central region in 2003.
- Calingiri and EGA Castle Rock required higher plant population than Carnamah despite similar grain yield levels. Wyalkatchem returned significant grain yield benefits to applied N provided yield potential was high and seed rate was not limiting.

AIMS

To maximise varietal performance in the central agricultural region by providing variety specific agronomic information on new and potential wheat varieties (local, interstate and private companies).

METHOD

The results are largely based on four trials conducted at growers' properties, two in each of the low rainfall (Nungarin, clay loam) and medium rainfall (Quairading, sandy duplex) areas in the 2003 cropping season. The varieties included those developed by Department of Agriculture, South Australia, Victoria and private companies. Leaf diseases were not present at these sites at significant levels in 2003. Varieties were sown at three times of sowing at fortnightly intervals. Four seed rates were used as calculated to result in 50 to 300 plants/m^2, and four applied N levels ranging from nil to 120 kg N/ha were used. Data were collected on grain yield, protein and screenings. Optimum sowing time, plant density and response to applied N were computed using advanced statistical procedures available in 'Genstat' (biometrics program).

RESULTS AND DISCUSSION

Time of sowing

Grain yield declined after late May in the Nungarin site at 65 kg/ha/day and after mid June in the Quairading site at 42 kg/ha/day on average. This is a much steeper yield decline with later sowing than average for the region. Since the steepness of this grain yield decline is very significant and because varieties performed differently at different times of sowing, matching variety to sowing time becomes of the utmost importance (Table 1).

Among APWs, Westonia and Wyalkatchem were high yielding at all times at both sites. They were the varieties of choice for sowing up to mid-June. Shenton was also excellent at Quairading but missed the top group at Nungarin, probably due to its poor establishment, and deserves further testing. Ruby, although of medium maturity, seems more competitive at late sowing. Kukri, Mitre, GBA Sapphire and Pugsley did not appear to be adequately adapted in the region in 2003.

In the hard category, EGA Bonnie Rock was the highest yielder at all times of sowing at the Nungarin site but Carnamah and Yitpi were competitive at the Quairading site. EGA Castle Rock was a low yielder at these sites in 2003.

Arrino and Calingiri of the noodles type, performed about equally upto mid-June at both sites in 2003. High protein levels at Nungarin (clay loam soil type and legume rotation) caused down grading noodle types.

Small grain screenings exceeded the 5% level only for Sapphire (TOS1 at Nungarin; but not significantly different from Carnamah at that TOS). None of the varieties exceeded 5% screenings mark at Quairading at any time of sowing.

For screenings, protein and gross margins on individual treatments, see extended version.

Gross margins

When compared over all grades at respective times of sowing, gross margins (calculated using Golden Rewards paygrade prices as on 6 January 2004) were more consistent with Westonia, Wyalkatchem, EGA Bonnie Rock and Calingiri (Table 1).

Seed rate

The optimum plant population was higher at the higher yielding site (Nungarin). Optimum numbers of plants/m^2 are shown in Figure 1. The optimum plant populations of Calingiri and EGA Castle Rock were greater than Carnamah, despite all three varieties having similar grain yield levels. The optimum populations shown here should be regarded as the minimum necessary to avoid making plant population a limiting factor. In most cases growers will want to increase seed rates above the minimum to improve weed competition and to minimise the impacts of wider rows and retained stubble. [For more details on factors influencing optimum population and seed rate, please see 'Unravelling the mysteries of optimum seed rates' - these Proceedings.]

Crop establishment was better for Carnamah but variable for Calingiri and EGA Castle Rock. Seed vigour and coleoptile length are the common reasons attributed to such effects. These results suggest that careful consideration of seed quality and soil conditions while calculating seed rate for targeting optimum plant density could pay dividends.

Applied N

Applied N in excess of about 60 kg/ha caused a yield reduction of Calingiri and EGA Castle Rock at Quairading; it gave marginal benefit to Carnamah but only when the seed rate was suboptimal. However, Wyalkatchem benefited from applied N when higher seed rates were used.

CONCLUSION

The WA-bred varieties Wyalkatchem, Westonia, EGA Bonnie Rock, Calingiri and Arrino yielded best in their respective quality classes in the central agricultural region at our two sites in 2003.

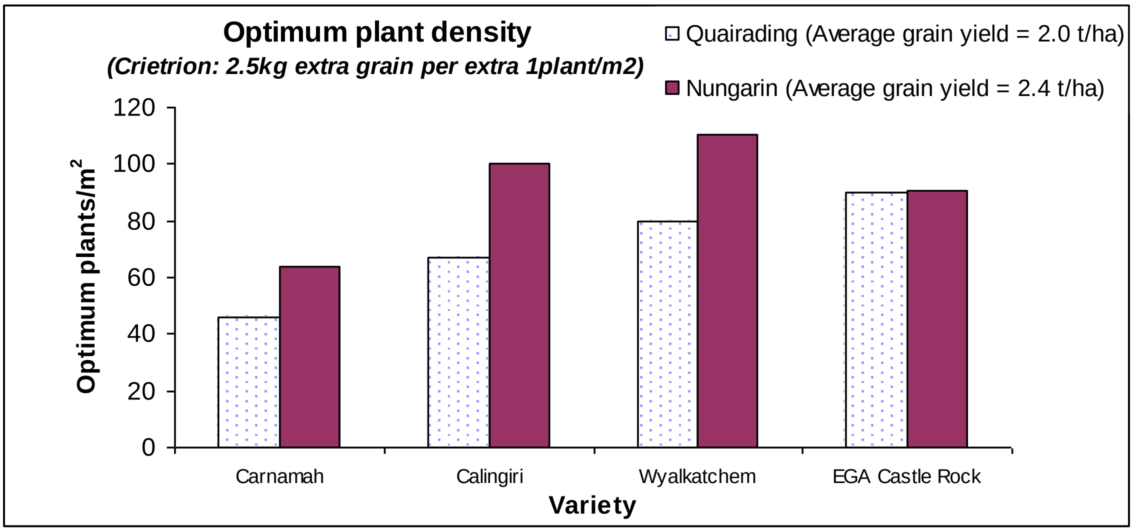

Figure 1. Optimum plant density of four varieties at two sites in the CAR in 2003.

Grain yield of Carnamah, Calingiri, Wyalkatchem and EGA Castle Rock at optimum plant density at Quairading was 2.1, 2.1, 2.4 and 1.9 t/ha, while at Nungarin was 2.4, 2.5, 3.0 and 2.2 t/ha. Corresponding seed rate (kg/ha) can be calculated using formula: (Target plant density * Average grain weight in mg/assumed Establishment %).

Table 1. Grain yield and gross margins of new wheat varieties at three times of sowing at two locations in the central agricultural region

(i) Values in bold indicate that variety was in the top significant group at that time of sowing. (ii) $$ means gross margins more than 95% of the maximum (over all grades and all varieties) at that time of sowing; One $ sign means gross margin between 90-95% of the maximum at that time of sowing. (iii) Trials were disease free; hence, gross margins will need to be adjusted according to varietal resistance, likelihood of disease occurrence and the fungicide costs. For resistance ratings, see Crop Variety Sowing Guide 2004.

Segregation	Variety	Nungarin sowing date			Quairading sowing date		
		23 May	06 June	20 June	30 May	12 June	26 June
APW	Annuello	2.76	1.87	1.72	1.88	1.60	**1.25[$]**
	GBA Ruby	2.81	**2.16**	**1.89[$]**	2.17[$]	**1.94[$]**	**1.34[$$]**
	GBA Sapphir	2.93	1.95	1.68	2.04	1.74	**1.36[$$]**
	Kukri	2.90	1.97	**1.94[$]**	1.95	1.60	**1.17**
	Mitre	2.63	1.77	1.75	1.99	1.71	1.06
	Pugsley	2.89	1.95	1.63	1.95	1.75	**1.18**
	GBA Shenton	2.69[*]	1.63[*]	1.57[*]	**2.30[$$]**	1.81	**1.18**
	Spear	2.64	1.88	1.63	2.08	1.66	**1.24[$]**
	Westonia	**3.23[$$]**	**2.38[$$]**	**2.15[$$]**	**2.31[$]**	**1.97[$]**	**1.37[$$]**
	Wyalkatchm	**3.24[$$]**	**2.45[$$]**	**1.84**	**2.29[$$]**	**1.96[$]**	**1.35[$$]**
AH	Carnamah	2.82	1.99	1.60	2.38[$$]	1.87[$]	1.34[$$]
	Cascades	2.60	1.62	1.49	1.90	1.48	1.12
	EGA Castle Rock	2.69	1.74	1.72	1.96	1.62	0.97
	EGA BonnieRock	3.31[$$]	2.31[$$]	2.04[$$]	2.30[$$]	1.99[$]	1.07
	Yitpi	2.80	1.96	1.70	2.29[$$]	1.75	1.18
ASWN	Arrino	**3.18[?]**	**2.20[?]**	1.63[?]	**2.27[$$]**	**1.92[$]**	1.04
	Calingiri	2.98[?]	1.92[?]	1.83[?]	2.24[$$]	1.85[$]	**1.26[$]**
	WAWHT2550	**3.06[?]**	1.92[?]	1.72[?]	2.18[$$]	**1.91[$]**	1.11
A. Soft	EGA Jitarning	2.58[?]	1.74[?]	**1.84[?]**	**2.33[$$]**	1.85[?]	**1.26[?]**
Steam buns	EGA Blanco	2.74	1.95	1.72	2.17[$]	1.89[$]	**1.31[$]**
LSD (0.05) for within Sowing Date comparisons			0.31			0.20	
Maximum gross return		**819**	**611**	**530**	**568**	**499**	**329**

* Actual plant density below average at this site (about 80%).

? Downgraded due to high protein.

KEY WORDS

wheat, new varieties, crop management, gross margins

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Agronomic responses of new wheat varieties - northern agricultural region 2003

Christine Zaicou-Kunesch, Melaine Kupsch and **Anne Smith**, Department of Agriculture; Geraldton

KEY MESSAGES

- Early May sowing was the first sowing opportunity and the most productive and economic at Mingenew. In comparison, marginal soil moisture at seeding in mid May and lack of summer rain resulted in the late May sowing being more productive and economic at Mullewa.
- **EGA Bonnie Rock** was the best performing AH variety at Mullewa across a range of times of sowing. In Mingenew, **Carnamah** was the best forming AH with an early sowing at Mingenew while EGA Bonnie Rock performed best with a later sowing.
- **GBA Ruby** and **GBA Shenton** are triple rust resistant and performed well with the late May sowing. They were less productive with an early June sowing.
- **WAWHT2499** is a potential Australian Hard (AH) wheat and best sown early June in Agzone 4. Black Point risk and yield penalties do not make it a choice for growers in Agzone 1. **WAWHT2525A** with metribuzin tolerance and triple rust resistance had better protein levels than the other varieties with similar yields. However it yielded about 3.7% less than Carnamah with a mid May sowing.

AIMS

This paper aims to provide a guide for the management of current and newly released varieties from Western Australia and other sources, with regard to the Northern Agricultural Region.

METHOD

Field based agronomy trials were located on yellow sandplain at Mingenew and sandy loam or clay loam at Mullewa in 2003. Response to sowing time was based on experiments using three sowing times, mid May (14 or 13), late May (25 or 24) and early June (11 or 10). Twenty four cultivars from WA and elsewhere were sown at each date. Quarantine restrictions related to the threat of Wheat Streak Mosaic Virus limited the inclusion of some varieties for the first time of sowing. A subset of six wheat varieties was also tested for seed rate and nitrogen response. Varieties were sown at four seed rates (target plant populations of 50, 100, 200 and 300 plants/m^2 and four nitrogen rates (nil, 30, 60, 120 kg N/ha) at Mingenew (four weeks after sowing) and Mullewa (at sowing). A basal phosphate fertiliser was applied. Nitrogen (N) response as used here is the change in yield between nil and the first N rate used. Response to seed rate was assessed as the estimated optimum plant population which was the point on the yield response curve where yield increased 2.5 kg/ha for each additional 1 plant/m^2. It is the minimum population (or seed rate) required under good conditions in a weed free environment. Disease levels were not present at these sites at significant levels in 2003.

RESULTS AND DISCUSSION

Soil type

Soil type and/or summer rain appeared to have a big influence on productivity in 2004. Screenings and lightweight grain were a major problem for growers in the low rainfall zone (L1) and in the majority of varieties (with the exception of Wyalkatchem) in this trial at Mullewa. In comparison, at the medium rainfall zone of Mingenew, screenings and light weight grain were not a major issue for growers or in the trial. Industry perception that Carnamah was more susceptible to screenings was not supported. However, along with a number of other varieties, it appears to have been more affected by light weight grain at Mullewa with later sowings (Table 1).

Time of sowing

Mid May sowing of the varieties at Mullewa was not the most productive or economic for most of the varieties. Production actually increased by about 12 kg/ha/day with a delay in sowing to 24 May. It is likely that the lack of summer rain and sandy loam soil type caused stress and had a big impact on

productivity and quality. However, it was more important to get the crop in early than to delay seeding until 10 June, which was even less economic. The delay in seeding from 24 May to 10 June decreased production by 22 kg/ha/day at Mullewa. At Mingenew the yield penalty from delaying seeding from mid May to late May was about 25 kg/ha/day. In comparison the yield penalty was 50 kg/ha/day with a further delay in seeding to early June.

EGA Bonnie Rock was the best performing AH variety at Mullewa across a range of sowing times. In comparison at Mingenew, Carnamah was the best forming AH with an early sowing at Mingenew and EGA Bonnie Rock performed best with the late May and early June sowings (Table 1). WAHT2525A is a cross of Sunelg and Blade. It has metribuzin tolerance, triple rust resistance and better protein levels than the other varieties with similar yields. Similar to CVT testing, it yielded about 3.7% less than Carnamah with a mid May sowing (Table 1). It was not as productive as GBA Shenton at a late May sowing. Both these varieties have triple rust resistance and would be useful for risk management. WAWHT2499, a potential AH wheat, it is a shorter season variety and with an early June sowing was the second ranked AH variety at Mullewa (see Table 2a on extended version of this paper on CD). Its Black Point (fungal staining) levels do not make it a choice for growers in the high rainfall areas.

Wyalkatchem, Westonia and EGA Blanco were the APW wheats that performed very well across all times of sowing. It is not possible to comment on the performance of GBA varieties across all times of sowing because of the unavailability of seed for the mid May seeding. However, both GBA Ruby and GBA Shenton performed well with the late May sowing. They were less productive with an early June sowing (see Table 1a and 2a of extended version of this paper on CD).

On the yellow sandplain of Mingenew (lupin stubble and 52 kg/ha applied N), each of the two noodle varieties produced quality grain. Mid and late May sowings of the noodle wheats were the most economic. Environmental conditions and residual nitrogen on the sandy loam of Mullewa led to protein levels exceeding 14% with 50 kg/ha of nitrogen on a lupin stubble (see Table 2a on extended version of this paper on CD).

Black Point

Black Point had a significant impact on grain quality at Mingenew, but not at Mullewa (see Table 1b in extended version of this paper on CD). It rained in late August and September. The majority of varieties reached 50% flowering between the mid to late August with time of sowing 1, by late August/Early September with time of sowing 2 and mid to late September with time of sowing 3. Delayed sowing reduced Black Point. However, this was less economic because of the yield penalty suffered. Consistent with CVT information, Cascades, and some eastern states varieties had low Black Point. EGA Castle Rock, (the triple rust resistant Cascades type) did not have the same level of Black Point resistance and levels were significantly higher. Fungal staining (Black Point) had a significant effect on downgrading the quality of the wheats at Mingenew and this is reflected in the gross margins of many of the varieties (calculated using Golden Rewards pay grade 25 November 2003).

Seed rates

At Mingenew, the expected plant population and observed plant populations were closely matched. Across all nitrogen rates at Mingenew, the minimum plant number necessary to avoid making plant population a limiting factor was 114 plants/m^2 for Carnamah, 83 plants/m^2 for Calingiri, 78 plants/m^2 for Wyalkatchem, 118 plants/m^2 for WAWHT 2525A, 80 plants/m^2 for WAWHT 2499 and 97 plants/m^2 for EGA Castle Rock. This corresponds to approximately 42 kg/ha for Carnamah, 51 kg/ha for Calingiri, 38 kg/ha for Wyalkatchem, 43 kg/ha for WAWHT 2525A, 32 kg/ha for WAWHT 2499 and 41 kg/ha for EGA Castle Rock. At Mullewa, the crop yields did not exceed 2.5 t/ha. Studies by Anderson *et al*. (2004) have shown that varieties do not show responses to seed rate until the yield of the crop exceeds 2.5-3 t/ha.

Nitrogen

Wyalkatchem was the only variety that responded to added nitrogen at Mingenew. It had an agronomic efficiency of 4.3 kg grain for each addition of 1 kg N up to 30 kg/ha N. This figure corresponds with the efficiencies defined in 2002 (Shackley 2002). All the other varieties were not responsive. The season, rotation and soil type resulted in no response to N at Mullewa.

Best wheat options for 2004

Growers will still need to match variety choice with grain yield and disease risk in 2004 (see Table 3 in extended version of this paper on CD). In the high rainfall zone, growers will need to consider varieties with reduced risk to leaf disease and blackpoint. In the low rainfall zones on loamy soils with no summer rain, varieties with reduced risk to screenings will need to be considered. However, good agronomy and disease management will be essential because of the range of characteristics of the different varieties.

Table 1. Effect of time of sowing on grain yield, quality and economic returns of wheat varieties on yellow sandplain at Mingenew and sandy loam at Mullewa in 2003

A) Variety		Yield (t/ha) - Mingenew			Yield (t/ha) - Mullewa		
		14 May	25 May	11 June	13 May	24 May	10 June
EGA Castle Rock	AH	3.48	3.27	2.75	1.58	1.7	1.25
Yitpi	AH	*	3.77	2.99		1.56	1.24
Carnamah	AH/APW	4.32	3.8	**3.19**	1.34	1.67	1.12
Cascades	AH/APW	4	3.59	2.6	1.69	1.88	1.47
EGA Bonnie Rock	AH/APW	3.67	3.96	**3.17**	**2.0**	***2.08***	***2.05***
GBA Shenton	AH^P	*	3.89	**3.24**		1.92	1.45
WAWHT_2499	AH^p	3.69	3.68	**3.15**	**1.84**	1.85	1.74
WAWHT_2525A	AH^p	4.16	3.61	3.05	**1.83**	1.91	1.52
Annuello	APW	*	3.5	2.55		1.77	1.27
EGA Blanco	APW	**4.78**	**4.15**	2.97	1.63	1.9	1.55
GBA Ruby	APW	*	3.81	**3.14**		1.97	1.55
Kukri	APW	*	3	2.86		1.59	1.39
Mitre	APW	*	3.74	3.01		1.67	1.24
Spear	APW	4.15	3.63	3		1.64	1.28
Westonia	APW	4.23	**4.17**	**3.12**	1.45	1.55	1.35
Pugsley	APW	*	**4.16**	**3.24**	**1.84**	1.82	***1.8***
Wyalkatchem	APW	***4.51***	**4.19**	**3.16**	1.65	1.93	**1.98**
Arrino	ASWN	4.02	3.59	2.94	1.35	1.82	1.68
Calingiri	ASWN	4.29	**4.28**	***3.38***	1.57	1.81	1.38
LSD (TOS*VAR)		0.30			0.2		
%CV		5.2			7.5		

NB: * denotes that Eastern States material not available at the time of planting; P denotes preliminary classification.

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KEY WORDS

wheat, varieties, agronomy, yield

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Paper reviewed by: Dr Wal Anderson

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Gairdner for high rainfall - where does Baudin fit in?

Blakely Paynter[1], Roslyn Jettner[2] and **Leanne Schulz[3]**, Department of Agriculture; [1]Northam, [2]Albany and [3]Esperance

KEY MESSAGES

- Gairdner and Baudin are high yielding barley varieties with superior export malt quality.
- In southern and central high rainfall areas, Gairdner is the variety of choice where growers are seeking tall crops for swathing and a variety with intermediate resistance to powdery mildew. Baudin should be selected where a short, stiffer-strawed variety is needed and where powdery mildew can be effectively managed.
- In medium rainfall and northern high rainfall areas, Baudin has a greater probability of meeting malting specifications than Gairdner because it has a rounder grain shape that translates to a lower level of screenings. Growers may choose to grow Gairdner because its taller straw offers ease of harvest in uneven terrain and it is less susceptible to net-type net blotch.
- In low rainfall areas, Baudin and Gairdner could be grown as early sown feed barleys with limited potential for delivery into the malting grade.

REGISTRATION OF BAUDIN BARLEY

In October 2003, the Western Malting Barley Council upgraded the Department of Agriculture's variety Baudin to the classification of General Malting. It has been commercially malted by Joe White Maltings in Ballarat for the past two years and brewed by the Swan and Kirin Breweries. Baudin represents a significant step forward in malting quality and should be well received by international barley markets, particularly Japan and China. The Western Malting Barley Council expects the release of Baudin will ensure Western Australia continues to be a preferred supplier of high quality malting barley.

CHARACTERISTICS OF BAUDIN VERSUS GAIRDNER

Baudin has a wider regional adaptation than Gairdner as its phenological development pattern is based on a high level of daylength sensitivity and a short basic vegetative period (Table 1). Baudin has a rounder grain shape and screenings should be lower by up to 5% through a 2.5 mm slotted screen. This plumper grain and high daylength sensitivity means that Baudin is less sensitive to changes in grain quality from altering crop management than is Gairdner and has wider adaptation to rainfall zones, sowing dates, rotations and soil types. It has advantages over Gairdner for straw strength and head loss, but is more susceptible to the leaf blotch diseases and powdery mildew.

Table 1. Comparison of Baudin and Gairdner for different traits

Genetics	Parents	Baudin	Gairdner
		Stirling x Franklin	**Onslow x Franklin 'sib'**
Phenology	Maturity group	Medium spring	Medium spring
	Basic vegetative period	Short	Medium-Long
	Daylength sensitivity	Very high	Medium
Physical traits	Early growth habit	Prostrate	Prostrate
	Height	Short	Medium
	Straw strength	Very good	Fair-Good
	Head retention	Very good	Moderately poor
	Grain plumpness	Moderately good	Fair
	Grain protein	Low protein variety	Low protein variety
	Pre-harvest sprouting	Low susceptibility	Low-Mod susceptibility
Disease resistance	Scald	Intermediate	Intermediate
	Net-type net blotch	Susceptible	Intermediate
	Spot-type net blotch	Susceptible	Susceptible
	Powdery mildew	Susceptible	Mod Susc/Intermediate
	BYDV	Moderately resistant	Resistant
	Barley leaf rust	Susceptible	Susceptible

Baudin appears to be more tolerant than Gairdner to a range of the registered herbicides for barley. Yield reductions to chlorsulfuron and picolinafen + MCPA have been noted for Baudin and to pendimethalin, metsulfuron and some mixtures containing MCPA for Gairdner.

GAIRDNER FOR HIGH RAINFALL - WHERE DOES BAUDIN FIT?

High rainfall areas

Gairdner is currently the highest yielding malting variety grown in high rainfall areas when sown early. It is the malting variety of choice for southern barley growers who require a tall crop for swathing to manage grain moisture at harvest. The intermediate resistance to powdery mildew is useful in areas with a high risk of powdery mildew infection reducing the cost of fungicide inputs and the risk of developing fungicide resistance.

Baudin can be selected as an alternative to Gairdner where a short, stiffer-strawed variety is useful at harvest to reduce lodging, head loss and excessive straw passing through the header. The strong straw strength allows Baudin to be sown following a legume crop or pasture (when screenings are managed) and the shorter stubble is an advantage in the following season for precision seeding using minimum tillage systems. Baudin may be sown later than Gairdner in southern high rainfall areas to reduce the risk from foliar fungal diseases however fungicide management of diseases such as powdery mildew, spot-type net blotch and barley leaf rust may still be required.

Central and northern high rainfall growers may benefit from the rounder grain shape and the more flexible development pattern of Baudin relative to growing Gairdner. Market signals suggest there is only room for one variety to be grown in the northern high rainfall areas, with a preference for Baudin.

Medium rainfall areas

Baudin has a greater probability of meeting malting specifications than Gairdner because it has a rounder grain shape that generally results in a lower level of screenings. However, crop management targeted at minimising screenings in Baudin is still critical in medium rainfall areas. Those growers receiving more than 400 mm annual rainfall will get greatest benefit from Baudin. Selecting a soil type with good moisture holding capacity and sowing during the second week in May increases the opportunity for Baudin to meet the malting specifications. Baudin also has a wider adaptation to a range of soil types. It displays a similar leaf reaction to boron toxic soils as for Gairdner, but performs better than it looks. The shorter straw is useful in continuous cropping situations.

Barley growers may choose to continue growing Gairdner because its taller straw allows for greater ease of harvest in uneven terrain and it is less susceptible to the fungal disease net-type net blotch. Gairdner is less sensitive to daylength and may be more suitable than Baudin for sowing in late April.

Low rainfall areas

Gairdner and Baudin could be sown as feed barleys with a limited potential for delivery as a malting barley except when spring conditions are favourable for achieving the malting specification. Gairdner has been successfully sown in late April on summer rain and will flower in the middle to later part of August. Seeding of Baudin should be delayed until May.

KEY WORDS

barley, Baudin, Gairdner, malting

ACKNOWLEDGMENTS

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Paper reviewed by: Christine Zaicou-Kunesch, Department of Agriculture

Oaten hay - varieties and agronomy

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[1]Northam and [2]Katanning

KEY MESSAGES

- Cutting time is important - earlier cutting leads to increased water soluble carbohydrates, increased digestibility and decreased neutral detergent fibre. Target watery ripe to early milk.
- Hay yields of the milling variety Carrolup and feed variety Wandering were similar to the best hay varieties - Winjardie, Brusher and Wintaroo - in 2003.
- The milling variety Carrolup is accepted by most export hay companies because it has a thin stem; but the new hay variety Wintaroo has the advantage of not browning off with hot, dry winds and has a darker leaf colour. Wintaroo is a high quality, purpose bred hay variety.

AIMS

Half a million tonnes of oaten hay is grown annually for export, on-farm use or traded domestically in Western Australia. The Department of Agriculture in partnership with the South Australian Research and Development Institute ('National Oat Breeding Program') are evaluating oaten hay varieties for Western Australia. The aim is to provide variety specific information for hay production.

HAY RESEARCH TRIALS IN WESTERN AUSTRALIA IN 2003

In 2003, six oaten hay variety trials were sown between Wongan Hills in the north to Katanning in the south. The agronomy program established three trials (10 varieties including two breeding lines) at Beverley, Williams and Katanning. The National Oat Breeding Program established three trials (18 varieties including six breeding lines) at Wongan Hills, York and Narrogin. The common varieties sown at all sites were Carrolup, Swan, Vasse, Wandering, Winjardie and Wintaroo. The trials were sown in late May to early June with small plot seeders to establish between 200 to 360 plants/m^2. Plots were sampled at the early milk stage (Z73-Z75) to determine hay yield. Sub-samples were taken, milled to 1.0 mm with a Cyclotec mill and analysed through a NIRS6500 for hay quality.

In addition, agronomic research trials were conducted at four locations (Calingiri, Meckering, Narrogin and Katanning) to examine the relationship between nutrition on hay yield and hay quality. One trial series evaluated the influence of phosphorus supply and another the influence of nitrogen interactions with potassium supply. The export hay company Gilmac also has privately funded research trials looking at the influence of nutrition, seeding date, seeding rate and cutting time on yield and quality.

RESULTS

Hay yields of 10 t/ha were recorded at all sites except Narrogin. Carrolup was the first variety to be cut for hay at each site, being cut in early to mid October. Swan and Wandering were cut within a few days of Carrolup, whilst Wintaroo was cut around one week later, Vasse 2 weeks later and Massif some three weeks later. Significant variability in hay yield was present at each site with CV% between 10% and 20%. Significant differences in hay yield were observed at all sites except Narrogin. Across sites, hay yields of Bettong, Esk, Eurabbie, Glider, Marloo, Massif and Vasse were generally inferior to the other varieties. Hay yields of the other four named varieties were similar to the milling variety Carrolup and the new hay varieties Brusher and Wintaroo.

Of the breeding lines evaluated, four (WAOAT2159, SV95073-13, SV96171-18-1 and SV97082-33) had similar hay yields to Brusher and Wintaroo. Hay yields of the most advanced hay breeding line SV93072-43 (scheduled for release in 2005) were inferior to Brusher and Wintaroo.

A Minolta SPAD meter was used to record green leaf colour (or chlorophyll content) of the top three leaves when cut for hay on two agronomy trials. Differences in green leaf colour were noted with varieties such as Swan and Wintaroo having higher chlorophyll content than Carrolup and Winjardie. Wintaroo is a variety that has a stay green trait and the florets needs to be monitored to ensure it is cut at the right time. Higher chlorophyll content was also noted in the two breeding lines - WAOAT2159 and WAOAT2177 - sown in those trials.

Table 1. Adjusted hay yield (t/ha and as % of Carrolup) at six different locations in 2003

Variety	Wongan	York	Beverley	Narrogin	Williams	Katanning
Date sown	**13 June**	**4 June**	**1 June**	**4 June**	**11 May**	**27 May**
Carrolup	**11.45**	**10.44**	**10.20**	**5.71**	**9.67**	**10.46**
Bettong	84%	84%	-	93%	-	-
Brusher	104%	95%	-	110%	-	-
Esk	-	-	82%	-	87%	89%
Eurabbie	74%	79%	-	108%	-	-
Glider	80%	89%	-	98%	-	-
Marloo	84%	76%	-	112%	-	-
Massif	-	-	87%	-	82%	94%
Swan	94%	81%	95%	112%	109%	93%
Vasse	77%	90%	95%	94%	106%	78%
Wallaroo	88%	105%	-	107%	-	-
Wandering	88%	88%	113%	105%	93%	85%
Winjardie	98%	86%	110%	116%	92%	94%
Wintaroo	100%	95%	121%	114%	93%	96%
LSD($P < 0.05$)	12%	15%	18%	n.s.	16%	17%

AGRONOMIC MANAGEMENT PACKAGE FOR EXPORT HAY

- Export hay company - talk to your local export hay company before sowing oats for hay. Find out what they want first, when they want it and their contractual arrangement. Each export hay company has differing requirements that may affect how you manage your crop.
- Seeding rate - Target 240 to 320 plants/m2 (110 to 150 kg/ha depending on variety grain size). Higher is not always better as it can lead to reduced stem thickness in inherently narrow stem varieties like Wintaroo. Higher seeding rates however do offer better weed competition.
- Nitrogen fertiliser application - between 45 to 60 kg N/ha (too much N will lead to a leggy crop and adversely affect hay quality).
- Row spacing - maximum of 180 mm (to assist with keeping hay swath off ground).
- Variety choice - sow different varieties to spread out cutting time.
- Paddock preparation - roll paddocks after seeding (minimises contamination).
- Weed control - choose paddocks with low ryegrass and wild oat burdens and control in-crop capeweed and radish.
- ARGT management - look to implement an ARGT management plan through the introduction of the twist fungus (Farmnote 22/2002). There is nil tolerance of ARGT for export and with export hay becoming a prescribed product, testing for ARGT will become compulsory.
- Disease control - check withholding periods on labels of all fungicides being considered for use. Do not apply fungicide within withholding period.
- Cutting time and management - usually occurs in October. Hay yield and quality are maximised when it is cut around early milk. Varieties with good colour like Wintaroo need to be monitored carefully, to make sure that they are cut at the right stage. The use of super conditioners can reduce the risk of weather damage by reducing the interval between cutting and baling from 10 to 14 days down to 4 or 5 days.

KEY WORDS

oaten hay, oat varieties, agronomy

ACKNOWLEDGMENTS

This research was conducted by Jocelyn Ball, Natalie Clark, John Sydenham and Toni Cure from the Department of Agriculture, Pamela Zwer and Peter McCormack from the South Australian Research and Development Institute and Bill Roy from Agricultural Consulting and Research Services. GRDC and RIRDC have provided additional funds to the host organisations for this research.

Project No.: DAW705 and National Oat Breeding Program

Paper reviewed by: Pamela Zwer, South Australian Research and Development Institute

In-furrow fungicide applications in liquid fertiliser

Dr Stephen Loss, CSBP Ltd

KEY MESSAGES

- The application of liquid fertilisers through seeders can provide improvements in nutrient efficiency compared to granular applications while allowing the simultaneous application of in-furrow fungicides and trace elements.
- The application of in-furrow fungicides and trace elements in liquid fertilisers provides considerable savings and increases flexibility to vary the rate of fertiliser and additives independently.
- Field research under low disease pressures suggests that the application of fungicides coated on solid fertilisers or mixed with liquids are equally effective.
- The simultaneous application of liquid fertiliser, fungicides and trace elements can result in precipitation and machinery blockages, but these are overcome by pre-mixing with water and good agitation before and during application.

BACKGROUND AND AIM

The adoption of liquid fertilisers in WA has been rapid, and over the past three years a large proportion of farmers have discarded granular Urea in favour of Flexi-N (urea ammonium nitrate solution, 32% N w/w). Most farmers adopting Flexi-N apply it through their existing boomsprayers because there is no expense associated with specialised machinery. However, in recent years, some large farmers have chosen to band liquid fertilisers through seeders as is common in North America. Seeder applications of liquid fertilisers may provide some improvements in nutrient use compared to granular applications and also allows the simultaneous application of in-furrow fungicides and trace elements.

Interest in the application of in-furrow fungicides with liquid fertilisers expanded during 2003 following the outbreak of stripe rust in WA in the previous season. Not only is mixing fungicides with liquid fertilisers cheaper than coating granular fertilisers (a saving of about $20 per tonne), but it provides flexibility for the farmer to vary fertiliser and fungicide application rates independently from paddock to paddock. Also, fungicide distribution in the furrow is likely to be more uniform in liquid fertilisers. CSBP, in collaboration with others, have been investigating these aspects of seeder-applied liquid fertilisers in recent years.

METHODS

Application of in-furrow fungicides with Flexi-N was evaluated in an initial field trial at Moora in 2002. The trial was sown with Carnamah wheat and included a nil fungicide treatment, 400 mL/ha Impact® or 1 L/ha Triad (EC formulation 200 gai/ha) in 100 L/ha Flexi-N banded 3-4 cm below the seed.

A series of nine more comprehensive trials were conducted in 2003 from Eradu down to Esperance with the aim of comparing disease management strategies. The trial designs varied from location to location, including the following treatments:

1. In-furrow fungicides (Impact® and Triad) coated on Agstar (15:13:0:11, starter fertiliser) or mixed with Flexi-N banded below the seed, drilled with the seed or applied on-furrow after the presswheel.
2. Seed dressing fungicides (Jockey® and Real®) and foliar fungicides (Tilt® and Triad).
3. A range of wheat varieties of varying disease susceptiblity (Arrino, Brookton, Carnamah, H45, Janz, Westonia, Wyalkatchem).

In most cases the trial plots were 2.1 m (9 rows) by 20 m long, arranged in a randomised block design with three replicates. All sites received 14 kg P/ha, 56-77 kg N/ha and K where soil levels were marginal.

RESULTS AND DISCUSSION

The main diseases present in the 2002 trial were *Septoria nodorum*, Powdery Mildew and a slight infection of Leaf Rust. The application of 400 mL/ha Impact® banded with the Flexi-N produced an

11% yield increase (450 kg/ha) above where no fungicide was applied. Triad was less effective in this trial. Based on a wheat farm gate price of $160/t and an Impact® cost of $18/ha, there was a net return of $54/ha. However, this trial did not include Impact® coated on the granular fertiliser to test whether the effectiveness of the fungicide was affected by the carrier.

Unfortunately, disease pressures were exceptionally low across the state in 2003, and there were no yield responses to fungicide applications at most sites. At Yealering, Condingup and Salmon Gums there were no significant diseases detected in the trials during the year, however, there were significant yield increases (up to 19% or 800 kg/ha) with the application of Impact® or Triad (Figure 1). Based on the same assumptions as above, the application of 400 mL/ha Impact® banded with the Flexi-N produced a net return of $71/ha in the absence of any detectable disease at Salmon Gums. The fungicides appeared equally effective when applied on solid or in liquid fertilisers, whether drilled with the seed or banded 3-4 cm below. Seed dressings and foliar applications also appeared to be effective under low disease pressure. These trials need to be repeated under greater disease pressure to generate more robust information, however, the data to hand suggest the application of in-furrow fungicides is equally effective when mixed with liquids or coated onto granular fertilisers.

Trial and farmer experience indicate there are few problems when mixing and applying Impact® in-furrow with Flexi-N, Flexi-NS or Liqui-NS. More problems were experienced with Triad depending largely on the manufacturer's formulation. Typical problems included separation of the fungicide and liquid fertiliser with a build up of residues on the filters over time, or precipitation of solid materials which block the orifice plates or nozzles, particularly where trace elements were also added. One formulation of Triad included a solvent which was particularly corrosive on the distribution hoses and rubber seals. Both Impact® and Triad require good tank agitation with liquid fertilisers before and during application, especially where the distribution hoses are long which provide an opportunity for separation. Premixing the additives with water and flushing the whole system with water at the end of each day (or once every 24 hours) are also recommended. Regular checks of filters, orifice plates and nozzles are also recommended.

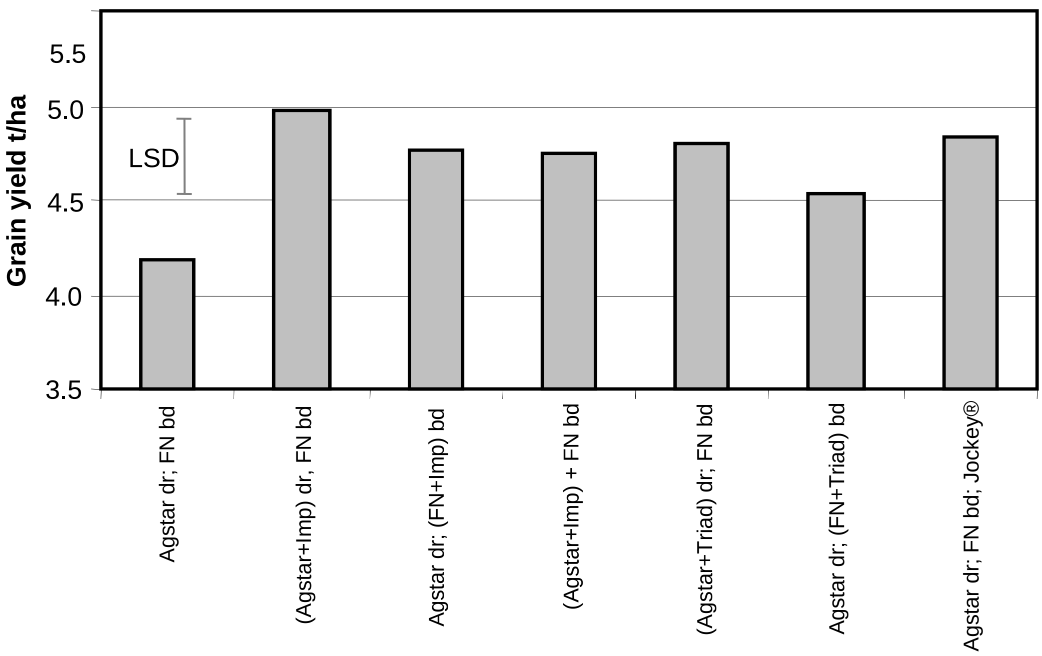

Figure 1. Wheat (H45) yields at Salmon Gums 2003 to various fungicide applications (LSD = least significant difference at 5% probability). FN = Flexi-N, Imp = Impact®, dr = drilled, bd = banded.

KEYWORDS

disease, plant nutrition, wheat, fluid fertiliser

Paper reviewed by: James Easton and Eddy Pol

Elemental sulphur as a fertiliser source in Western Australia

Ashleigh Brooks[1], **Justin Fuery**[2], **Geoff Anderson**[3] and **Prof Zed Rengel**[1]
[1]UWA, [2]Summit Fertilisers and [3]Department of Agriculture; Merredin

KEY MESSAGES

Wheat has a low efficiency of utilisation of sulphate applied at seeding on high rainfall, sand plain country. This is due to: (i) the soils having a low capacity to adsorb sulphate; and (ii) leaching rainfall in June and July. An alterative source of sulphur is elemental S. Experimental results confirm elemental S is a good slow release fertiliser and not subject to loss by leaching. It was hypothesised that soils with a history of elemental S application will have a higher rate of elemental S oxidation than soils without such a history. However, this was not supported by the results from either the column or glasshouse experiments. It appeared the native microbial populations which oxidise elemental S to sulphate were able to respond quickly to additions of elemental S, and a priming effect of a history of elemental S application might not be required for rapid oxidation of elemental S. For elemental sulphur to be an effective fertiliser, the particle size of the material needs to be less than 0.2 mm. At this particle size elemental sulphur is oxidised by the soil micro-organisms at a sufficient rate to satisfy plant demand for sulphur.

AIMS

The aim of the study was to examine factors which influence the effectiveness of elemental S as a sulphur fertiliser in WA agricultural soils. Two experiments were conducted in 2003. The aims of these experiments were:

(i) to compare leaching of ammonium sulphate and elemental S in cropping and pasture soils of different S fertiliser histories; and

(ii) to compare the root and shoot growth of canola (*Brassica napus* L.) fertilised with increasing rates of either ammonium sulphate or elemental S in pasture soils with different S fertiliser histories.

METHOD

Soil column experiment

The soils were collected from three farms near Piawanning. The sites had different land-use histories (crop or pasture) and different S fertiliser histories (sulphate S or elemental S).

A four-factor factorial experiment (land use history, S fertiliser history, S fertiliser source and application rates) was set up using soil columns. Elemental S and $(NH_4)_2SO_4$ at three rates (10, 50 and 250 mg S/kg) were applied to the top of pasture soil columns and were banded 5 cm deep for the cropping soils. The columns were then saturated to field capacity. Twenty mL of distilled water was applied daily for 42 days. Leachate was collected eight times over this period. Sulphate content of the leachate was measured using the turbidimetric method.

Glasshouse experiment

Canola (variety *Monty*) was grown in pots containing 3 kilograms of pasture soil. The experiment had three factors (S fertiliser sources and rates and soil S fertiliser history) and two replicates. Rates of S fertilisers were 0, 8, 16 and 32 mg S/kg soil. After 39 days of growth, the above-ground biomass was cut off just above the soil level and roots washed from the soil. Oven-dried roots and shoots (70^{o}C, five days) were weighed and analysed for S content.

RESULTS

Column experiment

Pasture soils had a lower rate of sulphate leaching when fertilised with elemental S compared to sulphate S. This difference generally increased with an increasing rate of fertiliser application.

The largest amount of sulphate leaching occurred earlier for the cropping soils compared to pasture soils. This effect was due to the placement of the fertiliser below the soil surface in the case of the cropping soil compared to surface placement for pasture soils. Again, the cropping soil, which was fertilised with sulphate fertiliser, had greater amount of sulphate leaching compared to soils fertilised with elemental S (Figure 1).

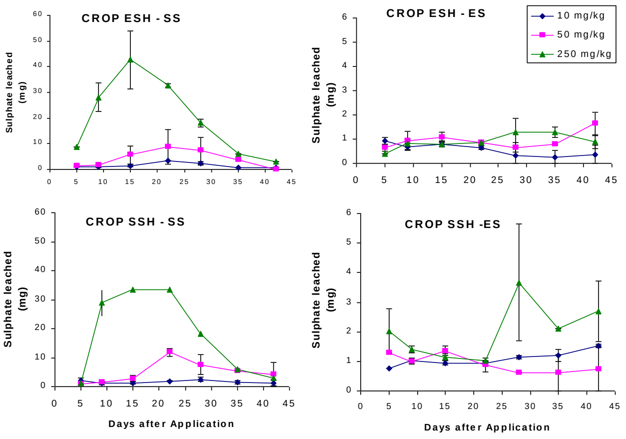

Figure 1. Leaching of sulphate from cropping soils of different S fertiliser histories (SSH = sulphate S, and ESH = elemental S history) fertilised with sulphate S (SS) and elemental S (ES) at three rates.

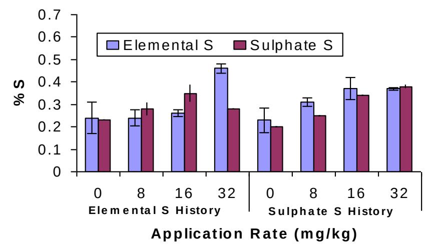

Figure 2. Sulphate concentration of canola root dry matter grown in soils of different S fertiliser histories (sulphate S or elemental S) that have received different forms of S of S (sulphate S or elemental S).

Glasshouse experiment

Shoot S content was greater when S fertiliser was sulphate S compared to the elemental S. In addition, shoot S content increased as the application rate of both S fertiliser sources increased. An increase in the application rate of sulphate S resulted directly in an increase in the amount of sulphate available for root uptake. In contrast, an increase in the amount of elemental S applied to the soil increased the surface area of contact between elemental S particles and S-oxidising micro-organisms, stimulating sulphate production for root uptake. The lack of significance between the fertilisers indicates that elemental S was equally effective as sulphate S in supplying sulphate to canola roots.

CONCLUSION

Sulphate S and elemental S fertilisers showed a similar capacity to supply sulphate to canola roots regardless of the fertiliser S history of the soil, suggesting that a priming effect of a history of elemental S application may not be required for rapid oxidation of elemental S. The low rate of sulphate leaching from the elemental S treatments suggests that elemental S has the potential to increase the efficiency of utilitation of S fertiliser applied at seeding in the cropping zone of Western Australia. However, given difficulties in handling elemental S of fine particle sizes, further research is required into procedures for incorporating fine elemental S into fertiliser granules.

KEY WORDS

fertiliser, sulphate, elemental sulphur

ACKNOWLEDGMENTS

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Paper reviewed by: Sandy Alexander

Genotypic variation in potassium efficiency of barley

Paul Damon and **Prof. Zed Rengel**, Faculty of Natural and Agricultural Sciences, UWA; Crawley, Western Australia

KEY MESSAGE

There are significant differences between barley varieties in their ability to grow where soil potassium (K) availability is suboptimal. There are also significant differences between barley varieties in potassium (K) efficiency ratio (= growth at suboptimal K / growth at optimal K) and thus growth response to soil K availability. Varieties have been identified which grow relatively well whether soil K availability is suboptimal or optimal.

AIMS

Better understanding of K cycling in soils and crops is important for improved grain production in WA, given the increased recognition of importance of applying K fertilisers. This study was aimed at identifying barley genotypes differing in uptake and utilisation of K to improve our knowledge of how varieties may be utilised to manage soil K in WA cropping systems.

METHOD

One hundred varieties of barley were grown in an evaporatively-cooled glasshouse in Perth, WA (31.58 S, 115.49 E) during September to November 2003. Virgin dark yellowish brown sand low in exchangeable K (11.7 mg K/kg) was collected from from near Watheroo, WA (MRA 6, A1 horizon; McArthur, 1991).

Plants were grown in sealed pots 7cm square and 16 cm deep containing 700 g of air dry soil. Soil was amended with (in mg/kg soil) N (66); P (20); Ca (41); Mg (8); S (14); Mn (3); Zn (2); Cu (0.5); B (0.1); Co (0.1) and Mo (0.1). Basal nutrients were applied to the soil surface in each pot, allowed to dry, and then mixed through the entire soil volume. Potassium was applied at either 0 (suboptimal K) or 88 mg K/kg soil (optimal K). Pots were watered to maintain gravimetric moisture content around 12% (w/w) using de-ionised water.

Replicates 1 and 2 were grown for a period of 28 days (avg temp 19.2°C) during September and October, while Replicate 3 was grown for 22 days during November (ave. temp. 21.3°C). Replicate 3 was harvested at approximately the same growth stage as replicates 1 and 2. Whole tops were dried at 65°C for 48 hours, allowed to cool and weighed. The K efficiency ratio was calculated as the ratio of total above-ground dry weight at suboptimal K to total above-ground dry weight at optimal K. Potassium efficiency ratio represents the relative response to soil K availability: a high K efficiency ratio indicates that a variety can produce similar dry weight at either optimal or suboptimal soil K.

RESULTS

Above ground dry weight

Plants grown at suboptimal K showed leaf symptoms consistent with K deficiency two weeks after sowing and growth was significantly reduced at harvest ($P < 0.001$ for the genotype effect). Mean dry weight for all varieties at suboptimal K ranged from 0.44 to 0.77 g/pot (average = 0.54 g/pot). In contrast, mean dry weight across varieties ranged from 0.64 g to 1.33 g/pot at optimal K (average = 0.96 g/pot).

Efficiency ratio

Varieties differed significantly in the K efficiency ratio based on above-ground dry weight ($P < 0.001$), with mean K efficiency ratio ranging from 0.43 to 0.73 (Figure 1). Efficiency ratio was determined primarily by the dry weight at optimal soil K. This may be because dry weight at optimal K had more leverage than dry weight at suboptimal K.

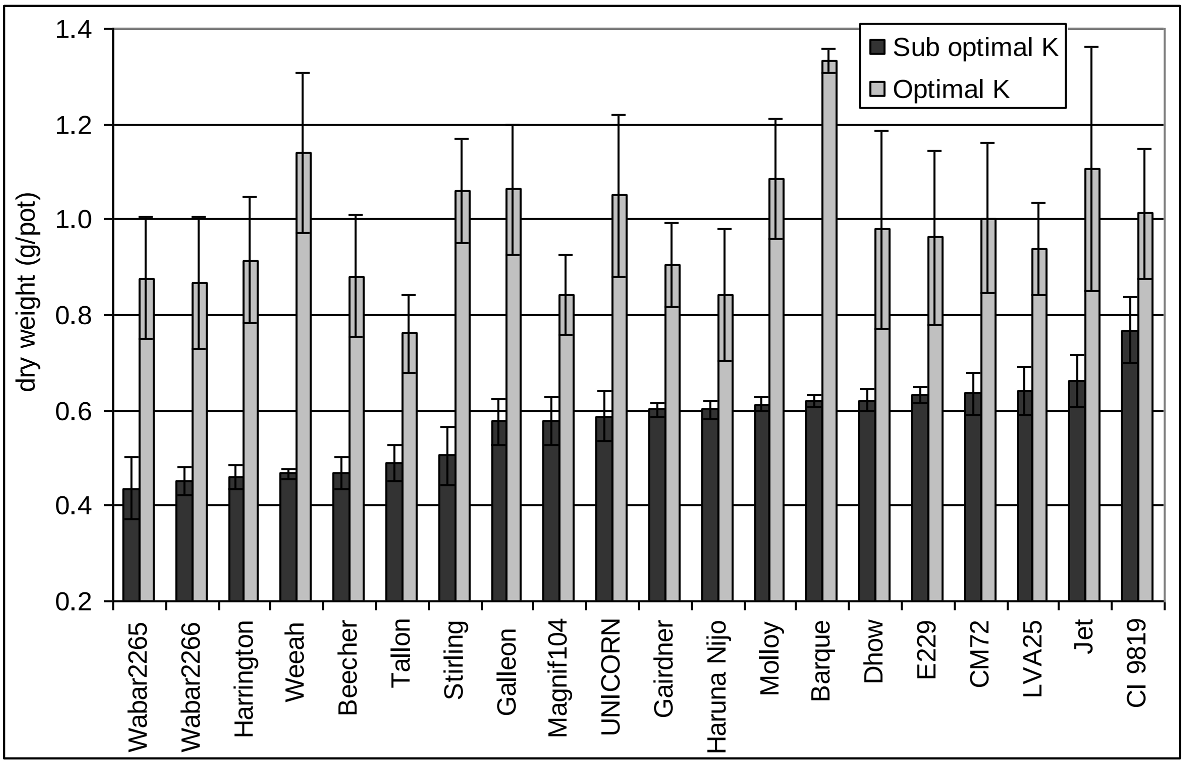

Figure 1. Above ground dry weight per pot of barley at optimal and suboptimal K. Only the best 13 and worst 7 varieties at suboptimal K are shown. Error bars are standard errors of means. LSD (5%) for optimal K = 0.12 LSD (5%) for suboptimal K = 0.07.

Potassium uptake and concentration

Chemical analysis will be conducted on above-ground tissue samples of varieties identified as relatively efficient and relatively inefficient. This information may elucidate differences between varieties in uptake and utilisation of potassium and explain the observed differences in growth where K is at the suboptimal level.

CONCLUSION

There is significant variation between barley varieties in their growth where soil K availability is suboptimal. Cultivars Barque, Molloy and Jet grew relatively well at either optimal or suboptimal soil K (good growth and high K efficiency ratio). Stirling and Weeah grew relatively well at optimal soil K but not where soil K was suboptimal (low K efficiency ratio). Chemical analysis of tissue K concentration will provide knowledge of the capacity for varieties to take-up soil K and of their K requirement. Together, this knowledge will increase our understanding of how soil K can be better managed in WA cropping systems.

KEY WORDS

barley, potassium

ACKNOWLEDGMENTS

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GRDC Project No.: UWA00031

Paper reviewed by: Dr Bill Bowden, Department of Agriculture, Northam

Genotypic variation in potassium efficiency of wheat

Paul Damon and **Prof Zed Rengel**, Faculty of Natural and Agricultural Sciences, UWA; Crawley, Western Australia

KEY MESSAGE

There is a large variation between wheat varieties in their ability to grow under low soil potassium (K) conditions. Varieties also differed significantly in K efficiency and hence response to K availability. Varieties with high yield potential at both adequate and suboptimal soil K levels have been identified.

AIMS

Better understanding of K cycling in soils and crops is important for improved grain production in WA, given the increased recognition of importance of applying K fertilisers. Potassium efficiency is a measure of the ability of plants to produce optimal yield in soils with suboptimal K availability. This study was aimed at identifying wheat genotypes differing in K efficiency to improve our knowledge of how soil K can be managed in WA cropping systems.

METHOD

Field trial

One hundred varieties of wheat were grown to maturity in a K-responsive sand (containing 19 mg of extractable K/kg soil in the 0-10 cm profile (A1-A2)) at the UWA Shenton Park Field Station, from May to November 2003 (172 days). Germplasm was selected for maximum genetic diversity. Attention was paid to include local, agronomically desirable lines and current advanced breeding lines from the Department of Agriculture to maximise the direct benefit of the research to WA farming systems.

Total rainfall received at the site during the experimental period was 480 mm. No symptoms of water stress were observed. Di-ammonium phosphate was broadcast at sowing and then at two to four weekly intervals at 200 kg/ha. Urea was broadcast at 90 kg/ha 14 weeks after sowing (WAS) when most varieties were between booting and anthesis. Calcium, Mg, S and trace elements were applied as 'Manutec' trace element blend broadcast at 50 kg/ha at 5 and 20 WAS. Potassium was applied as muriate of potash (KCl) broadcast at either 0 (suboptimal K) or 50 kg/ha (optimal K) at sowing and then every two to four weeks (200 kg KCl/ha total). Plots were single rows, 80 cm long and 30 cm apart. Plots were sown with 20 seeds and were thinned to about 16 plants per plot 2 WAS.

Mature plants were harvested in November; 25 WAS. Harvested whole tops were dried and weighed. Seed was collected by threshing whole tops and separating harvestable seed from small seed and other plant material on a Clarke Seed Cleaner. Seed was dried at 65°C for 48 hours, then allowed to cool and weighed. Potassium efficiency ratios for the above-ground biomass and grain yield were calculated as the ratio of dry weight at suboptimal K to dry weight at optimal K. Harvest index was calculated as the ratio of grain dry weight to above-ground dry weight.

Glasshouse

One hundred and fifty-four varieties of wheat were grown in an evaporatively-cooled glasshouse (ave. temp. 17.4°C) in Perth, WA (31.58 South, 115.49 East) for six weeks in May and June 2003. Virgin dark yellowish brown sand low in exchangeable K (11.7 mg/kg) was collected from near Watheroo, WA (MRA 6, A1 horizon; McArthur, 1991). All varieties grown in the field experiment were also grown in the glasshouse experiment.

Plants were grown in sealed pots 7 cm square and 16 cm deep containing 700 g of air-dry soil with (in mg/kg soil) N (66); P (20); Ca (41); Mg (8); S (14); Mn (3); Zn (2); Cu (0.5); B (0.1); Co (0.1) and Mo (0.1). Potassium was applied at either 0 (suboptimal K) or 88 mg K/kg soil (optimal K). Pots were watered to maintain gravimetric moisture content around 12% using de-ionised water as required.

Plants were harvested at 6 WAS. Whole tops were dried at 65°C for 48 hours, allowed to cool and weighed. The K efficiency ratio was calculated as the ratio of total above-ground dry weight per pot for –K treatment to total above-ground dry weight per pot for +K treatment.

RESULTS

Field trial

Statistical analysis (ANOVA) showed significant variety x K treatment interaction for grain yield ($P < 0.001$) and the above-ground dry weight ($P < 0.1$). This suggests that growth and yield penalties due to K deficiency differ between varieties. Mean dry weight per plant at maturity for the –K treatment varied from 0.3 to 15.5 g for above-ground biomass and from 0.04 (Westonia) to 5.46 g (Cunderdin) for grain yield.

There was a significant difference between varieties in the efficiency ratio for grain yield ($P < 0.001$) and above-ground dry weight ($P < 0.001$). The K efficiency ratio for grain yield varied from 0.02 (Westonia) to 1.3 (Cross 105) (average across all varieties 0.56). The K efficiency ratio for above-ground dry weight at maturity varied from 0.07 (Westonia) to 1.05 (Cunderdin) (average across all varieties 0.64).

The variety x potassium interaction effect was significant for harvest index ($P < 0.005$). The K efficiency ratio for grain dry weight was correlated with harvest index at low K and with K efficiency ratio for above-ground dry weight ($P < 0.001$). However, ranking of genotypes for K efficiency based on grain dry weight was different from that based on the above-ground dry weight. Grain yield at low K was strongly correlated with K efficiency ratio for grain dry weight ($P < 0.001$).

Cascades, Wyalkatchem, Wawht2147, Wawht2213, Brookton, WAWHT2661, Carnamah and Cunderdin all produced high grain yield at low K and similar grain yield at adequate K. Stilletto, Warigal, Perenjori, WAWHT2281, WAWHT2394 and Spear produced high grain yield at low K, but produced considerably better grain yield at adequate soil K (so had a low K efficiency ratio).

Glasshouse

The variety x potassium interaction for total above-ground dry weight was significant ($P < 0.001$). Mean above-ground dry weight varied among genotypes from 0.04 to 0.51 g/pot for the –K treatment 6 WAS. The genotype effect significantly influenced the K efficiency ratio ($P < 0.001$). The K efficiency ratio based on dry weight at 6 WAS varied from 0.12 to 0.47.

Growth of wheat plants in the glasshouse was not correlated with top dry weight or grain yield of the same varieties in the field. Furthermore, K efficiency ratios measured in the glasshouse were not significantly correlated with efficiency ratios based on grain dry weight in the field. However, K efficiency ratios for above-ground dry weight in the glasshouse and the field were significantly correlated ($P < 0.1$). The growth responses observed in the glasshouse may therefore be a good indication of the ability of varieties to perform in the field.

CONCLUSION

Varieties of wheat which are efficient and inefficient for growth and yield where K is suboptimal have been identified. Analysis of content and concentration of K in tissue will provide knowledge of K uptake and utilisation for these varieties. This information will improve our understanding of how K cycling in WA cropping systems can be managed.

KEY WORDS

wheat, potassium

ACKNOWLEDGMENTS

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GRDC Project No.: UWA00031

Paper reviewed by: Dr Bill Bowden, Department of Agriculture, Northam

Managing protein through strategic N applications

Eddy Pol and **Dr Stephen Loss**, CSBP Ltd

KEY MESSAGES

- Growers may be able to boost protein contents of cereals by the late application of 30-50 L/ha Flexi-N in wet seasons where yields are likely to be high.
- More work is needed to reliably predict the benefits of late Flexi-N application and investigate ways to avoid leaf scorch.
- Growers should remember they are primarily paid for yield, and should continue to ensure good early N so that crop yield is not compromised, especially in Gairdner barley where late Flexi-N applications tended to exacerbate high screenings.

BACKGROUND

Many areas of Western Australia produce wheat with low protein content, especially in wet years when nitrogen (N) applied at seeding is lost through leaching and yields are not limited by a lack of moisture in spring. Wheat protein can be increased with late application of Urea, however, the benefits are highly dependent on rainfall after application. As Flexi-N (urea ammonium nitrate solution, 32% N w/w) can be taken up directly by the leaves, it should provide more reliable increases in protein. In the United Kingdom and elsewhere, late applications of liquid N are applied at head emergence through to soft dough stages to boost wheat protein.

From 2000 to 2002, CSBP conducted a number of trials investigating the ability of Flexi-N applied at flag leaf to flowering stages to increase wheat protein content. Dry seasonal conditions at most sites resulted in low yield potentials and high protein contents, and late Flexi-N application was not advantageous. At some sites late Flexi-N application caused some scorching of the flag leaf, especially with rates above 70 L/ha applied when the crop was beginning to suffer from moisture stress. Nonetheless, there were significant increases in grain protein and profits with late applications of Flexi-N at three sites where yields were 3 t/ha or more. These results led CSBP to undertake additional trials in 2003.

METHODS

Two field trials were conducted at Yerecoin and Meckering in 2003 to investigate the effects of late Flexi-N application on Prime Hard wheat (Carnamah), Noodle wheat (Calingiri) and Malting barley (Gardiner). The plots were 2.1 m (9 rows) by 40 m long, arranged in a randomised block design with three background N rates (13, 55 and 97 kgN/ha). Both sites were supplied with more than adequate phosphorus and potassium fertiliser. At the flag leaf stage of Carnamah, half of the trials were sprayed with 50 L/ha Flexi-N (neat) in a split plot design.

Two other opportunistic trials were also conducted in farmer-sown paddocks. At Dowerin, Flexi-N was applied at nil, 38 and 76 L/ha to Tamaroi (durum) wheat at the flag leaf stage, including three replicates. At Eradu, Flexi-N was applied at nil, 50 and 100 L/ha to Calingiri wheat at the milky dough stage, including two replicates.

RESULTS AND DISCUSSION

Seasonal conditions were favourable at the main trial sites and hence both were relatively high yielding (up to 3.8 t/ha at Yerecoin and 4.8 t/ha at Meckering) and N responsive (Table 1). Yield responses to background N application were about 0.7 t/ha at Yerecoin and 1.0 t/ha at Meckering. At Yerecoin, the late application of Flexi-N caused no detectable leaf scorch and increased yields in all varieties by an average of 0.47 t/ha - the improved growth and yield potential were visually apparent within 7-10 days of the Flexi-N application. Screenings were less than 3% in both wheat varieties, regardless of the late Flexi-N treatment, but in the Gairdner barley, late Flexi-N increased screenings from on average 17 to 26%, especially at the high background N level. Hectolitre weights were unaffected by the late Flexi-N treatment in all three varieties.

At Meckering, the yields were somewhat variable and the late application of Flexi-N had no significant effect on yields in all varieties. Scorch damage on the flag leaf was rated as up to 10% in Carnamah. Screenings were less than 8% in both wheat varieties, with a significant trend of higher screenings with the late Flexi-N treatment. In the Gairdner barley, late Flexi-N increased screenings from on average 43 to 65%, especially at the high background N level. Hectolitre weights were also reduced with the late Flexi-N treatment.

Unfortunately, grain protein data was not available for the Yerecoin site at the time of preparing this paper. At Meckering, grain protein was increased by about one percent with the late application of Flexi-N, regardless of the variety or background N treatments.

At Dowerin, the application of 38 L/ha Flexi-N at the flag leaf stage increased Tamaroi wheat protein from 12.3 to 12.8%, and to 13.4% when this was increased further to 76 L/ha (data not presented). Flag leaf damage was less than 5% at the high Flexi-N rate. Grain yields (3.45 t/ha), screenings and hectolitre weights were unaffected by the late Flexi-N treatments. At Eradu, the application of 50 L/ha Flexi-N increased protein content of Calingiri wheat from 9.2 to 10.0% and this increased to 10.6% at 100 L/ha. Leaf scorch was rated as up to 50% at 100 L/ha, but yields (3.42 t/ha), screenings and hectolitre weights were unaffected by this leaf damage.

These results and previous trial data demonstrate that growers can increase the protein contents of cereals by late applications of 30-50 L/ha Flexi-N where yields are likely to be high. Cereal payment structures are primarily geared towards yield, and growers should continue to ensure good early N supply so that crop yields are not compromised. This is especially the case in Gairdner barley where late Flexi-N applications tended to exacerbate high screenings. More work is needed to reliably predict the benefits of late Flexi-N application and investigate ways to avoid leaf scorch and high screenings.

Table 1. Effect of late Flexi-N (FN) on grain yield, protein, hectolitre weight and screenings of three cereal varieties at two sites in 2003. * protein data for Yerecoin site was unavailable when preparing this paper

YERECOIN

Variety	Backgrnd N kg/ha	Grain Yield t/ha		Grain Protein %		Hectolitre kg/HL		Screenings %	
		No late FN	Late FN	No late FN	Late FN	No late FN	Late FN	No late FN	Late FN
Carnamah	13	2.121	2.637	*	*	79.8	80.3	2.3	2.4
Carnamah	55	2.366	2.921	*	*	79.5	80.0	2.2	2.3
Carnamah	97	3.318	3.695	*	*	77.9	79.7	1.9	1.8
Calingiri	13	2.529	3.102	*	*	78.4	79.6	2.2	2.3
Calingiri	55	2.554	3.199	*	*	78.7	79.6	2.6	2.3
Calingiri	97	3.034	3.782	*	*	78.9	78.8	2.8	2.9
Gairdner	13	1.929	2.632	*	*	68.2	66.0	12.6	18.1
Gairdner	55	2.733	3.282	*	*	66.1	65.8	15.1	23.7
Gairdner	97	3.110	3.612	*	*	66.2	65.0	22.8	36.9
	Mean	2.633	3.207			74.8	75.0	7.2	10.3
	LSD 5%	0.146	*P* < 0.001			0.9	*P* = 0.83	1.7	*P* < 0.001

MECKERING

Variety	Backgrnd N kg/ha	Yield t/ha		Protein %		Hectolitre kg/HL		Screens %	
		No late FN	Late FN	No late FN	Late FN	No late FN	Late FN	No late FN	Late FN
Carnamah	13	3.300	3.586	10.0	10.6	77.8	73.2	3.0	4.4
Carnamah	55	3.717	3.690	11.6	12.7	74.7	67.6	4.2	6.0
Carnamah	97	4.095	4.030	12.2	13.4	69.2	65.0	6.1	7.8
Calingiri	13	3.805	3.596	9.0	10.0	75.8	74.7	2.2	2.7
Calingiri	55	4.112	3.931	9.6	11.7	77.4	69.6	2.2	3.6
Calingiri	97	4.753	4.397	10.9	12.1	76.1	66.7	2.2	5.6
Gairdner	13	3.936	3.882	8.5	10.4	62.9	60.3	28.7	45.1
Gairdner	55	4.309	4.008	9.9	10.9	54.7	56.3	41.2	60.3
Gairdner	97	4.375	4.150	10.6	13.3	57.8	46.7	60.1	90.7
	Mean	4.045	3.919	10.3	11.7	69.6	64.4	16.7	25.1
	LSD 5%	0.279	*P* = 0.36	0.7	*P* < 0.001	2.9	*P* < 0.001	3.9	*P* < 0.001

KEYWORDS

plant nutrition, wheat, barley, fluid fertiliser

Paper reviewed by: James Easton

Nitrogen management for wheat in high rainfall cropping areas

Narelle Hill[1], Ray Tugwell[1], Dr Wal Anderson[1], Ron McTaggart[1] and **Nathan Moyes[2]**, [1]Department of Agriculture and [2]Landmark

KEY MESSAGES

Timing nitrogen (N) according to soil and weather conditions can give a 60% lift to wheat yields. In 2003 waterlogging reduced N uptake in Calingiri wheat during crop growth at Cranbrook. Our trial results suggest that timing of N application was critical and should be more dependent upon rainfall and waterlogging. These results need confirmation at other sites and seasons but the probability of waterlogging and the expectation of specific grain quality and final grain yield will all influence future strategies. It is likely that some N will be required to ensure adequate plant numbers and tillers. To avoid substantial losses of N and profits, our results suggest that subsequent applications should be determined at least in part, according to major rainfall and waterlogging to replace N lost and to maximise final wheat grain yield.

AIM

To determine optimum nitrogen application times under waterlogging to increase crop yield and quality.

METHOD

One small plot trial (1.45 m x 30 m) was sown at Cranbrook (GSR (April-October) = 464 mm), following a canola crop in 2002. The site was selected, as it was known to be prone to waterlogging. Soil tests in the top 10 cm were pH ($CaCl_2$) 4.5, 2.1% organic carbon (OC), 42 ppm total Nitrogen (N), 33 ppm Phosphorus (P), 38 ppm Potassium (K), 12 ppm Sulphur (S), 0.2 ppm Cu, 0.4 ppm Zn.

Calingiri wheat was sown on 7 June 2003 at 80 kg/ha using a cone seeder fitted with knifepoints and presswheels at 18 cm spacing. 100 kg/ha Muriate of potash was top dressed before seeding and 145 kg/ha Triple superphosphate mid row banded at seeding. 320 kg/ha Urea (total) was applied to selected plots at specified times and rates indicated in Table 1. An additional 53 kg N/ha was applied to the back half of treatments four and five on 25 September. Optimum management was practised during the growing season to ensure only water and nitrogen could limit crop yield and quality. Two dipwells were inserted in each plot immediately post sowing. Rainfall, yield and quality components, plant tissue analysis immediately before N application, and free water in the root zone were measured.

RESULTS

Rainfall and free water in root zone

Daily rainfall (mm) and weekly depth to water below the soil surface (cm) show that water in the root zone at Cranbrook in 2003 increased most after significant rainfall, and was considered waterlogged (depth to water less than 30 cm below the soil surface) four times (Figure 1). It was after the first waterlogging that the first split N treatment was applied (27 August 2003).

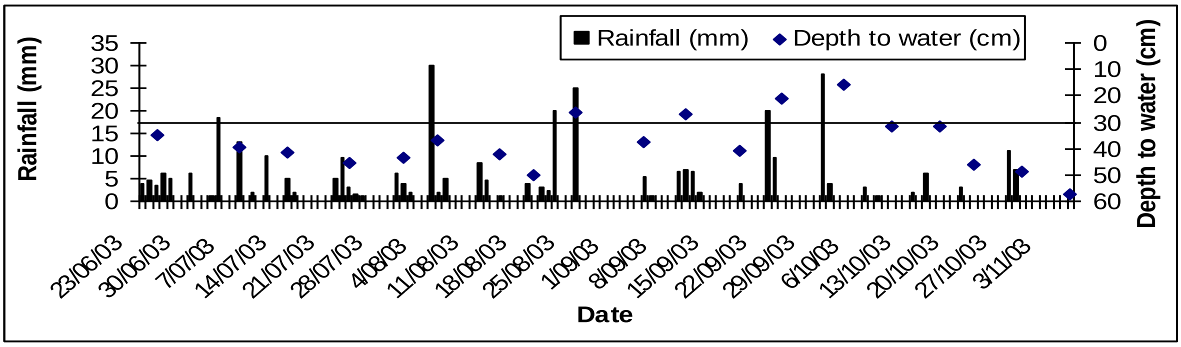

Figure 1. Average rainfall (mm) and depth to water (cm) at Cranbrook in 2003.

Plant analysis

N (%) in the whole plant was adequate for each treatment prior to 1st node N application (23 July). However, prior to successive applications of N, N (%) was low for all treatments except where N was applied after waterlogging (sampled 14 August, 24 September and 22 October). Magnesium and sulphur were at very low levels in the plant at all sampling times.

Grain components, quality and yield

Grain yield (t/ha) was increased by 60% when N was split applied at seeding (33%) and again after the first waterlogging event (66%) compared to when it was all applied at seeding (Table 1). The major response was due to the application of N after waterlogging as yields weren't significantly different to when N was split evenly between seeding, 1st node and after the waterlogging event (treatment 5).

The increase in grain yield (t/ha) was a result of an increase in the number of tillers/m^2 and dry matter production, but not seed weight (mg), which was reduced when N was split at seeding and again after waterlogging (Table 1). There were no significant differences between treatments for seed number/head (35/head), plants established (173/m^2) and plants remaining (107/m^2).

The Calingiri wheat did not achieve noodle grade (9.5-11.5% protein) for any of the treatments except when N was applied as the split application at seeding, 1st node and after waterlogging, and when extra N was applied later (Table 1). Screenings were below 10% for all treatments.

Table 1. N timing on tillers/m^2, seed wt (mg), dry matter (t/ha), screenings (%), protein (%) and grain yield (t/ha) on Calingiri wheat at Cranbrook, 2003. 33% N = 53 kg N/ha, 66% N = 107 kg N/ha

No.	Treatment	Tillers/ m^2	Seed wt (mg)	Dry matter (t/ha)	Scrns (%)	Protein (%)	Grain yield (t/ha)
1	Nil	239	37	4.5	2.7	9.1	2.2
2	All N at seeding (160 kg N/ha)	228	36	4	2.3	9.1	2.2
3	33% N at seeding, rest at 1st node	272	38	5.3	2.7	9.1	2.7
4	33% N at seeding, rest after waterlogging	344	34	7.5	4.7 (*5.5)	9.3 (*10.4)	3.5 (*3.8)
5	33% N at seeding, 1st node and after waterlogging	426	35	8.9	4.3 (*5.8)	9.5 (*10.7)	3.5 (*4.0)
	LSD ($P < 0.05$)	*34*	*3*	*1.0*	*2.1*	*0.8*	*0.6*

(*) Additional 53 kg N/ha applied to back half of treatment on 25 September 2003.

CONCLUSION

Waterlogging occurred four times during the growing season at Cranbrook in 2003, a year considered normal for the high rainfall, cropping zone. Waterlogging reduced N uptake during crop growth by loss (probably leaching) out of the root zone, and accounted for a reduced final grain yield of up to 60%. Timing of N applications was critical and appears related to rainfall events and subsequent waterlogging, which can have a significant detrimental effect on grain quality and final crop yield. A possible strategy could be to apply some N at seeding to get the crop started and to ensure adequate tiller numbers. Subsequent applications could be made with regards to rainfall and waterlogging probability, with major rainfall and waterlogging requiring more N. Further confirmation of this strategy will be sought in future at other sites and in other seasons.

KEY WORDS

nitrogen, waterlogging, wheat yield

ACKNOWLEDGMENTS

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Paper reviewed by: Dr Wal Anderson, Mr Ron McTaggart, Mr Charles Kidd

Flag smut resistance in current WA wheat varieties

John Majewski and **Dr Manisha Shankar**, Department of Agriculture; South Perth

KEY MESSAGES

- Flag smut susceptible varieties are sown over a high proportion of area in WA, requiring the use of seed dressings.
- Historically, flag smut has been a major disease of wheat in WA. Despite current use of flag smut susceptible wheats, effective chemical control of the disease ensures it has minor impact in Western Australia.
- EGA Bonnie Rock is very susceptible to flag smut and will require regular use of a seed dressing effective against flag smut. An effective seed dressing routine is also recommended for other susceptible varieties, including Wyalkatchem.

AIM

To evaluate wheat varieties for resistance to flag smut.

METHOD AND RESULTS

Varieties were sown in replicated rows in mid-late June 2003 at Medina Research Station. Flag smut inoculated seed was planted at a depth of around 7 cm into a free draining deep sand at a density of approximately 10 seeds per m row. Varieties Tammin, Eradu and Machete were included as known susceptible controls and Amery and Spear as resistant controls. Disease incidence (% plants with flag smut) was assessed after flowering.

EGA Bonnie Rock developed most disease, similar to Tammin (VS control). EGA Blanco and Wyalkatchem were similar to susceptible controls Eradu and Machete (Figure 1). Clearfield STL and EGA Castle Rock were less susceptible, similar to Carnamah and Cascades. Little or no infection occurred on Spear, EGA Jitarning and Harrismith which were comparable to the resistant control Amery.

Changes to varietal use patterns result in changing reliance on methods of flag smut control (Table 1). At present flag smut susceptible varieties are sown to a high proportion of area in WA, requiring the regular use of seed dressings.

Current resistance ratings and CVT resistance scores for varieties tested in WA are presented in Table 2.

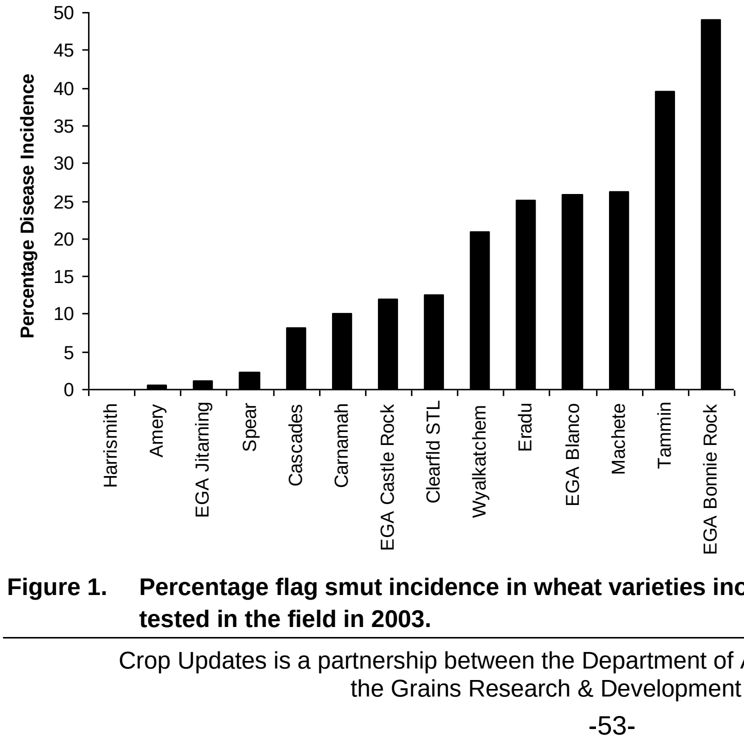

Figure 1. Percentage flag smut incidence in wheat varieties inoculated with *Urocystis agropyri* and tested in the field in 2003.

Table 1. Predominant commercial varieties in Western Australia, 1983/4, 1993/4 and 2002/3 with their resistance to flag smut

	Flag smut resistance*	Per cent area		
		83/84	93/94	02/03
Carnamah	MS			25
Westonia	MS			19
Calingiri	R			18
Arrino	S			8
Camm	R			4
Stiletto	S			3
Cascades	I			2
Spear	MR		25	2
Halberd	MR	25	14	2
Eradu	S		13	2
Machete	S		5	2
Brookton	S			2
Cadoux	S		2	1
Wilgoyne	R		7	
Aroona	S		5	
Gamenya	S	44	3	
Tincurrin	S	3	3	
Gutha	MR/MS		3	
Corrigin	MR		2	
Dagger	MR/MS		2	
Blade	R		1	
Madden	S	14		
Egret	R	4		
% susceptible		60	30	62
Total		89	84	90

Table 2. Variety responses to wheat flag smut

Variety	Resistance rating	Resistance score
Amery	R	7
Arrino	S	3
Cadoux	S	3
Calingiri	R	7
Camm	R	7
Carnamah	MS	4
Cascades	I	5
Clearfld STL	MS	4p
EGA Blanco	S	3p
EGA Bonnie Rock	VS	2p
EGA Castle Rock	MS	4p
EGA Jitarning	R	7p
Eradu	S	3
Halberd	MR	6
Harrismith	R	7
Janz	MR	6
Machete	S	3
Spear	MR	6
Stiletto	S	3
Westonia	MS	4
Wyalkatchem	S	3

R = Resistant, MR = Moderately resistant,
I = Intermediate, MS = Moderately susceptible,
S = Susceptible, VS = Very susceptible
p Provisional assessment

CONCLUSION

Despite extensive use of flag smut susceptible wheats, very few samples of flag smut have been received by the Western Australian Department of Agriculture diagnostic laboratories in the last five years (D. Wright, pers. comm.). This indicates that the disease remains endemic rather than epidemic. We presume that this is due to effective control with seed dressing fungicide. Some new wheat varieties are susceptible to flag smut. Continued use of seed dressing fungicides for control of flag smut in susceptible wheat is highly advisable.

KEY WORDS

resistance, flag smut, *Urocystis agropyri,* wheat varieties

ACKNOWLEDGMENTS

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Paper reviewed by: Dr Rob Loughman

Rust resistance update for wheat varieties in WA

Dr Manisha Shankar, John Majewski and **Jamie Piotrowski**, Department of Agriculture; South Perth

KEY MESSAGES

- A new strain of stem rust virulent on Wyalkatchem wheat has been detected at low frequency in southern areas (Esperance and Ongerup districts).
- The strain of stem rust epidemic on Camm and Yitpi in southern areas in 2003 is likely to remain dominant should stem rust occur in 2004.
- The low impact of stripe rust in 2003 provides growers with the opportunity to target stripe rust risk strategies compared to blanket control strategies used in 2003.
- WA variety ratings for rust resistance have been updated on the basis of field screening in WA in 2003.
- New strains of leaf, stem and stripe rust erode progress in breeding for disease resistance.
- New strains arising by mutations in one part of Australia can migrate to other parts of Australia. Biosecurity for rust diseases in Australia remains an industry priority.

RUST OCCURRENCE IN WA IN 2003

Wheat stem rust - Puccinia graminis *f.sp. tritici*

A late stem rust epidemic occurred in south eastern and south coastal areas following early reports of stem rust carryover in July on Camm, Halberd and Westonia in the Salmon Gums, Westonia and Newdegate areas. Outbreaks in crops commenced in late August and September in the Esperance region, the Lakes area and parts of the south coast, primarily on Camm and Yitpi. In mid-October high levels of infection were found on a crop of Spear wheat near Pingrup and low levels on a crop of Calingiri wheat near Gnowangerup. By late October infection was widespread throughout many southern areas including outbreaks reported from Gnowangerup to Ravensthorpe, Pingaring to Lake King and Scadden to Grass Patch. Late infections continued during early November and were widespread in the Great Southern and South Coastal areas.

High infection was reported on Wyalkatchem in the Esperance region and at Ongerup in October. Samples submitted to the University of Sydney's Australian Rust Survey revealed added virulence for a resistance gene Sr15 present in Wyalkatchem. The new strain was not detected in central or northern areas. The Camm/Yitpi strain of stem rust will predominate for at least one or possibly two seasons.

Wheat leaf rust - Puccinia triticina

Wheat leaf rust was reported in August/September from Esperance, Newdegate, Ravensthorpe and Geraldton areas. Levels of infection remained relatively low. However, late infections during October/November were widespread in the southern region.

Stripe rust - Puccinia striiformis *f.sp. tritici*

There was no stripe rust recorded between the end of of 2002 and September of 2003. The first report was in early September on a crop of Carnamah near Burracoppin. By mid-September it was found in the Scadden area and in a crop of Calingiri at North Burracoppin. Two more reports were received by end September, one on Westonia wheat at the Merredin Research Station and another trace of the disease North West of Merredin. It was reported continuously during early to mid October in the Burracoppin and Merredin areas in low levels. A hot spot was also detected in a Calingiri wheat crop North of Katanning and West of Ongerup on Wyalkatchem and Carnamah wheats. By end of October and during early November the disease was found in several locations, i.e. Broomehill; Tambellup; Arthur River, Woodanilling, Gnowangerup, Kondinin, Hyden and Mukinbudin.

The appearance of the disease late in the season did not pose the high risk that results from an early infection. The levels of the disease were far less that those that occurred last season. Very few crops had appreciable infection at flowering and infected heads were rare.

The future pattern of stripe rust infection in WA remains unclear but experiences from Eastern Australia and Europe suggests that stripe rust may be difficult to predict, the major influence is the availability of host plants to bridge the summer dry period between this season and the next. The lower impact of stripe rust in 2003 will provide growers with the opportunity to target at-risk varieties and at-risk regions compared to the broad blanket control strategy taken in 2003. Regions where summer / early autumn rainfall is sufficient to support green plant material will have a higher risk for infections in season 2004.

Biosecurity and rust migration

WA stripe rust was detected for the first time in NSW and Victoria in 2003. The WA Camm strain of stem rust was detected in South Australia for the first time in 2003. This follows the occurrence of the WA Camm strain of leaf rust in South Australia in 2002. Several important strains of leaf and stripe rust occuring in eastern Australia have not yet occurred in WA. Rust can traverse the continent from both wind and accidental human movement. Mutational changes occurring in one region of Australia can subsequently affect other regions by migration, slowing the progress of breeding for resistance to rust diseases. Biosecurity for rust diseases remains an important strategy for the WA wheat industry.

RUST RESISTANCE RATING UPDATE

Wheat varieites were screened for rust resistance in the field in 2003. Updated scores of major wheat varieties are presented in Table 1.

Table 1. Rust resistance of wheat varieties

1-9 scale: 1 = Extremely susceptible; 2 = Very susceptible; 3 = Susceptible; 4 = Moderately susceptible; 5 = Intermediate; 6 = Moderately resistant; 7 = Resistant; 8 = Highly resistant; 9 = Immune

Variety	Stem rust	Stripe rust	Leaf rust	Variety	Stem rust	Stripe rust	Leaf rust
Ajana	6/3	4p	2	Frame	7	5	6-4
Amery	2	4p	3	Gamenya	7/4	4	3
Arrino	3	4p	3	GBA Ruby	7p	7p	5-6p
Blade	7	6	6-4	GBA Sapphire	8p	6p	8*p
Brookton	7	2	5-3	Halberd	2/7	4	6-5
Cadoux	3	3	5-3	Harrismith	8	2	8*
Calingiri	4	4	6	H45	8/5	2	7
Camm	3	7	3	Janz	8	6	8*
Carnamah	7	4	5	Kalannie	3	2p	3
Cascades	6	3	3	Machete	7	4 5	3
Corrigin	2	3	2	Nyabing	7	2	7*
Cunderdin	7/4	4p	7	Perenjori	6	5	5
Datatine	8	4-5p	8*	Spear	7/3	4	3
EGA Blanco	6/4	4	5	Stiletto	8/6	4	3
EGA Bonnie Rock	4-5	3	8	Tincurrin	2	3	2
EGA Castle Rock	8	7p	8	Westonia	2	2	4-5
EGA Jitarning	8	6p	8*	Wilgoyne	7	7	5
Eradu	6	4p	3	Yitpi	3	6	6

p Provisional assessment, limited data.

/ Scores separated by a '/' indicate the response to the currently predominant and alternate strains of rust existing in WA.

- Scores separated by a '-' indicate the range of rust response observed under different disease pressures and different environments.

* Some races in Eastern States can attack these varieties.

KEY WORDS

Stem rust, leaf rust, stripe rust, resistance

ACKNOWLEDGMENTS

Support of breeding, pathology and crop variety testing staff is acknowledged. Field screening for rust resistance is supported by GRDC. Thanks to AGWEST Plant Laboratories and Pestfax for collating seasonal rust records.

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Paper reviewed by: Dr Rob Loughman

Stripe rust in WA - where was it and what can we learn from 2003?

Dr Robert Loughman and **Ciara Beard**, Department of Agriculture; South Perth and Geraldton

KEY MESSAGES

- Infrequent stripe rust survival was a feature of the first recurrence of this disease in WA in 2003.
- Limited survival in conjunction with extensive adoption of risk reduction practices (green bridge management, variety selection, use of fungicides at seeding and foliar fungicides) resulted in low impact from stripe rust in 2003 compared to 2002.
- An epidemic of stem rust in southern areas required extensive use of fungicide spray late in the season, particularly for varieties Camm and Yitpi.
- In the absence of early disease pressure there was a frequent lack of yield response from fungicide used at seeding in 2003.
- Long acting seed dressings and in-furrow fungicides are likely to retain a place in WA production packages as a consequence of grower experience with them in 2003.
- Better targeting to situations of high risk is warranted (varietal susceptibility and proximity to volunteer cereals).
- Targeted stripe rust risk management with fungicides at seeding will need to be used in conjunction with use of fungicide sprays where required in spring to control later disease onset from leaf rust, septoria, yellow spot or stem rust.

INTRODUCTION

A favourable 2003 seasonal climate outlook, the potential for wheat stripe rust and the need for the WA wheat industry to rebound strongly after extreme drought resulted in rapid adoption of high input crop protection packages in 2003. While the lack of pressure from stripe rust last year was a welcome relief, questions remain about the impact of the disease, the extent of adoption of costly fungicides and how to manage equivalent situations in future. Adoption of fungicide protection at seeding was remarkably strong, estimated to be in excess of 50% of wheat plantings and costing $20-30m. By winter there was recognisable carryover of both leaf and stem rust in southern areas but no stripe rust could be detected on volunteer wheat at any stage last autumn. What happened to stripe rust and what were the grower outcomes?

2003 IN REVIEW

Puccinia striiformis f.sp. *striiformis*, the causal fungus of stripe rust in wheat, recurred in three regions in WA in the 2003 growing season. In the eastern wheatbelt (east of Merredin) infection was recognised in early September. In the south-east (Scadden, north of Esperance) occurrence was in mid September while in the south west (Ongerup-Katanning) infection was recognised in early October. In each case the disease were observed at early stages in the epidemic cycle. Stripe rust appeared to survive independently in each region. The three areas were recognised from Green Bridge Day surveys as having developed abundant volunteer cereals.

Within the recognised risk areas, survival appeared infrequent. While the three survival areas had received the most abundant summer rain, other areas with autumn green bridge cereals (e.g. wheat) resulted in stem and leaf rust carryover but not stripe rust. The stripe rust pathogen appeared less well adapted to autumn survival than leaf or stem rusts.

Stripe rust re-established later than expected in prone areas and subsequent outbreaks developed slowly. Several factors are likely to have contributed. **Less highly susceptible varieties were grown**. For example Westonia plantings, which were at 19 per cent and still increasing in 2002, dropped back to less than 10 per cent in 2003. **Fungicides at seeding were widely adopted** to

delay disease onset. The uptake of Jockey®, Impact® in-furrow, Triadimefon® in-furrow, Real® and other seed dressings resulted in seeding fungicide use exceeding an estimated 50 per cent of wheat area in both high and low risk areas in WA. **Pre-emptive fungicide spraying in spring** occurred once stripe rust had been reported in a district, diminishing opportunity for disease establishment. Fungicide sprays were also often used to maximise production due to the very good cropping year, contributing to control of stripe rust.

EARLY SEASON MANAGEMENT OF WHEAT DISEASE: WAS IT WORTH IT?

Effects in the absence of stripe rust

The nature of initial stripe rust finds in early September (infrequent hot spots) indicated that the infected crops are likely to have been exposed to infection from about six weeks old. While this was the case for a few crops, the vast majority of crops treated with fungicide at seeding did not encounter stripe rust or other early leaf disease within the expected window for seed treatment activity of 8-16 weeks (depending on product and rate). Was there any benefit from applying this early season treatment?

A large program of fungicide and stripe rust management scenarios were examined in a range of replicated plot and large scale demonstrations conducted throughout the wheatbelt by the Department of Agriculture, agronomy companies, chemical companies and farmer groups. The main feature was a comparison of untreated seed with some form(s) of extended early season disease control, some including foliar spray later in the season. Despite the breadth of the activity, none of these experiments and demonstrations developed any stripe rust. Yields throughout these activities were generally excellent (mostly over 3 t/ha). Most had negligible disease. Fifteen of 19 experiments had no yield response to seeding fungicides. In all 10 demonstrations (including replicated large plot demonstrations) no seeding fungicide responses were observed. Of four experiments where seeding fungicide responses were observed, yield response was 0-0.2 t/ha with yields around 3-4 t/ha in two experiments and 0-0.8 t/ha with yields around 4-5 t/ha (Table 1).

Delaying disease onset

Two trials in the northern wheatbelt that were closely monitored throughout the season showed some of the seed treatments delayed the onset of leaf rust.

At a site in Mingenew where Westonia was treated with a range of seeding fungicides, leaf rust was first observed 12 weeks after seeding (WAS) in untreated plots. By 14 WAS leaf rust was found on plots treated with Baytan® @ 150 g/100 kg seed, Real® at 150 mL/100 kg seed, Triadimefon in-furrow @ 200 g/ha and Impact® in-furrow @ 200 mL/ha. By 16 WAS leaf rust was found in all plots. The treatments that significantly reduced % leaf area diseased (17 WAS) were: Real® @ 300 mL/100 kg seed, Jockey® @ 450 mL/100 kg seed, and Impact® in-furrow @ 400 mL/ha. The only treatment to increase yield significantly ($P < 0.05$) was a Triadimefon spray at booting (from 3.8 to 4.2 t/ha). Similar results were found at the other trial site in Northampton.

Despite the widespread use of early season fungicides at seeding, a wheat stem rust epidemic developed in the south-east and southern coastal regions of WA affecting Camm and Yitpi. If susceptible varieties are grown, strategies for the effective management of stem rust, traditionally a late onset disease, require active crop monitoring after head emergence then foliar fungicide application at the first onset of the disease.

CONCLUSIONS

Seasonal circumstances resulted in the widespread adoption of strategies to manage disease risk, particularly that of stripe rust, in 2003. Few benefits were evident and low disease levels were attributable to several reasons. 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, the amount of localised green bridge present in autumn and grower's ability to spray large areas of crop should it occur suddenly. The results from 2003 indicate a more targeted approach to fungicide use at seeding is warranted. Extension can focus on situations of high risk in relation to varietal susceptibility and proximity to green bridge volunteer cereals. This has greater potential to capture benefits in stripe rust

risk management with fungicides at seeding and can be used in conjunction with use of fungicide sprays where required in spring to control later disease onset from leaf rust, septoria, yellow spot or stem rust.

To better understand of the value of fungicides at seeding more experience with stripe rust survival in WA will be required as well as better understanding of their potential for improved control of other diseases.

Table 1. Summary of 2003 field activities comparing seed sown without fungicide treatment with seeding fungicides and foliar fungicides for management of stripe rust and other leaf disease (those reports available at time of printing)

Source	Activity	No.	Trial locations and yields (t/ha)	Observations
DAWA	Rep'd plot exp'ts	7	N'ton (3.7), ChValley(3.7), Ming(4.0), Ming(5.5), Arrino (4.0), Newd (3.5), Kat (3.0)	No yield response to seeding fungicides at any site. Foliar fungicide response to leaf rust at 1 expt at Mingenew, no effects at other sites.
DAWA (with Leibe Group)	Rep'd demo's	6	Buntine (2.0), W.Hills (3.0), Merr (2.5), Kat (3.5) Newd (1.5), Gibson (3.7)	No seeding fungicide responses.
Elders	Rep'd plot exp't	1	Kukerin (3.9)	No significant responses.
Elders	Variety x fung demo's	4	Eradu (1.6), Allanooka (3.1), Eneabba (3.4),	No evidence of responses across four varieties.
Landmark	Rep'd plot exp't	1	Mingenew (4.0)	Impact® I-F 400mL/ha increased yield by 0.2 t (*P* = 0.05) compared to six other treatments at seeding.
CSBP	Rep'd plot exp'ts	9	Various.	At Yealering (2.8 t/ha), a range of seeding fungicides increased yield by 0.2 t/ha in one of two varieties. At Condingup (3.7 t/ha) and Salmon Gums (5 t/ha) Impact® IF, Triadimefon® IF or Jockey increased yield by 0-0.8 t/ha in one of two varieties. Very little leaf disease present.
Nufarm	Rep'd plot exp't	1	Bolgart (4.5)	Use of Impact® I-F 400 mL/ha increased yield by 0.2 t (*P* = 0.05) in one of four varieties.

KEY WORDS

wheat, leaf disease, fungicide, seed dressing

ACKNOWLEDGMENTS

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NB: Mention of trade or company names does not imply endorsement or preference of any company's product by the Department of Agriculture. Any omission of a trade name is unintentional.

Project No.: DAW663 and DAW00022

Paper reviewed by: Graham Mussell

Foliar disease management - a key factor in the adoption of Baudin and Hamelin barley

Dr Kithsiri Jayasena[1], Dr Rob Loughman[2], Kazue Tanaka[1] and **Grey Poulish[1]**, Department of Agriculture; [1]Albany and [2]South Perth

KEY MESSAGES

- Baudin is susceptible to powdery mildew, spot-type net blotch, barley leaf rust and net-type net blotch.
- Hamelin is susceptible to all leaf diseases (similar to Stirling). The diseases most likely to affect Hamelin in medium to low rainfall regions in 2004 are powdery mildew and net-type net blotch.
- Growers adopting these new varieties need to plan disease management strategies applicable to their growing environments.
- Hamelin and Baudin will require early protection from powdery mildew by applying a seed dressing fungicide (e.g. Armour, Baytan, Real or equivalents).
- Well grown crops of Baudin and Hamelin should be monitored for possible spraying from late stem extension (Z35) for signs of leaf rust, powdery mildew, scald or net blotches (depending on rotation and seasonal rainfall).
- For Baudin (and Gairdner), results from high rainfall experiments over 2 years indicate disease protection with a foliar fungicide during later crop development was more beneficial than extending the protection during early development with Triad in-furrow.

DISEASES IN 2003 AND OUTLOOK FOR 2004

Net-type net blotch and powdery mildew were seen early in the season in the Katanning area in response to above average rainfall. In the high rainfall region of the south coast, the predominant diseases were powdery mildew, barley leaf rust and spot-type net blotch. Loose smut was also present. The wet conditions experienced for the southern harvest in 2003 may help to establish some green bridge barley as a host for leaf rust. Survival of these plants will be greatest on heavy soils. Crop rotation will be important in 2004 as stubble borne diseases such as scald, powdery mildew and net blotches will be at higher levels in stubbles following the good season in 2003 than following the drought of 2002. Spring rainfall remains a major factor in disease development and impact.

EXPERIMENTAL RESULTS FROM 2002 AND 2003

Experiments conducted at Gibson and Wellstead, WA in 2003 demonstrated that diseases such as powdery mildew and barley leaf rust on Baudin and Hamelin can be effectively controlled with fungicides.

At Gibson, five barley varieties (Baudin, Gairdner, Hamelin, Stirling and WABAR2175) were grown in a replicated field trial and treated with either a seed dressing, in-furrow fungicide treatment, foliar fungicide or a combination as described in Figure 1. Powdery mildew was present at very low levels prior to heading then developed to moderate levels during grain filling. Leaf rust was present and remained at a low level. A significant variety x fungicide response for yield was observed ($P = 0.013$).

Yield of Baudin and Gairdner responded to foliar fungicide sprays. Hamelin and Stirling responded to fungicide applied at seeding and to foliar fungicide sprays. WABAR2175 had high yield regardless of fungicide treatments. These results warrant further investigation of variety specific management for leaf disease in barley.

The comparable experiment at Wellstead in 2003 experienced severe leaf rust. All fungicide treatments significantly improved yield (Table 1). Application of fungicide spray at Z45 and Z60 gave the highest yield regardless of earlier treatment. Yield response to the fungicide treatments was the same for each variety.

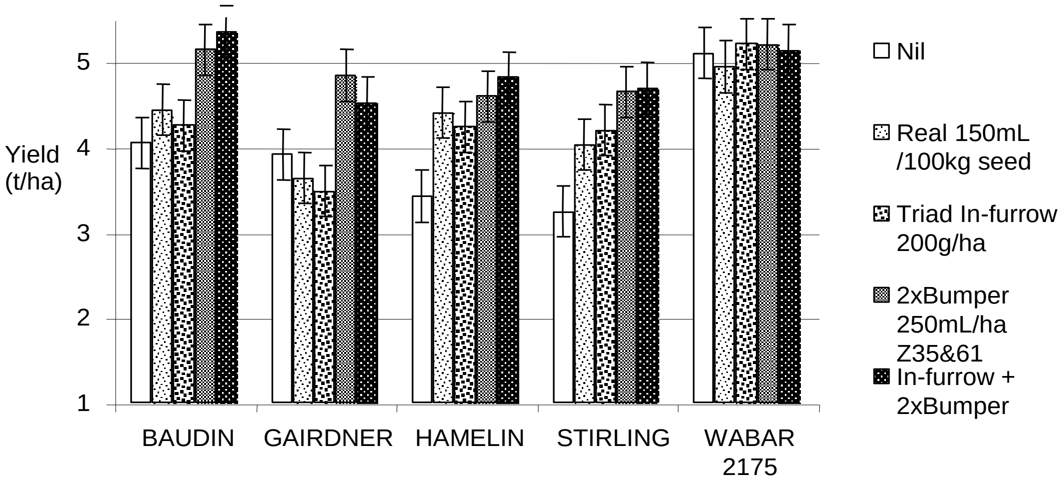

Figure 1. Yield responses to fungicide treatments in five barley varieties affected by powdery mildew and leaf rust at Gibson, 2003.

Table 1. Effect of fungicide treatments on leaf rust and yield of barley, Wellstead 2003

Treatment	**% Leaf rust**		**Yield**	
	Z33 (26 August)	**Z85 (23 October)**	**(t/ha)**	**%**
	Av. (L2-L3)	**Flag**		
1. Untreated	Trace	72	2.32	100
2. Real 150 g/L FS @ 150 mL/100 kg seed	0	72	2.46	106
3. Triadimefon 500 WP @ 200 g/ha	0	72	2.41	104
4. 2 x Bumper @ 250 mL/ha at Z45 and Z60	-	4	2.71	117
5. Treatments 3 and 4 together	-	4	2.74	118
LSD (*P* < 0.05)		1	0.27	

In 2002, four varieties (Baudin, Gairdner, Hamelin and Stirling) were grown in a replicated field trial at Gibson, WA and treated with either a seed dressing, in-furrow fungicide, foliar fungicide or a combination treatment as described in Table 2. Barley leaf rust developed early and became very severe. The greatest increase in yield was 36% achieved with the combination in-furrow plus foliar treatment. Despite the early disease onset, the single most effective treatment was the application of the foliar fungicide at early flag leaf emergence (Z37). Yield response to the fungicide treatments was the same for each variety.

Table 2. Effect of fungicide on disease severity and yield of barley affected by leaf rust, Gibson 2002

	% Leaf rust (10 October) av. (F, F-1)	**Yield (t/ha)**	**%**
1. Untreated	41	2.23	100
2. Baytan 150 g/L FS @ 150 g/100 kg seed	37	2.53	113
3. Triadimefon 500 WP-in-furrow @ 200 g/ha	21	2.71	122
4. Tilt250EC 250 mL/ha at Z37	19	2.87	128
5. Treatments 3 and 4 together.	16	3.04	136
LSD (*P* < 0.05)	4	0.20	

CONCLUSION

Yield and quality characteristics make Baudin and Hamelin important options for the WA barley industry. These new varieties are susceptible to diseases, requiring integrated management approaches. Avoid sowing Hamelin and Baudin on paddocks cropped to barley in the previous year.

Hamelin and Baudin require early protection from powdery mildew with a seed dressing fungicide (e.g. Armour, Baytan, Real or equivalents). This is the first priority when budgeting for disease management in these varieties.

For disease management during latter stages, foliar fungicides provide maximum flexibility in achieving cost effective disease control and should be the next expenditure priority after seed dressing. Fungicide sprays applied in spring are effective at controlling a breadth of foliar diseases (subject to registered uses), including spot-type net blotch (see Jayasena *et al*. 2001).

Fungicide applied at seeding can assist in control of certain diseases. Where crop productivity is high and returns justify additional inputs, consider augmenting early protection in the young crop by using longer acting treatments at seeding (e.g. in-furrow fungicides). Hence long acting treatments at seeding assist with mid season protection and may reduce but not replace fungicide sprays when diseases threaten crops.

There is potential for future varieties with improved resistance (such as WABAR2175) to enhance profitable and sustainable barley production by reducing requirements for fungicide use.

KEY WORDS

Baudin, Hamelin, fungicides, foliar diseases

FURTHER READING

Jayasena, K. Knight, Q. and Loughman, R. (2001). 'Strategies for leaf disease management in malting barley', *2001 Cereals Update Booklet*, pp. 57-58, Agribusiness Crop Updates, Department of Agriculture WA and Grains Research & Development Corporation, Western Australia, ISSN 1445-0592.

ACKNOWLEDGMENTS

We thank Mt Barker and EDRS RSU staff for excellent technical assistance and GRDC for funding.

NB: Mention of trade names does not imply endorsement or preference of any company's product by the Department of Agriculture. Any omission of a trade name is unintentional.

Project No.: DAW00022

Paper reviewed by: Roslyn Jettner

Validating aphid and virus risk forecasts for cereals

Dr Debbie Thackray, Rohan Prince and **Dr Roger Jones***,* Department of Agriculture and Centre for Legumes in Mediterranean Agriculture

KEY MESSAGES

- A decision support system (DSS) based on a predictive model is available to consultants and growers through an Internet site (http://www.agric.wa.gov.au/bydv). It forecasts the need for insecticides to control aphid vectors of barley yellow dwarf virus (BYDV) in cereals in different regions of the WA grainbelt. The DSS allows efficient targeting of insecticides, avoids costly prophylactic use, and provides environmental benefits.
- Data was collected over five years from cereal blocks at five different sites throughout the grainbelt, for use in validating the predictive model, and data from the last two years (2001-2002) are presented here. Results confirmed that early aphid arrival in crops is closely linked to pre-growing season rainfall. This in turn is linked to greater spread of BYDV and consequent yield losses.
- The BYDV Internet site also provides growers, advisers and others with information on BYDV and aphids, current management recommendations, photographs of aphids and virus symptoms, maps predicting likely risk areas, and an explanation of the forecasting model and how to assess risk.

AIMS AND METHOD

To validate the outputs from the BYDV predictive model against real data, large, square blocks of wheat were established at five sites in 1998, 1999 and 2000, at four sites in 2001 and at two sites in 2002, in the WA grainbelt. These sites represent annual rainfall from 330 to 1035 mm. In 2001, the sites were DAWA Research Stations at Merredin (annual rainfall 330 mm), Avondale (420 mm), Badgingarra (600 mm) and Mount Barker (750 mm), and in 2002 they were Badgingarra and Mt Barker. In 2001, there were two times of sowing at Mt Barker, early May and early June. The other sites were sown in early June only. In 2002, there were two times of sowing at each site, early May and early June. Sites were visited every two to three weeks during the growing season, when numbers of aphids were recorded and wheat plants sampled to test for BYDV incidence. Findings were used for final validation of the forecasting model and DSS for use by consultants and growers.

RESULTS

In 2001, very little rainfall was recorded from January to April at Badgingarra and Avondale (Table 1). Consequently, there was little graminaceous plant material available on which aphids could survive, so none were recorded in the wheat blocks at either site until the end of August, by which time most plants had reached GS 41-47 (booting). No BYDV was detected at either site by GS 60 (flowering), at which stage it becomes hard to detect the virus reliably in laboratory tissue print tests (Figure 1).

At Mt Barker in 2001, rainfall was below average for March-April, although this site received more April rainfall (37 mm) than any other did in that year. The first aphids were only recorded at the end of July, two months later than in 2000, and BYDV incidence had only reached 1% by the final sampling date. At Merredin, although there was very little rainfall in March and April (3 mm), there was a very high pre-season rainfall event in January along with above average rainfall in February, totalling 158 mm for the two months. The resulting high soil moisture maintained grasses and weeds throughout most of the dry March and April period leading to earlier aphid arrival than would have been anticipated from the March-April rainfall figures alone. Aphids were present on sticky traps at the first visit after sowing, but, as in 1999 when aphids arrival was also early, BYDV incidence only reached 0.5% by the final testing date. One explanation for this surprisingly low incidence is that in low rainfall zones, smaller proportions of aphids vector BYDV than in higher rainfall zones. Also, the low levels of BYDV recorded at the end of 1999 and 2000 in this area both suggest that few virus infection sources were present at the start of the following growing seasons, despite the abundance of early aphid vectors in each year.

In 2002, Badgingarra rainfall was above average for March to April with the greatest amount (41 mm) in April. This facilitated early aphid build up on grasses and weeds before the growing season. Although the first aphids were seen on sticky traps in the wheat blocks on 3 July, none were recorded in the crop until 17 July, about 5 weeks earlier than in 2001. BYDV incidence reached 8% by GS 41 (early booting) in the early sowing, and aphids peaked at 36 aphids per tiller on 10 September. BYDV

incidence in the later sowing reached 6% when testing finished at GS 45 (boots swollen) on 10 September, with the highest aphid numbers also recorded on that date (20 per tiller).

Mt Barker had a total of 140 mm of rain in March and April in 2002 and aphids were first recorded on 27 June, peaking at 19 per tiller in late August in the early sowing, after which a fungus quickly killed the majority of them. BYDV incidence reached 15% by GS 55 (1/2 ear emerged). In the late sowing, aphids peaked at 13 per tiller in late August and BYDV incidence reached 55% at the last sampling.

Table 1. Wheat validation blocks at two sites in 2001 and 2002 - March to April rainfall, date aphids first recorded, and final BYDV incidence

Site	March-April rainfall (mm)*		Date aphids first recorded**		% BYDV incidence**	
	2001	2002	2001	2002	2001	2002
Avondale	2	n/a	29 August	n/a	0	n/a
Badgingarra	5	52	21 August	17 July	0	8
Merredin	3	n/a	19 June	N/a	0.5	n/a
Mount Barker	37	140	26 July	27 June	1	15

n/a = Not applicable as sites not monitored here.
Rainfall is from SILO Patch Point data set (Queensland Department of Natural Resources).
** Where there are two sowing times, aphid and BYDV data are from the early times of sowing.

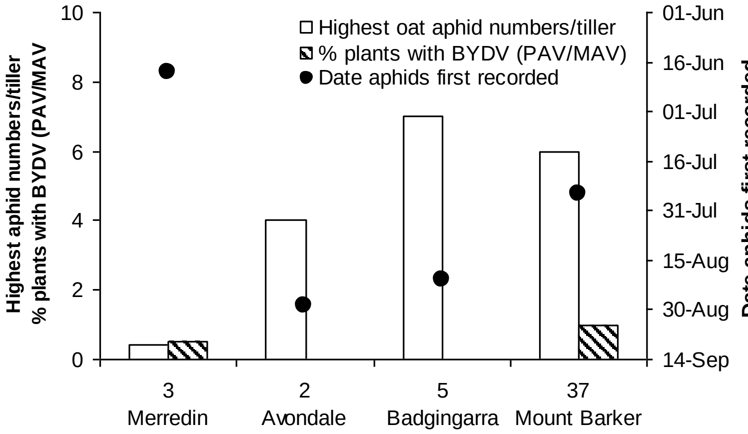

Figure 1. Date aphids first recorded, highest aphid numbers per tiller and highest % BYDV incidence in early sown wheat blocks at four sites in different rainfall zones in 2001.

CONCLUSION

In previous years, aphids arrived earliest at the validation sites with highest pre-growing season rainfall in March-April and latest at sites with lowest March-April rainfall, regardless of the rainfall zone they are in. In 2001, the relationship between rainfall and aphid arrival was similar, except for Merredin, with early arrival of aphids despite very little rainfall in March and April. However, when total rainfall data included January and February figures, there was a strong correlation between this and the date aphids were first recorded for all four sites. In 2002, aphids again arrived earliest and spread the most BYDV at the site with highest rainfall in March-April (Mount Barker).

Using this information, the DSS was refined, to improve the accuracy of model forecasts across all rainfall zones. The model utilises local rainfall and temperature data from January-April in making predictions for aphid arrival and BYDV spread in cereal crops, and subsequent yield losses. Forecasts are given each year through the Internet (http://www.agric.wa.gov.au/bydv), PestFax, Press, etc. Sub-title.

KEY WORDS

BYDV, aphids, cereals, model

ACKNOWLEDGMENTS

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Paper reviewed by: Brenda Coutts

Swathing Gairdner barley at 30% moisture

Peter Nelson[1] and **Nigel Metz**[2], [1]Cooperative Bulk Handling and [2] Fitzgerald Biosphere Group

KEY MESSAGES

- It is possible to swath a 5t/ha crop of Gairdner barley when the grain is at 30 to 35% moisture content. We found that the swath did not fall through the stubble and the crop harvested easily.
- To maximise grain yield, hectolitre weight and minimise screenings, Gairdner barley must not be swathed until the grain has reached physiological maturity and moisture content is below 35%.
- As Gairdner barley is a tall variety, if left standing in the field until harvestable (moisture content below 13.5%) it can become weather damaged, lodge, lose heads, thereby losing yield and quality. We lost 2 t/ha of grain from head drop while waiting for the direct headed crop to become harvestable.

BACKGROUND AND AIMS

Swathing of tall barley crops is a common practice in southern Western Australia. It is used to reduce the potential for yield loss from lodging and head loss in addition to rapidly maturing the crop effectively. This reduces the period that the crop is exposed to damaging weather. Barley can be swathed at physiological maturity when there is no further increase in grain dry weight and the grain moisture content is around 30%. Gairdner barley growers have argued that they cannot swath Gairdner at a grain moisture content of 30% because the swathes are too heavy, do not rest on the stubble and are more difficult to pick up. This trial examined the practical aspects of swathing Gairdner barley at different grain moisture content levels whilst comparing the grain quality and yield from the swathing treatments with a direct heading treatment.

METHOD

Gairdner barley was sown at Gairdner on the 10 May 2003 folllowing a canola crop in 2002. The crop was seeded at 70 kg/ha on 20 cm row spacings. Starting on 29 October (grain moisture content at 41%) the crop was swathed at near daily intervals until 7 November. A section of the crop was left standing and direct harvested one month later on 13 December when moisture content of the grain was at 13% and suitable for storage. All farm operations were carried out using broadacre machinery.

The moisture content of the grain was determined by a ‘Brabender’ oven. Three samples were taken from each swath with insect numbers, hectolitre weight, screenings, protein concentration, moisture content and germination percentage were recorded. The yield was taken from each swath without replications. A weather station recorded temperatures, relative humidity and rainfall. Temperatures were taken at the top, centre and bottom of swath (data not shown).

RESULTS AND DISCUSSION

Grain yield and grain quality

Physiological maturity occurs at maximum grain fill. Swathing the crop prior to this stage interrupts the grain filling process. In this trial swathing the Gairdner barley prior to the grain reaching physiological maturity (moisture content above 35%) reduced the grain yield, lower hectolitre weight and higher screenings (Table 1). Delaying the swathing operation for one day improved the hectolitre weight and level of screenings however a yield decline was still measured.

Waiting until physiological maturity was reached maximised grain yield and grain quality. There was a 0.6 t/ha improvement in grain yield, improved hectolitre weight and decreased screenings. Once physiological maturity had been reached, time of swathing had little effect on grain yield. Neither

germination %, grain protein or grain colour were affected by moisture content at swathing (above and below 35%).

Delaying harvest of the standing crop of Gairdner barley until the grain had reached a moisture level that was suitable for storage (moisture content below 13.5%) resulted in significant lodging and head loss and greatly increased the difficulty of harvesting the crop. It was interesting to note that this treatment had the lowest level of screenings. Direct harvesting of the standing crop reduced the yield by approximately 2 t/ha at an economic loss to the grower of $380 per hectare.

Insect contamination

Contamination by bronzed field beetles was greatest in the earlier swathed crops. The longer the swath remains on the ground prior to harvest the greater the potential for contamination. Department of Agriculture, Albany carried out soil measurements of insects in this paddock.

Table 1. Grain quality, grain yield and insect numbers of Gairdner barley from swathing at different times and when direct harvested

Treatment and date of operation	Moisture content @ swathing (%)	Moisture content @ harvest (%)	Hectolitre weight (kg/hl)	Screenings % (< 2.5 mm)	Grain colour (L)	Bronzed field beetle no./kg	Germ % (%)	Grain yield (t/ha)
Swathing								
29 October	41.0	10.2	67.7	23.9	54.8	29	97	4.30
30 October	40.0	11.3	69.1	12.4	54.8	27	97	4.51
31 October	33.6	10.5	69.7	10.2	55.1	15	98	4.93
3 November	28.2	10.3	69.6	9.3	55.2	7	98	5.13
4 November	31.2	10.4	69.3	10.7	55.1	2	96	4.99
5 November	20.6	10.4	69.5	11.4	55.2	6	97	5.17
6 November	18.8	10.4	69.2	12.3	55.1	2	97	5.21
7 November	17.3	10.2	69.1	12.6	54.8	1	97	4.93
Direct head								
13 December		13.1	66.5	6.1	55.2	0	99	3.04

Swathing a high moisture crop and then harvesting

In this trial only 7 mm of rain fell on the swaths prior to harvesting. All the swaths, from 41% moisture content down to 17%, were harvested easily and all rested on the 20 cm row spacing stubble. This is not always the case and in some years heavy rainfall can force the swaths onto the ground. To minimise this effect the row spacing should not be greater than 20 cm and the swaths should run at right angles to the seeding direction. Insect and sand contamination of the harvested grain can be a problem when swaths, due to inclement weather, are on the ground for some time.

Looking to the future the authors feel that due to the above two problems that if aeration and drying facilities were available it would be far better to direct head the crop at 20-22% moisture content, keep the grain under aerated storage and then dry the grain down to 12% moisture content for shipping deliveries.

CONCLUSION

Gairdner can be successfully harvested after swathing around 30% moisture content. Waiting to swath until the crop is below 20% moisture was not detrimental to grain yield or grain quality. Due to low colour none of the treatments achieved malting quality. The trade off between swathing at 30% and below 20% is an increased risk of crop lodging and head loss versus reducing the contamination problem from insects.

Swathing at a moisture level above 35%, prior to physiological maturity, reduces grain yield. Direct heading of Gairdner in southern regions is also risky due to excessive lodging and head loss prior to grain reaching a moisture content that is suitable for storage.

Swathed Gairdner crops should be harvested as soon as they have reached a deliverable moisture content to maximise grain quality and minimise weather damage.

Perhaps in future, to minimise sand and insect contamination of swathed crops, crops will be direct headed at 20-22% moisture content, kept under aerated storage, and then dried to 12% moisture content for shipping.

KEY WORDS

swathing, Gairdner, barley, moisture

ACKNOWLEDGMENTS

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Paper reviewed by: Blakely Paynter and Roslyn Jettner

Development of a web based grower decision aid application for cereal growers

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KEY MESSAGES

Nowadays, the computer is one of the most important mechanisms to provide information. By using computers and specialised agricultural decision based software, overall farm management can be improved. Decision aid software can provide a means for growers to improve critical decision making on paddock and soil management, weed and pathogen control and varietal choice. Although decision making can be improved by using agricultural decision aid software, traditional standalone systems have some problems that have reduced their usefulness and popularity. By using the Internet technology, decision aid software can become more efficient in terms of development cost, usability, maintainability and flexibility.

BACKGROUND AND AIMS

Stripe Rust is a disease that can cause 50-60% yield loss in wheat. A decision aid application, e-Variety Guide for Stripe Rust (e-VGSR), has been created by the Crop Modeling Research Group at the Department of Agriculture, Western Australia (DAWA) in order to assist the growers to manage stripe rust on their farms. The existing application is implemented in standalone Excel spreadsheets. Indeed, most of the Crop Modeling groups decision aid applications are implemented in this way. This strategy has lead to the following problems:

- High development cost. The Department of Agriculture, for example, has to create and deliver more that 600 copies of CDs, every time they release a new application.
- Data inconsistency. Most of the agricultural software are data driven applications. In order to obtain correct estimation results from the application, up-to-date data must be provided. However, as each user has their own copy of the application, the data in the application will be out-of-data after a period of time, and thus, the estimation results will become incorrect.
- Poor Software quality. Many agricultural software products are prepared by agricultural scientists, with limited formal software engineering training. Therefore, software quality may not be guaranteed.

The project aims are:

- to solve the problems above by converting the existing e-VGSR to a web based version with data base connectivity; and
- to provide a concrete example of web based application to the agricultural industry.

METHODS AND RESULTS

A proof of concept web application has been implemented in October 2003. This web based e-VGSR has been implemented with an Oracle data base connection. The web based e-VGSR provides the same functionalities as the original does. The web based version of e-VGSR has also taken into account some factors which are specific to web implementation including;

- Network Bandwidth. There are a number of farmers using slow Internet connections (e.g. 14,400bps). Therefore, in order to provide faster data transmission between the web server and the user, graphical presentations (e.g. bar charts) are presented to the user if and only if the user requests.
- Web browser. Some farmers are using old versions of web browsers. So that everyone can use the web based e-VGSR, the web based e-VGSR is implemented as simple as possible. In other words, unlike other modern web pages that provide animations and sounds, the web based e-VGSR is mainly text based.

- Monitor. Similarly, some farmers are using old and small monitors. The user interface (e.g. colours and format) of the web based e-VGSR is designed to satisfy all potential users.

Figure 1 shows the main page of the web based e-VGSR. Users can change the settings in the light green area and obtain the estimation result in the white area at the bottom of the web page. Similarly, users can change other settings in other categories by clicking the buttons at the top of the web page.

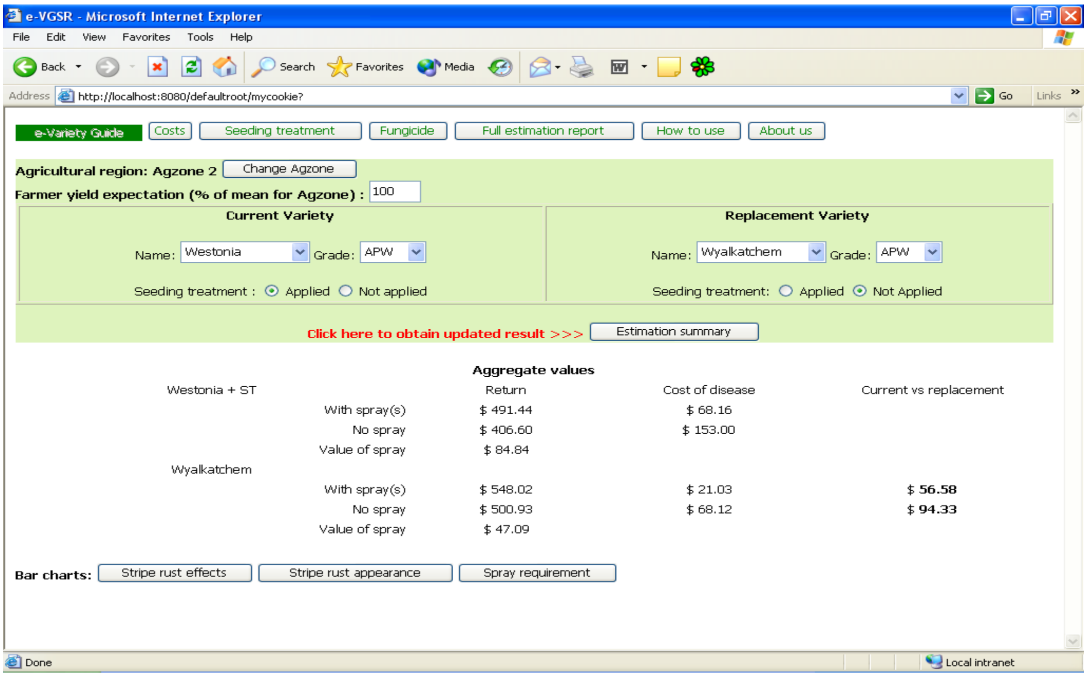

Figure 1. The web based e-VGSR.

CONCLUSION

It is expected that the development of a web based e–VGSR application will solve many of the deficiencies of the standalone version. This is because: 1) there is only one copy of the application located on the web server, and thus, the CD creation and delivery cost can be eliminated; 2) users can use the most up-to-date data with the application as the web based e-VGSR is connected to the central Oracle data base; and 3) as the implementation of web based applications require more software engineering techniques, the software quality can be enhanced.

This project was carried out as preliminary investigation for further research collaboration between Edith Cowan University and DAWA. This research aims to develop strategies to improve the delivery of paddock management decision aid models through the use of online and mobile software systems. Future research will investigate how current decision aid and paddock management software applications are developed and used by growers and agricultural consultants. The research project will determine the following the adoption and usage of these technologies, what growers would prefer in terms of user interface and the most appropriate design and implementation. The project will also investigate how software component technology can be used to produce software that can be easily reworked to incorporate new research information. The research would test the success of these strategies by establishing the best way to incorporate predictive model software into a 'paddock management software tool'.

KEY WORDS

Agricultural software, decision making, web based application, e-Variety Guide for Stripe Rust (e-VGSR).

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Paper reviewed by: Mr Michael Collins, Edith Cowan University

Wheat varieties updated in 'Flowering Calculator' - a model predicting flowering time

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KEY MESSAGES

- In 2003, flowering data was collected from 20 current and potential new varieties across three sowing dates and five locations in WA.
- This data is to be used to update the ability of the model 'Flowering Calculator' to predict the flowering time of current wheat varieties grown in a range of locations and sowing times.

BACKGROUND

Choice of sowing date and variety is the key to maximising yield potential. Earlier sowing should mean better water use efficiencies and higher yields. Successful adoption of this strategy hinges on matching variety to sowing time to maximise growth, while minimising the likelihood of frost after flowering yet avoiding the incidence of high temperature events and terminal drought during grain fill. Many options are now available when making this choice. The Flowering Calculator is a tool that enables the user to compare flowering outcomes relative to risks of frost and high temperature events and the likelihood of experiencing optimum conditions during grain development.

The Flowering Calculator provides procedure to calculate flowering time using average daily temperature and day length data.

- The user can interrogate daily temperature data records to provide information on incidence of frost and critical mean temperature events after flowering, high temperature events towards the end of grain filling and variation in flowering time.
- Outcomes from variety selections can be assessed relative to user defined flowering windows and end of season dates, for any date of sowing.
- The user can define frost, critical temperature and high temperature events in terms of severity (temperature) and duration (consecutive days).
- The user can select one or more years of temperature and record to calculate year specific flowering times whilst identifying the occurrence of frost, critical temperature, and high temperature events in those years.

Parameter data are supplied to enable flowering time to be calculated for a selection of varieties for each of several crop species using a range of phenological models. The models were selected on the basis of: (i) enabling easy generation of parameters as new varieties come to hand using sowing date, flowering date, and daily temperature and site latitude data; and (ii) accessing existing and developing parameter data bases.

The model used is as follows:

$$1/D = a + b(\text{Temp mean}) + c(\text{Day length mean})$$

where: D = the duration from sowing to flowering

a, b & c = are coefficients related to basic vegetative period (BVP), temperature response and photo-period response respectively.

AIMS

Flowering data collected by the project 'Variety specific agronomy for wheat yield and grain quality in the Western Region - DAW0012' is to be used to generate parameters for 'Flowering Calculator' to predict the flowering times for the current wheat varieties grown in a range of locations and sowing times in WA.

METHOD

Flowering dates were observed for twenty current and potential new varieties sown at three sowing dates at Mullewa, Mingenew, Nungarin, Quairading and Katanning in 2003.

The sum of the mean daily temperature was calculated from sowing to flowering from the closest weather station located near each of the sites.

The latitude of the location was used to calculate the mean day length.

These values where then used to calculate the regression parameters for each varieties, to be used in the Flowering Calculator

RESULTS AND CONCLUSION

Information will be presented at the crop updates.

KEY WORDS

wheat, varieties, flowering, sowing

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