



2010

CROP UPDATES

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CROP UPDATES 2010

Table of Contents

PLENARY	Page
Challenges facing western Canadian cropping over the next 10 years Hugh Beckie	1
 CROP SPECIFIC	
Breeding	
The challenge of breeding canola hybrids – new opportunities for WA growers Wallace Cowling	7
Chickpea 2009 crop variety testing of germplasm developed by DAFWA/CLIMA/ICRISAT/COGGO alliance Tanveer Khan, K Adhikari, K Siddique, J Garline, L Snith, S Morgan, C Boyd	9
PBA Pulse Breeding Australia – 2009 Field Pea Results Ian Pritchard, Chris Veitch, Colin Boyd, Stuart Morgan, Alan Harris, Tony Leonforte	13
PBA Pulse Breeding Australia – 2009 Chickpea Results Ian Pritchard, Chris Veitch, Colin Boyd, Murray Blyth, Shari Dougal, Kristy Hobson	16
Decision Support	
A tool for identifying problems in wheat paddocks Ben Curtis, Doug Sawkins	19
DAFWA Seasonal Forecast for 2010 David Stephens	22
Disease	
Enhancement of black spot resistance in field pea Kedar Adhidari, T Kahn, S Morgan, C Boyd	23
Fungicide management of yellow spot in wheat Ciara Beard, Kith Jayasena, Kazue Tanaka, Anne Smith	26
Resistance to infection by <i>Beet western yellows virus</i> in four Australian canola varieties Brenda Coutts, Roger Lawes	30
Yellow spot carryover risk from stubble in wheat-on-wheat rotations Jean Galloway, Pip Payne, Tess Humphreys	34
Fungicide for the future: Management of Barley Powdery Mildew and Leaf Rust Kithisri Jayasena, Kazue Tanaka, William MacLeod	37
2009 canola disease survey and management options for blackleg and Sclerotinia in 2010 Ravjit Khangura, WJ MacLeod, M Aberra, Milan	41
Impact of variety and fungicide on carryover of stubble borne inoculum and yellow spot severity in continuous wheat cropping Geoff Thomas, Pip Payne, Tess Humphreys, Anne Smith	45

	Page
Disease continued ...	
Limitations to the spread of <i>Wheat streak mosaic virus</i> by the Wheat curl mite in WA during 2009	50
Dusty Severtson, Peter Mangano, Brenda Coutts, Monica Kehoo, Roger Lawes	
Viable solutions for barley powdery mildew	55
Madeline Tucker	
 Marketing	
The importance of varietal accreditation in a post-deregulation barley marketing environment	59
Neil Barker	
Can Australian wheat meet requirements for a new middle eastern market?	62
Robert Loughman, Larisa Cato, Ken Quail	
 Variety performance	
Sowing rate and time for hybrid vs open-pollinated canola	65
Mohammad Amjad, Mark Seymour	
HYOLA® National Hybrid vs OP Canola Hybrid F1 vs retained seed generation trial results and recommendations for growers	69
Justin Kudnig, Mark Thompson, Anton Mannes, Michael Uttley, Chris Fletcher, Andrew Etherton, Nick Joyce, Kate Light	
HYOLA® National Hybrid vs OP Canola sowing rate trial results and plant population recommendations for Australian growers	73
Justin Kudnig, Mark Thompson, Anton Mannes, Michael Uttley, Chris Fletcher, Andrew Etherton, Nick Joyce, Kate Light, Peter Hamblin, Michael Lamond	
Desi Chickpea agronomy for 2010	79
Alan Meldrum, Wayne Parker	
New wheat varieties – exploit the benefits and avoid the pitfalls	83
Steve Penny, Sarah Ellis, Brenda Shackley, Christine Zaicou, Shahajahan Miyan, Darshan Sharma, Ben Curtis	
The influence of genetics and environment on the level of seed alkaloid in narrow-leafed lupins	92
Greg Shea, Bevan Buirchell, David Harris, Bob French	
 FARMING SYSTEMS	
Pests and Disease	
Preserving phosphine for use in the Grain Storage Industry	99
Chris Newman	
 Farming Systems Research	
Demonstrating the benefits of grazing canola in Western Australia	102
Jonathan England, Stephen Gherardi, Mohammad Amjad	
Buloke barley yield when pasture-cropped across subtropical perennial pastures	105
David Ferris, Phil Ward, Roger Lawes	
Is pasture cropping viable in WA? Grower perceptions and EverCrop initiatives to evaluate	110
David Ferris, Tom Wiley, Peter Dolling, Peter Barrett-Lennard	

	Page
Farming Systems Research continued ...	
Best-bet management for dual-purpose canola John Kirkegaard, Susan Sprague, Hugh Dove, Walter Kelman, Peter Hamblin	115
Pastures in cropping systems – with and without sheep Brad Nutt, Angelo Loi	119
Can technology substitute for a lupin break? Wayne Parker	122
Canola row spacing with and without long term stubble retention on a sandy clay loam at Merredin Glenn Riethmuller	125
Impact of stubble retention on water balance and crop yield Phil Ward, Ken Flower, Neil Cordingley, Shayne Micin	128
 Analysis and Modelling	
Using POAMA rainfall forecasts for crop management in South-West WA Senthold Asseng, Peter McIntosh, Mike Pook, James Risbey, Guomin Wang, Oscar Alves, Ian Foster, Imma Farre, Nirav Khimashia	132
Adaptation to changing climates and variability – results of the Agribusiness Changing Climates regional workshop John Blake, W Anderson, D Beard, R Grieve, M Lang, J Lemon, R McTaggart, D Gray, M Price, D Stephens	135
Farmers' management of seasonal variability and climate change in WA David Beard, D Gray, P Carmody	141
Is there a value in having a frost forecast for wheat in South-West WA? Imma Farre, Senthold Asseng, Ian Foster, Doug Abrecht	145
Does buying rainfall pay? Greg Kirk	148
Which region in the WA wheatbelt makes best use of rainfall? Peter Rowe	150
POAMA – the Predictive Ocean-Atmosphere Model for Australia Guoming Wang, Oscar Alves	152
Exploring the link between water use efficiency and farm profitability Cameron Weeks, Peter Tozer	156
 Precision Agriculture	
A plethora of paddock information is available – how does it stack up? Derk Bakker	161
Variable rate prescription mapping for lime inputs based on electromagnetic surveying and deep soil testing Frank D'Emden, Quentin Knight, Luke Marquis	165
Trial design and analysis using precision agriculture and farmer's equipment Roger Lawes	169
Farmer perspectives of precision agriculture in Western Australia: Issues and the way forward .. Roger Mandel	173

GENETICALLY MODIFIED CROPS	Page
Evaluation of the environmental and economic impact of Roundup Ready® canola in the Western Australian crop production system James Fisher, Peter Tozer	176
Controlling wild radish (<i>Raphanus raphanistrum</i>) in Roundup Ready® ¹ Canola: Outcomes from the Nufarm 2009 Roundup Ready small plot trial program Mike Jackson	180
Weed control strategies for glyphosate tolerant crops John Moore	185
Results of the 2009 Western Australia Roundup Ready® canola trials James Neilson	190
 NUTRITION	
Modelling P runoff losses from agricultural systems Geoff Anderson, Wen Chen, Richard Bell, Ross Brennan	194
Evaluation of deep banded biochars or biochar-mineral complex for increasing wheat yield or replacing fertiliser Paul Blackwell, Allan Herbert, Stephen Davies	196
Improving fertiliser management: Redefining soil test-crop response relationships for canola in Western Australia Wen Chen, Ross Brennan, Richard Bell, Mike Bolland, Geoff Anderson	200
Phosphorus placement for wheat and lupins in WA cropping systems Wen Chen, Richard Bell, Ross Brennan, Mike Bolland	204
The benefits of fertilising pastures for following crops James Easton, Ryan Guthrie, Rowan Maddern	208
Good nutrition produces high quality wheat in the high rainfall zone of Western Australia Darren Hughes, Robert Belford, Wal Anderson, Ian Edwards	211
Lime to get maximum benefit from soil phosphorus Reg Lunt, Bill Bowden	215
Variable rate top up N – Is it worth the trouble? Nigel Metz	218
 SOILS	
Impact of soil inversion, soil dilution and claying on non-wetting sandplain soils Stephen Davies, Peter Newman, Breanne Best	223
Long-term effect of lime application on soil pH, crop yields and annual ryegrass competition Chris Gazey, Joel Andrew	229
 WEEDS	
Herbicides	
Herbicide control of slender iceplant Andrew Blake, Lorinda Hunt	234

WEEDS continued ...	Page
Herbicide tolerance of saltbush and bluebush Andrew Blake, Lorinda Hunt	237
Chemical control of windmill grass Catherine Borger, Glen Reithmuller, Abul Hashem	239
Use high water rates when applying pre-seeding herbicides to fields with high stubble density ... Catherine Borger, Abul Hashem	243
Herbicide tolerance of lupins – influence of soil type and rainfall Harmohinder Dhammu, David Nicholson	247
Response of new barley varieties to herbicides Harmohinder Dhammu, Vince Lambert, Russell Quatermaine	251
Herbicide tolerance of new wheat varieties Harmohinder Dhammu, David Nicholson	254
 Herbicide Resistance	
Use of below label rate can lead to evolution of herbicide resistant weeds Roberto Busi, Todd Gaines, Suoheesh Manalil, Stephen Powles	257
Herbicide mixtures can effectively kill herbicide-resistant weeds Aik Cheam, Siew Lee	260
Selective spray-topping: Does it abort seed production of herbicide-resistant wild radish? Aik Cheam, Siew Lee	263
The search for a new lupin herbicide Peter Newman	265
 Integrated Weed Management	
Colonisation of agricultural regions in Western Australia by flaxleaf fleabane Catherine Borger, Greg Doncon, Abul Hashem	269
Weed suppression by crop competition in barley, canola and wheat Abul Hashem, Catherine Borger	273
Mouldboard plough continues to kick goals Peter Newman, Steve Davies	277
The answer my friend is to burn in light wind Peter Newman	280
Using image analysis to detect three-horned bedstraw seed in grain samples John Moore, Murray Gillespie	284
Can we manage brome and barley grass in cereals? Sally Peltzer, Abul Hashem, Alex Douglas	286
Controlling mature fleabane Sally Peltzer	289

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Happy reading.



Janet Paterson—DAFWA Science Communication Officer
EDITORIAL COORDINATOR

Challenges facing western Canadian cropping over the next 10 years

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KEY MESSAGES

- Challenges facing western Canadian growers over the next 10 years include: Stagnant yields and marginal/negative economic returns in cereal crop production, trade irritants related to GM adventitious presence or contaminants (real or imagined) in grain shipments, retiring farmers with no heir apparent, and weed resistance.
- Like Australia, weed resistance (primarily to group A and B herbicides) is a looming barrier to sustained crop production. Resistant weeds are expected to infest over half of all annual-cropped acreage over the next 10 years; new mode-of-action herbicides and greater adoption of integrated weed management practices will be needed to sustain yields.
- Research has shown that crop rotation diversity is the long-term solution to weed resistance; greatest profit potential in oilseeds (especially canola) and pulses (e.g. peas, lentils, chickpeas) over the next decade will reduce the area cropped to cereals to less than 50 per cent of total annual-cropped area for the first time in the history of agriculture in western Canada.

SNAPSHOT OF AGRICULTURE IN CANADA

In 2001, there were 246 923 farms across Canada, compared with 140 516 in Australia. In 2006, the number of farms in Canada had declined by 7 per cent to 229 373. Farm size in western Canada varies widely, but a 1 200 ha farm would probably be a typical size of many farms. Types of farms across Canada are the following: Field crops 40 per cent, beef 27 per cent, dairy, hog, or poultry 26 per cent, and fruits/vegetables 7 per cent. Organic farms comprise 7 per cent of all farms (16 132): Certified 1.5 per cent, not yet certified 5.2 per cent, and in transition from conventional 0.3 per cent.

The Canadian Prairies in western Canada cover a total area of 113 million ha (Figure 1). The principal annual field crops are grown on about 30 million ha (over 90 per cent of national total), with about 10 million ha in perennial forages, hay, or pasture. The growing season in the Prairies is from early May to the end of August, generally ranging from 105 to 120 days. Average annual precipitation varies from about 500 mm in eastern and northern regions (sub-humid Parkland region; black and grey soils with organic matter ranging from 4–10 per cent) to about 300 mm in the southern Prairies (semi-arid Grassland region; brown or dark brown soils with organic matter ranging from 2–4 per cent). Of the precipitation that falls on the Prairies, 20–25 per cent is snow, 40 per cent is rainfall during the growing season, and 35–40 per cent is rainfall outside the growing season. About two-thirds of the water used by crops is from rain that falls during the growing season, the remainder from soil moisture stored outside the growing season.



Figure 1 Canadian Prairies: Provinces of Alberta, Saskatchewan, and Manitoba

Conservation tillage has been increasingly adopted across the Prairies. About 46 per cent of land is no-till, 26 per cent minimum tillage, and 28 per cent conventional tillage. In 1996, no-till and min-till were practiced on only 16 and 31 per cent of land, respectively. No-till is more prevalent in the Grassland than Parkland region because of soil moisture conservation and less crop harvest residue.

CHALLENGES OVER THE NEXT 10 YEARS

1. Profitability (or lack thereof)

Besides death and taxes, the other certainty for a farmer is the struggle to maximize profits from crop production. When crop prices go up, input costs are sure to follow—‘charge what the market will bear’ is the guiding principle of crop input providers. Farmers have little control over commodity prices or input costs; they choose the crop(s) that will potentially offer the highest returns and hope the weather cooperates for attaining target yields. In 2010, prices for most crops are expected to be similar to those in 2009, except slightly higher malting barley prices and lower lentil prices (Table 1).

Fertilisers (primarily nitrogen and phosphorus) account for 30 to 40 per cent of input costs. Although fertiliser prices fell in 2009 from record prices in 2008 (ca. \$600/Mt for urea), the rising price of oil will inevitably lead to higher fertiliser prices over the next 10 years. Barring another major global recession, increasing demand for oil by the emerging economies of China and India over the next 10 years will likely result in fertiliser costs approaching 50 per cent of input costs for cereal and oilseed crop growers. Consequently, increased area sown to pulse crops—primarily peas and lentils—over the next decade is a certainty. Presently, pesticides (mainly herbicides) account for 25 to 30 per cent of input costs. Because of the increasing number of generic products with the expiration of patents on many popular herbicides, herbicide costs are not expected to rise significantly over the next 10 years. Of concern to canola growers is the significant cost of seed (including the technology-use fees), presently one-third of input costs in growing canola (mostly hybrids). The two most popular canola systems are RoundupReady and LibertyLink—over 80 per cent market share. The high cost of seed has resulted in many farmers cutting seeding rates as low as possible (down to 3 kg/ha), which can be risky if dry or cold soil conditions prevail during crop emergence.

Based on net returns after total rotational expenses, lentils (\$189/ha) and canola (\$61–78/ha) are expected to be the most profitable crops (Table 1). Lentils are mostly grown in the Grassland region, while canola is mainly grown in the Parkland region. Although canaryseed is very profitable, the limited market restricts production to less than 200 000 Mt. After total rotational expenses are factored in, only marginal returns at best are achieved from growing cereals. The net returns shown in Table 1 do not include freight and elevator charges. Where I farm 80 km south of Saskatoon, Saskatchewan, nearly

40 per cent of gross returns for wheat is deducted! The Prairies is land-locked; farmers depend on reliable rail service to the port terminals at Vancouver (west coast), Thunder Bay (St. Lawrence seaway, eastern Canada), or Hudson Bay (arctic port). Therefore, net returns for exported cereals are dismal.

Table 1 Net returns (\$ Canadian; 1 Australian dollar = 0.95 Canadian) after variable expenses/total rotational expenses^a (Source: Crop Planning Guide 2010; www.agriculture.gov.sk.ca)

Crop	Grassland region ^b	Parkland region ^b	Expected prices (2010)
Spring wheat	43/–10	62/1	\$192
Durum wheat	53/–1	–	183
CPS wheat ^d	51/–2	78/16	
Feed barley	48/–5	66/4	172 ^e
Oats	–	59/–2	189
Lentils	249/189	–	484
Peas	62/2	57/–10	220
Flax	78/24	70/9	354
Canaryseed	112/58	116/55	440
Canola	115/61	139/78	396

^a Variable expenses include seed, fertiliser, pesticides, fuel, etc.; total rotation expenses are variable expenses plus capital cost expenses such as depreciation, overhead, etc.

^b Semi-arid Grassland and sub-humid Parkland regions of the Prairies (see Figure 1).

^c Per metric tonne (Mt); All prices expected to be similar in 2010 vs. 2009 except slightly higher prices for malting barley and lower prices for lentils.

^d Canada Prairie Spring wheat (lower protein than 'Spring wheat').

^e Price for malting barley.

2. Crop production – stagnant cereal yields

Over the past 50 years, the seeded pasture area has remained constant while fallow area has declined by 60 per cent, with a similar increase in cropped area. Since 1976, the area grown to cereals has fallen by 30 per cent, whereas oilseed and pulse (mainly peas and lentils) cropped areas have increased by the same amount over this period (Figure 2). In 2009, cereals comprised 53 per cent of annual crops area, oilseeds (mainly canola) 28 per cent, pulses 10 per cent, and fallow 9 per cent.

Some common crop rotations in western Canada are: (1) wheat-fallow; (2) barley-barley; (3) wheat-canola; (4) canola-canola; (5) wheat-lentils or peas-wheat-canola; (6) wheat-canola-barley-lentils or peas; and (7) wheat-canola-barley-alfalfa. Therefore, in many rotations cereals (wheat, barley, oats) still comprise half or more of cropped land. On my 1000 ha farm, I follow a wheat-canola-wheat or barley-lentil rotation. Canola is usually grown once every three or four years because of disease considerations (e.g. sclerotinia, blackleg). Pulses are rarely grown in consecutive years because of disease-buildup potential (e.g. ascochyta) or weed pressure (pulses are not weed-competitive).

In the past five years, wheat area (spring, durum, winter) has fluctuated but essentially has remained constant (10 million ha) (Figure 3). Winter wheat is grown on less than 500 000 ha annually. Wheat production during each of the past five years has been about 25 million Mt. Average yields of durum, spring, and winter wheat in 2009 were 2 400, 2 800 and 3 100 kg/ha, respectively (or 2.4, 2.8, 3.1 Mt/ha). Over the past five years, yields have fluctuated considerably due to variable weather conditions, but have not significantly increased. Wheat yields have changed little in the past decade. Barley area has generally declined during the past 5 years, from 4.4 million ha to 3.3 million ha, with subsequent reduction in production from 11.5 million Mt to 9 million Mt. Average yields have remained stagnant at about 3 000 kg/ha. Unless more resources are allocated to cereal breeding, profit margins in cereal production will remain slim to none. Many farmers now view cereals as a break crop between more profitable crops—pulses or oilseeds.

The area grown to pulses (peas, lentils, chickpeas) has increased slightly over the past five years from 2.3 million ha to 2.6 million ha; production has increased from 4.5 million Mt to 5.0 million Mt. Average pea and lentil yields have not changed markedly (2 300 and 1 500 kg/ha, respectively), but chickpea yields have increased 20 per cent over this period (1 900 kg/ha average yield in 2009). Even though prices are expected to drop in 2010, lentil area is expected to increase 15 per cent from that in 2009 because of significant profit potential (Table 1).

In contrast to wheat and barley, the canola area has increased steadily over the past five years from 5.5 million ha to 6.4 million ha in 2009 (Figure 4). Production has increased from just under 10 million Mt to 12 million Mt. It is estimated that 15 million MT will be needed by 2015 to meet demand. Average yields have increased slightly to about 1 900 kg/ha in 2009. However, genetic modification, hybrids, and the large private breeding investment have raised yields significantly over the past decade. In 2009, a number of producers achieved yields of 2 800 kg/ha. Ten years ago, yields half of that would be considered good. Seeded area is expected to increase 5 per cent in 2010, with expected price averaging \$396/Mt. There is a nearly 7 million Mt crushing capacity in western Canada, with a minimum of 6 Mt exported. Hauling canola to crushing facilities negates paying freight and elevator charges.

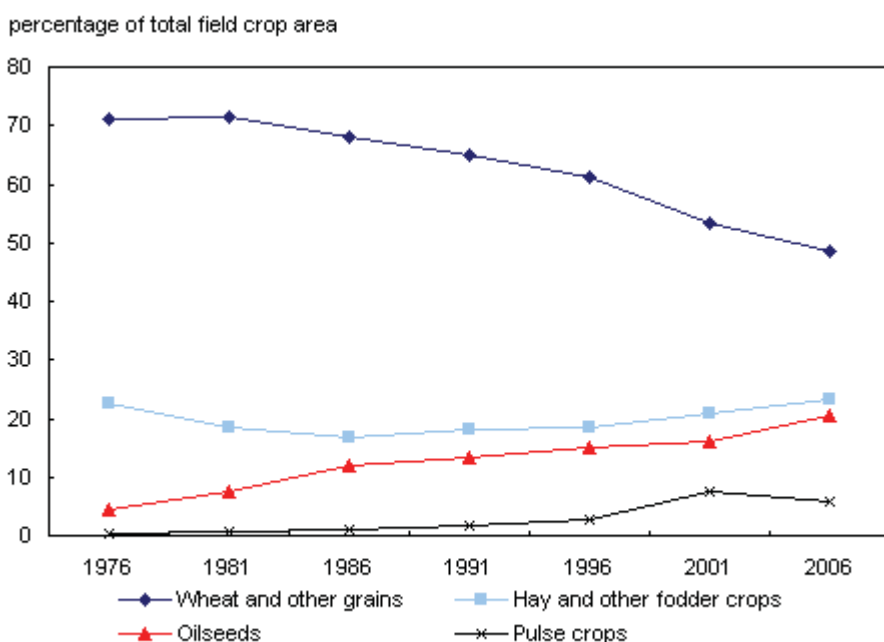


Figure 2 Trends in cereal, oilseed and pulse (annual legume) crop area in western Canada since 1976

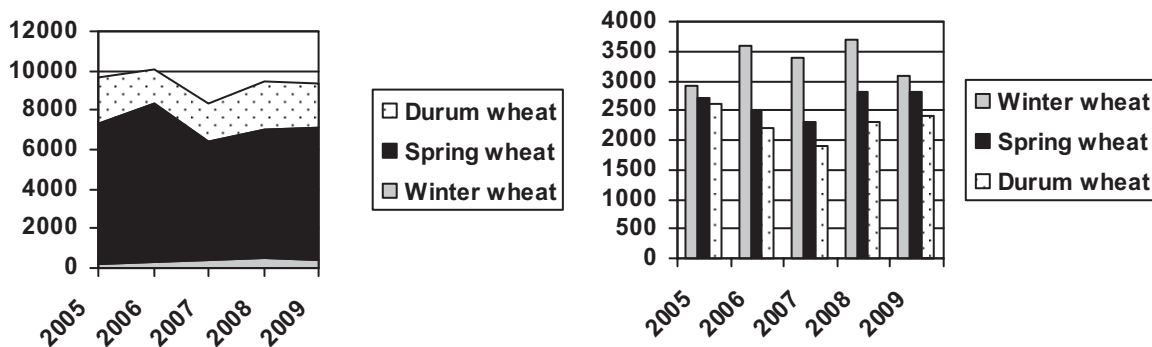


Figure 3 Wheat area ('000 ha) and yields (kg/ha) in western Canada: 2005–2009
(Source: Statistics Canada; www.statcan.gc.ca)

3. Weed resistance – the biggest challenge

Although not yet as widespread and prevalent as across many parts of Australia, weed resistance will be the most important challenge to annual crop production in western Canada over the next 10 years. Based on field surveys, I estimated herbicide-resistant weeds infested nearly 20 per cent of land cultivated to annual crops—nearly 5 million ha—in early 2000s; today, that figure is about 40 per cent. Wild oat (*Avena fatua*) is our most economically-damaging weed, which is abundant across the entire Prairies. Over the next decade, group A (ACCase inhibitor) resistance will impact more than half of all wild oat populations in annual crops in western Canada (Figure 5). We have not had a new mode-of-action wild oat herbicide in over 25 years. The area infested with group B (ALS inhibitor)-resistant broadleaf weeds is increasing rapidly. Farmers now assume all kochia (*Kochia scoparia*) and spiny annual sow-thistle (*Sonchus asper*) populations are resistant to group B herbicides. Consequently, pulse crop growers, who rely heavily on group B herbicides, will be facing daunting weed control challenges. We are locked into group A and B herbicides in all our crops except canola. Over two-thirds of our wheat and barley acres each year receive a group A herbicide application. Herbicide diversity is urgently needed. Only RoundupReady or LibertyLink canola offers a reprieve from over-reliance on those high-risk chemistries. Preemergence herbicide use has declined sharply over the past 20 years and currently less than 5 per cent of cropped land receives these treatments (e.g. trifluralin, ethalfluralin, triallate). Wild oat resistance will result in a resurgence in use of these old herbicides, even though their performance is inconsistent and moisture-dependent. The long-term solution to weed resistance is greater cropping diversity and adoption of integrated weed management practices such as greater cereal seeding rates, fertiliser application synchronised with crop uptake, and weed-competitive crop varieties.

Fortunately, we do not yet have glyphosate resistance in western Canada. The selection pressure for glyphosate resistance is still low to moderate across most cropping systems in the Prairies. Selection pressure for resistance from the common burndown (pre-emergence) use of glyphosate is significantly less than in-crop use (e.g. RoundupReady canola). RoundupReady corn or soybean is grown on less than 200 000 ha across the Prairies, and primarily in southern Manitoba.

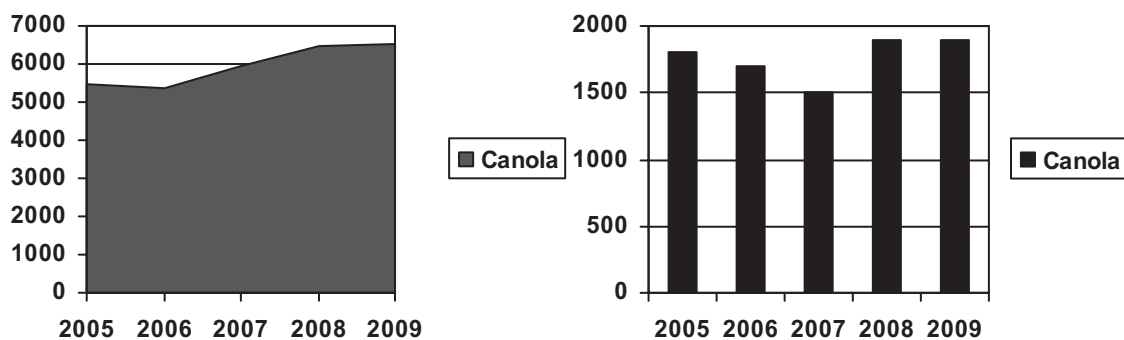


Figure 4. Canola area ('000 ha) and yields (kg/ha) in western Canada: 2005–2009

(Source: Statistics Canada; www.statcan.gc.ca)

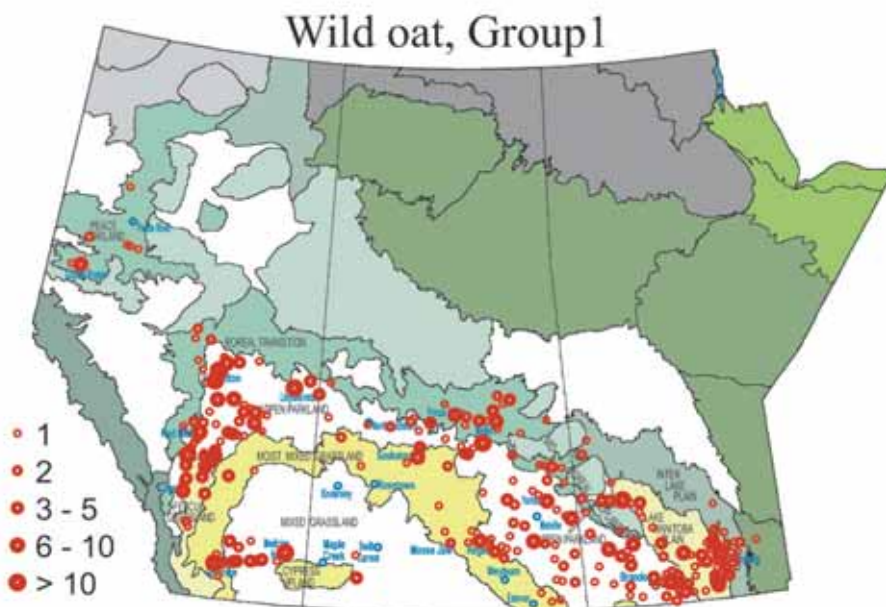


Figure 5 Group 1/A (ACCase inhibitor) resistance (legend denotes number of cases) in wild oat (*Avena fatua*) across the Canadian Prairies based on samples submitted by growers: 725 cases from 1996 to 2006; an additional 217 cases were confirmed in 2007 and 2008 crop years (not shown). Random field surveys indicate that herbicide-resistant wild oat currently infests 40 per cent or more of annually-cropped fields.

4. Aging farmers and more rented land

Of total cropland, 60 per cent is farmed by the landowners themselves while 40 per cent is rented or leased. The percentage of land rented or leased is expected to increase over the next 10 years. In general, these operators are more focused on short-term profit than long-term sustainability. The average age of farmers is 52: 9 per cent are under 35 (vs. 21 per cent in 1991), 50 per cent are 35–54 years old (vs. 47 per cent in 1991), and 41 per cent are 55 years or older (vs. 32 per cent in 1991). Therefore, our farmers are getting older with declining numbers of young farmers entering the profession. Moreover, half of all farmers have off-farm employment to supplement their income. There are not many occupations where half of all members have a second job! This demographic challenge will only be solved by more immigrant farmers from overseas—Australians are always welcome!

5. Trade irritants likely to increase

With a population of 34 million, Canada exports the majority of what it produces. Living next to the United States has been likened to a mouse living next to an elephant. Canada exports two-thirds of all agricultural products south of the border. The other major importing nations are Japan, the EU, China, and Mexico. Even though Canada signed the North American Free Trade Agreement with the United States and Mexico over 20 years ago, protectionism is always a constant threat to free trade—whether recently with canola meal shipments halted in 2009 or in the past with wheat export restrictions. Current cessation of canola seed shipments to China because of their apparent concern over blackleg disease, or stoppage of flax seed exports to Europe because of traces of unapproved GM flax found in conventional flax seedlots, illustrates how vulnerable farmers are to global trade irritants and highlights the increasing importance of identity preservation from farmgate to consumer plate. Traceability and efficient detection methods for adventitious presence of GM in seedlots will become increasingly vital in maintaining and enhancing trade in agricultural products. Setting a realistic threshold (e.g. 0.1 per cent) for unapproved GM adventitious presence—rather than zero—would facilitate rather than hinder global trade, which is essential for avoiding another global recession.

KEY WORDS

annual legumes, barley, canola/oilseed rape, herbicide resistance, net returns, trade, wheat

The challenge of breeding canola hybrids – new opportunities for WA growers

Wallace Cowling, Research Director, Canola Breeders Western Australia Pty Ltd

KEY MESSAGES

Canola hybrids with new herbicide tolerance, such as hybrid triazine (HT™), Clearfield® and Roundup Ready®, are transforming the canola industry in Western Australia. Many WA farmers will grow hybrid canola for the first time in 2010. If Australia follows the trends observed in Canada and Europe over the past 15 years, hybrid canola will increase in market share over open-pollinated varieties over the next few years. The potential rewards for growing canola hybrids are large. Yields of canola hybrids are normally 10–15 per cent above open-pollinated types, and hybrids have extra vigour and stress tolerance resulting in a more secure crop. This paper addresses the complex process of producing quality canola hybrid seed. It is both risky and expensive to breed hybrid canola and produce quality hybrid seed, but the cost is justified by the higher returns to growers and the entire canola industry.

AIMS

This paper will describe various systems used for producing hybrid canola seed, some of the risks involved, and steps taken to minimise risks and maximise seed quality.

METHOD

F1 hybrid seed is first-generation seed formed from a cross between two parent varieties. Breeders have to test many combinations to find which has the best hybrid vigour. It is possible, but too expensive, to make F1 hybrid seed by hand. A male-sterility system is necessary—where a male-sterile variety is grown next to a pollinator. Non-GM hybrid systems include Ogu-INRA (cytoplasmic system, licensed by INRA France) and MSL (hybrid system licensed by NPZ Lembke Germany). The only GM hybrid system is InVigor®, an in-house system owned by Bayer Crop Science. All systems come with their own inherent benefits and problems, and all follow the same system.

The male-sterility hybrid system

F1 hybrid seed is produced on a male-sterile line. The male-sterile, or mother line, does not produce pollen. It must only be pollinated by the pollinator variety in order to produce high quality F1 hybrid seed; therefore isolation from other canola crops is important. The two varieties should flower at similar times, or flowers must be trimmed on one of the lines to promote good ‘nicking’ of flowering time. Bees are necessary to promote pollen flow from the pollinator variety to the male-sterile line. Locating hives at the right place at the right time is crucial for success. High temperatures and drought stress must be avoided by locating the production field in a mild climate with adequate moisture (irrigation).

Ogu-INRA system: The pollinator variety must be bred to carry ‘restorer’ genes, which restore fertility in the F1 hybrid.

MSL system: Any variety can act as a restorer; no special breeding of the pollinator is required.

InVigor® system: The male-sterile line is bred to contain the male sterility gene ‘Barnase’. The pollinator variety is bred to carry the fertility restorer gene ‘Barstar’.

Production of seed of the male-sterile line: This is the ‘engine’ behind the F1 hybrid seed production system. High standards of purity and isolation are required for production of seed on the male-sterile line. When the male-sterile line is pollinated by a ‘maintainer’ line, the seed produced is male-sterile. The production of F1 hybrid seed is a two step process—production of male-sterile line seed, followed by production of F1 hybrid seed. Clearly, the breeding and production of male-sterile lines, maintainer lines and restorer lines is a time-consuming and expensive process for canola breeding companies.

RESULTS

Why choose an F1 hybrid canola variety? The major reason is to exploit the higher potential yield of the hybrid and higher profit from the ≥ 15 per cent yield advantage. Growers must purchase high quality hybrid seed each year in order to exploit this hybrid vigour.

Why not save seed from hybrids? Seed harvested from a canola hybrid, if grown out again, will produce a crop that is highly variable, with lower yield. There will be great variation in height, disease susceptibility (blackleg problems), seed quality (variable oil) and flowering date. Many plants may be sterile. It doesn't make economic or biological sense to save seed of an F1 hybrid. In the case of Roundup Ready® canola, it is illegal to save seed.

The decision to grow a canola hybrid should be based on your confidence to produce a profitable hybrid crop: Is this the right time and place to grow F1 hybrid seed? If not, then stay with the best open-pollinated canola variety for your farm, which has secure yield, quality and growth attributes. To begin with, always grow F1 hybrid canola seed on paddocks with the greatest yield potential, and provide adequate nutrition and weed control. However, with experience, canola hybrids can be grown profitably on more marginal soils where the greater stress tolerance of hybrids will be apparent. Be prepared to adapt your seeding machinery to maximise stand establishment and yield.

Why is hybrid seed so expensive? Hybrid breeding is major investment for a canola breeding company, on top of open-pollinated variety breeding. This takes time, money, risk, and expertise. Hybrid seed production is risky and low yielding, but high in value. Hybrid seed production will require specialist growers, and a specialist seed industry. High quality seed is paramount. Growers of canola hybrids will demand high quality seed for the higher price.

What's new in canola hybrids?

Several canola hybrids are new in 2010:

Triazine tolerant hybrids: CB™ Jardee HT™, CB™ Tumby HT™, CB™ Mallee HT™, Hyola751TT

Clearfield® hybrids: 46Y83, 45Y82

Roundup Ready® hybrid: CB™ Eclipse RR, V5001 (speciality oil)

CONCLUSION

New herbicide tolerance and improved genetics will increase the adoption of hybrid canola. The canola industry will be stimulated throughout the chain from breeder to oil processor by the increased adoption of hybrid canola. While hybrid seed production is risky and highly technical, the potential rewards for the canola industry are great.

KEY WORDS

F1 hybrid canola

Roundup Ready® is a registered trademark of Monsanto Technology LLC.

Chickpea 2009 crop variety testing of germplasm developed by DAFWA/CLIMA/ICRISAT/COGGO alliance

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KEY MESSAGE

- All entries in the crop variety testing (CVT) trials of 2009 had good ascochyta blight resistance.
- 14–18 lines from the Stage 3 and Stage 4 trials are likely to be retained for the Stage 4 trials in 2010/2011.

BACKGROUND

The desi chickpea (*Cicer arietinum* L.) is well adapted to a range of fine textured soils of south Western Australia and was readily adopted when introduced in the mid 1990s. The area rose quickly to 80 000 ha in 1999 but with the outbreak of ascochyta blight it declined sharply and very little chickpea is now grown in the state.

In 2005, a new breeding project based on an international partnership between DAFWA, UWA, ICRISAT and COGGO (the Council of Grain Grower Organisations Ltd) was started with the aim of accelerating the development of ascochyta resistant, high quality varieties adapted to Western Australia. This paper reports the results from the 2009/2010 CVT trials of the advanced germplasm developed in this project.

AIMS

- To evaluate breeding lines developed in the project for yield, seed quality, ascochyta resistance and related agronomic characteristics.
- To select lines for inclusion/retention in the Stage 4 CVT trials of 2010/2011.

METHODS

The germplasm consisted of two groups of breeding lines. The Stage 3 group consisted of 30 breeding lines which entered the CVT system for the first time in 2009. The Stage 4 group consisted of 16 lines that have been in the CVT system for two or more years. There were two control varieties, Genesis510 and Genesis836.

A spatial row-column design was used with 3 replications with two directional blocking (along the rows and columns). Forty eight entries including two controls were sown at Katanning (sown 29 May), Yandanooka (sown 25 May), Carnamah (sown 28 May), Pithara (sown 2 June), Bolgart (sown 3 July) and Mullewa (sown 26 May). Plot width varied from 1.10–1.54 m and length from 15–26 m. Plot length harvested varied from 15–18 m. The plot yield data was converted to kg/ha before analysis. The analysis used ASREML3 by fitting a restricted maximum likelihood (REML) model with spatial trends to rows and columns. The predicted breeding line estimates from this statistical model (i.e. Best Linear Unbiased Predictors—BLUPs) and associated error estimates were then used to construct the table of means for each series of trials. Subsequent multi-environment analyses (METs) were used to make across series and years variety summaries.

Agronomic management varied to suit the paddock conditions. Trials received 1–2 sprays of Bravo (75 per cent chlorothalonil) at 1 L/ha as a prophylactic measure. Little ascochyta blight was noticed and its effect on yield would have been minimal, if any.

All entries in these trials were also tested in a replicated disease nursery sown at Medina on 12 May, 2009 where a uniform epidemic of ascochyta blight developed. Ascochyta resistance (ar1) on a 0–9 scale (0 = no disease and 9 = plant totally blighted) was recorded on 10 August and selection index under disease conditions (snd1) on a 3–0 scale (3 = unaffected by disease, 0 = totally decimated by disease) was recorded on 30 September.

RESULTS

Katanning was the lowest yielding site and Bolgart the highest (Tables 1 and 2). The Katanning trial, also, had a very high co-efficient of variation (CV) rendering the yield data of limited value. Bolgart, despite its high yields, experienced conditions atypical to this location due to delayed sowing on 2 July. This late sowing caused flowering to occur under warmer spring temperatures and that may have masked any genotype differences in the pod setting sensitivity to cold temperatures. Due to a lack of seed supply, a number of entries were not represented at Mullewa for Stage 3 entries.

All Stage 3 and Stage 4 entries had good ascochyta resistance and in some lines very high degree of resistance persisted to maturity. In Stage 3 entries, 7 lines out-yielded control (Genesis836) based on overall mean (Table 1). Eight lines out-yielded control at two of the three representative sites (Yandanooka, Carnamah and Pithara). WACPE2199 and WACPE2201 were the most promising for yield and they both also had good height and the highest 100 seed weight. WACPE2202 which performed well at Pithara and Bolgart was found to be early podding which might have helped in the shorter seasons at these sites (Bolgart due to late sowing). WACPE2198 which is the tallest of all entries also showed good branching and pod numbers out-yielded Genesis836 only at Pithara and Yandanooka. Seed abortion within pod is the likely reason for its less than anticipated performance. Amongst lines that out-yielded control, WACPE2208 is notable for its very high degree of resistance and early flowering, but it had low 100 seed weight. Overall, 8–10 lines from Stage 3 entries are likely to be selected for Stage 4 trials in 2010/2011.

In Stage 4 entries, 9 of 16 lines had an overall yield greater than control (Genesis 836). WACPE2155 which also has very good ascochyta resistance was the most promising (Table 2). WACPE2136 which has been in trials for four years continued to show high yield and good resistance. WACPE2133, also a promising line from previous years, showed good yield at Yandanooka and performed slightly better than the control at Katanning. The tallest of the Stage 4 entries, WACPE2160 gave good yield only at Pithara. It is anticipated that about half of the 2009 Stage 4 entries may be retained for the CVT trials in 2010/2011.

KEY WORDS

chickpea, desi, breeding, ascochyta blight, resistance, variety performance, CVT

ACKNOWLEDGEMENTS

We thank the Research Support Units, Crop Variety Testing and Biometrics Unit for conducting trials and statistical analysis. Financial support from DAFWA, COGGO, UWA and ICRISAT are gratefully acknowledged.

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Paper reviewed by: Mr Ian Pritchard and Mr Dean Diepeveen

Table 1 Grain yield, ascochyta blight resistance (ar1, 0–9, 0 = no disease and 9 = plant totally blighted), selection index under disease conditions (snd1, 3–0, 3 = unaffected by disease, 0 = totally decimated by disease) and 100 seed weight in g (100sw) in Stage 3 lines at Katanning (KATA), Yandanooka (YAND), Carnamah (CARN), Pithara (PITH), Bolgart (BOLG), and Mullewa (MULL) in 2010.

Variety	Yield expressed as % of Genesis836							ar1	Snd1	100s w
	KATA	YAND	CARN	PITH	BOLG	MULL	Overall			
Genesis510	70	109	98	101	96	99	97	4.33	1.83	15.30
Genesis836	100	100	100	100	100	100	100	3.67	2.00	17.70
WACPE2180	101	104	89	104	90	–	96	2.50	3.00	20.30
WACPE2181	87	95	83	70	96	–	89	3.17	3.00	14.50
WACPE2182	83	90	87	86	92	90	89	3.67	3.00	17.45
WACPE2183	76	75	76	78	87	–	80	3.33	2.67	17.00
WACPE2184	73	77	77	76	88	–	81	3.00	2.67	16.55
WACPE2185	95	76	73	61	89	76	79	2.67	3.00	19.00
WACPE2186	117	74	72	75	85	–	82	3.33	2.67	15.73
WACPE2187	99	89	82	78	93	90	88	3.00	2.83	15.15
WACPE2188	115	83	83	70	92	74	85	2.83	2.83	15.75
WACPE2189	108	84	81	59	90	–	85	4.33	2.50	16.80
WACPE2190	84	100		74	86	–	81	2.67	2.83	17.30
WACPE2191	83	85	79	70	94	86	84	3.33	2.50	16.75
WACPE2192	80	79	79	67	93	–	82	3.33	2.50	16.90
WACPE2193	118	85	74	71	92	–	86	2.33	2.67	16.45
WACPE2194	106	87	84	78	91	85	88	3.00	2.67	17.40
WACPE2195	95	94	94	92	93	–	94	3.33	2.33	17.00
WACPE2196	95	117	104	96	97	–	104	2.83	2.50	16.27
WACPE2197	73	107	99	79	88	–	93	3.50	2.50	17.02
WACPE2198	90	105	87	107	97	94	96	3.67	2.67	16.50
WACPE2199	147	119	107	98	99	–	111	4.00	2.00	19.55
WACPE2200	99	91	106	101	92	–	98	4.00	2.17	19.15
WACPE2201	97	118	105	106	106	–	108	4.50	2.00	19.35
WACPE2202	90	90		107	102	–	90	3.83	2.17	18.15
WACPE2203	87	96	109	96	108	–	103	2.50	2.67	17.50
WACPE2204	133	86	79	86	99	–	93	3.33	2.17	16.05
WACPE2205	93	110	95	93	91	–	97	3.83	2.50	13.45
WACPE2206	124	107	97	88	96	–	101	3.67	2.33	15.45
WACPE2207	92	106	93	99	97	–	98	3.67	2.50	15.85
WACPE2208	83	118	113	96	87	–	102	3.00	2.83	13.65
WACPE2209	116	103	105	89	99	–	103	4.17	2.00	15.55
Genesis836 yield (kg/ha)	644	1348	1783	866	1984	1253	1313			
CV%	28.6	12.7	6.4	14.4	8.8	9.6				

Table 1 continued ...

Variety	Yield expressed at % of Genesis836							ar1	Snd1	100s w
	KATA	YAND	CARN	PITH	BOLG	MULL	Overall			
Genesis510	70	109	98	101	96	99	97	4.33	1.83	15.30
Genesis836	100	100	100	100	100	100	100	3.67	2.00	17.70
WACPE2117	75	110	107	80	81	91	93	3.33	2.17	16.02
WACPE2133	102	110	96	91	95	92	97	3.50	2.67	17.80
WACPE2136	100	118	118	81	95	92	103	3.67	2.67	13.90
WACPE2151	125	107	95	88	103	–	103	3.83	2.00	20.49
WACPE2152	88	116	107	89	94	102	101	3.83	2.33	18.45
WACPE2155	126	120	106	103	93	108	107	3.33	2.67	16.33
WACPE2156	122	123	103	104	89	97	104	3.67	2.50	12.54
WACPE2160	74	94	94	105	97	94	94	4.17	2.00	17.82
WACPE2162	69	107	105	104	101	102	101	4.00	2.00	18.60
WACPE2165	80	90	91	84	103	83	91	3.33	2.50	14.30
WACPE2166	90	122	98	96	99	103	102	4.00	2.33	15.10
WACPE2168	82	116	97	88	96	97	98	4.17	2.00	15.75
WACPE2170	93	105	86	95	87	92	92	3.67	2.33	15.43
WACPE2171	96	119	94	87	94	97	98	3.67	2.33	14.35
WACPE2172	62	121	99	88	100	104	100	4.00	2.17	17.85
WACPE2173	97	112	109	95	94	96	101	3.33	2.50	15.64
Genesis836 yield (kg/ha)	644	1348	1783	866	1984	1253	1313			
CV%	28.6	12.7	6.4	14.4	8.8	9.6				

PBA Pulse Breeding Australia – 2009 Field Pea Results

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BACKGROUND

Field pea breeding in Australia is undertaken by Pulse Breeding Australia (PBA). The program is nationally focused and involves collaboration between VicDPI, I&I NSW, SARDI, DAFWA and the University of Sydney. The main objective of this program is to expand the field pea industry in Australia through the development of new varieties with broad adaptation across Australia and also with suitable adaptation for specific production regions of Australia. Western Australia is responsible for evaluating new breeding lines being developed by the program, and undertaking a breeding and screening component for improving black spot resistance. This paper describes planned and potential field pea lines to be released in the next two to three years and yield data for planned releases and commercial varieties from experiments undertaken in WA in 2009. Stage 3 is the final testing stage in the breeding program, and top lines selected from here enter the National Variety Testing scheme.

In 2009 Stage 3 trials were planned for sowing at Dalwallinu, Merredin, Pingrup and Wittenoom Hills. Due to seasonal conditions no trials were sown at Merredin consequently trials unique to Merredin were transferred to Dalwallinu.

AIMS

To identify breeding lines with improved and stable yield, appropriate phenology, lodging and pod shatter resistance at harvest and improved disease resistance in WA.

METHOD

Stage 3 trials comprised 3 replications with plot size 1.25 x 8 m using a spatially balanced row-column design. Treatments included a set of control varieties. The yield data were analysed using the statistical package ASREML. In NVT trials plot width varied from 1.10–1.54 m and length from 15–26 m. A spatial row-column design with 3 replications and blocking in two dimensions, along the rows and columns, was used. Treatments included a set of control varieties. The yield data were analysed using the statistical package ASREML.

RESULTS

NVT sites at Pingrup and Lake King experienced hard growing conditions throughout the season and the Bolgart site experienced a very wet (and late) start to the season, but all remaining sites experienced good growing conditions for all or part of the 2009 growing season. Good yields were obtained at Dalwallinu, Mingenew, and Wittenoom Hills. The performance of OZP0601 a line planned for release in 2010, and OZP0801 a potential variety release (results not presented here), were particularly encouraging. Table 1 shows the results of these trials along with those NVT trials with acceptable levels of experimental error.

DISCUSSION

OZP0601: An early flowering Kaspera type variety. It is broadly adapted and has higher yield potential than Kaspera in short growing seasons and low rainfall environments. It has a similar disease profile to Kaspera, but is less susceptible to late season powdery mildew. In 2009 OZP0601 continued to perform well (2006–09) relative to Kaspera and was one of the highest yielding lines in WA trials. Release is planned for 2010. Note: Both OZP0601 and 602 are being multiplied in eastern Australia to reduce the incidence of PSbMV in the seed.

OZP0602: An early to mid flowering Kaspera type variety. It is broadly adapted and has higher yield potential than Kaspera in short growing seasons and low rainfall environments. It has a similar disease profile to Kaspera but is less susceptible to late season powdery mildew. It has a longer flowering window than 601. OZP0602 continued to perform well relative to Kaspera in 2009, but seed availability limited the number of trials it could be included in. Release is planned for 2010.

OZP0703: A new early to mid flowering semi-dwarf dun type variety. It is broadly adapted and has higher yield potential than Kaspera in short growing seasons and low rainfall environments. It has performed well in southern WA trials over the last two seasons. It has good resistance to bacterial blight and the new strain of downy mildew in SA. It is not shatter resistant and may lodge. Release is planned for 2010.

Potential Variety Releases

OZP0804: A high yielding Kaspera type line. OZP0804 has high tolerance to boron and is resistant to powdery mildew. OZP0804 is mid to late flowering, appears to be broadly adapted, and also appears to have much higher resistance to the new strain of downy mildew in SA. It is one of the best performing OZP lines in Stage 3 and NVT trials. Potential release > 2012.

OZP0805: A high yielding Kaspera type line. It is resistant to powdery mildew, PSbMV, and BLRV. It is early to mid flowering and appears to be broadly adapted. Only limited trial data was collected in 2009 due to poor seed availability. It is one of the best performing OZP lines in Stage 3 and NVT trials, and should be of particular interest to WA growers because of its resistance to PSbMV. Potential release > 2012.

KEY WORDS

field pea, Pulse Breeding Australia (PBA)

ACKNOWLEDGMENTS

This research is funded by the Grains Research and Development Corporation (GRDC). Technical support from Research Support Units at Wongan Hills, Northam, Katanning and Esperance is acknowledged. Trials were conducted on the properties of Mr Harry Hyde (Dalwallinu), Mr Ian Reid (Pingrup) and Mr Chris Reichstein (Wittenoom Hills)

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Table 1 2009 WA combined PBA S3 and NVT field pea yield data (% Kaspa)

Trial	NVT	NVT	NVT	NVT	NVT	PBA S3	NVT	PBA S3	NVT	PBA S3	NVT	Mean
Nearest town	Pingrup	Lake King	Bolgart	Quairading	Grass Patch	Dalwallinu	Wittenoom Hills	Wittenoom Hills	Mingenew			
Sowing date	24 June	18 June	3 July	27 May	8 June	26 May	5 June	10 June	27 May			
Variety	%Kaspa	%Kaspa	%Kaspa	%Kaspa	%Kaspa	%Kaspa	%Kaspa	%Kaspa	%Kaspa	%Kaspa	%Kaspa	% Kaspa
Kaspa t/ha	0.65	0.68	1.24	1.31	1.48	2.70	2.97	3.10	2.01	1.79		
Bundi	132	134	102	89	75	100	95	94	95	102		
Kaspa	100	100	100	100	100	100	100	100	100	100		
Sturt	120	138	125	124	91	83	87	82	113	107		
Yarrum	57	109	115	69	87	85	89	87	90	88		
Parafield	86	122	90	77	93	90	91	124	96	97		
Dunwa	108		98	84	101		100		100	99		
Helena	114	125	118	111	95		83		113	109		
OZP0601	143	146	112	86	103	97	102	97	87	108		
OZP0602		138				101		103		114		
OZP0703	122	118	107	87	93	84	114	104	84	101		
WAPEA2211	92	78	86	67	84		76		100	83		
CV%	9.7	10.1	13.6	12.6	14.4	9.5	8.5	16.9	10.6			

PBA Pulse Breeding Australia – 2009 Chickpea Results

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BACKGROUND

The Pulse Breeding Australia (PBA) chickpea program is a collaborative program led by GRDC and carries out chickpea (desi and kabuli) breeding and evaluation. The PBA chickpea program comprises active programs in New South Wales (Industry & Investment NSW, Tamworth, Wagga), Victoria (VIC DPI Horsham), South Australia (SARDI, Clare), Queensland (Queensland DPI, Warwick, Biloela) and Western Australia (DAFWA, Perth). It is supported by the Germplasm Enhancement node of PBA. The desi subprogram is led by Tamworth and the kabuli subprogram by Horsham. The major objective of the PBA chickpea program is to develop superior desi and kabuli chickpea varieties that will increase chickpea production and profitability in Australia through increased yield potential and stability, and lower production costs from reduced inputs and improved seed quality. To achieve this, the breeding effort is focussed on developing breeding lines with:

- appropriate phenology for regional environments
- improved disease resistance (ascochyta blight, phytophthora root rot, botrytis grey mould, root lesion nematodes and virus)
- good seed quality (size, colour and milling)
- tolerance to soil limitations (boron and salinity)
- tolerance to common broadleaf herbicides.

AIMS

To identify breeding lines with increased yield potential from appropriate phenology, improved seed quality, disease resistance in WA and tolerance to soil limitations and common broadleaf herbicides.

METHOD

Stage 3 trials comprised 3 replications with plot size 1.25 x 8 m using a spatially balanced row-column design. Treatments included a set of control varieties. The yield data were analysed using the statistical package ASREML. In NVT trials plot width varied from 1.10–1.54 m and length from 15–26 m. A spatial row-column design with 3 replications and blocking in two dimensions, along the rows and columns, was used. Treatments included a set of control varieties. The yield data were analysed using the statistical package ASREML.

RESULTS

All reported sites in 2009 experienced good growing conditions, and it was particularly pleasing to see excellent weed control at all sites due to the simazine (1.0–2.0 L/ha), + Balance® (100 g/ha) applied post sowing pre emergent mix. Good yields were obtained at all sites except Pithara, where, due to the shallow soil, good early growth was followed by lack of moisture in spring. The late sown Bolgart trial benefitted greatly from late spring rains. Table 1 shows the results of those Stage 3 and NVT trials with acceptable levels of experimental error.

DISCUSSION

Released Varieties

Variety selection should be based primarily on ascochyta blight resistance and yield. There is potential for crop failure if selected varieties do not have the necessary level of ascochyta blight resistance. Varieties currently available are PBA Slasher, Genesis 510 and Genesis 836.

Genesis 836 has the least tolerance to ascochyta blight of all current varieties. It is rated as MS, moderately susceptible. This tolerance is sufficient in low rainfall areas where low disease pressure exists. Genesis 836 is the oldest of current varieties and will be superseded by PBA Slasher and soon to be released varieties.

Genesis 510 is the benchmark for ascochyta blight resistance. It is rated R, resistant, to ascochyta blight and is suited to higher rainfall areas where ascochyta blight pressure is greatest or as a zero or very low disease risk in low rainfall areas. It has a short, bushy, architecture with lower pod height and is slightly earlier maturing than Genesis 836.

PBA Slasher, which is rated R, resistant to ascochyta, was released in 2009. Yields of PBA Slasher have been higher than Genesis 836 in PBA and NVT trials (2002–08) except in the low rainfall north east. It is rated as mid flowering (3–7 days earlier than Genesis 836) and mid maturity. PBA Slasher has lower salt tolerance than Genesis 836. PBA Slasher is better suited to the medium rainfall northern areas of WA. PBA Slasher has medium sized seed with a tan-brown seed coat and excellent milling quality.

Potential Variety Releases

CICA0603 is a high yielding line showing good adaption in WA, particularly in the short season areas of the north. It has better ascochyta resistance than Genesis 836, but not as good as Genesis 510 or PBA Slasher. CICA0603 has large seed which is tan in colour.

KEY WORDS

chickpea, Pulse Breeding Australia (PBA), ascochyta blight

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Table 1 2009 WA combined PBA S3 and NVT desi chickpea trial yield data(% Genesis 836)

Trial	PBA S3		PBA S3		NVT		NVT		NVT		NVT		NVT		AVE	AVE
Nearest town	Coorow	Coorow	Mingenew	Mingenew	Mullewa	Mullewa	Pithara	Pithara	Yandanooka	Yandanooka	Carnamah	Carnamah	Bolgart	Bolgart		
Sowing date	28 May		27 May		26 May		3 June		25 May		28 May		3 July			
Variety name	t/ha	Gen 836 %	t/ha	Gen 836 %	t/ha	Gen 836 %	t/ha	Gen 836 %	t/ha	Gen 836 %	t/ha	Gen 836 %	t/ha	Gen 836 %	t/ha	Gen 836 %
CICA0603	1.41	117	1.82	143	1.33	106	0.73	85	1.59	119	1.94	109	1.81	91	1.52	110
CICA0604	1.54	127	1.45	114	1.30	104	0.78	91	1.50	112	1.88	106	1.98	100	1.49	108
CICA0717	1.41	117	1.53	120	1.38	110	0.64	74	1.52	113	1.86	104	1.48	75	1.40	102
CICA0819	1.25	103	1.25	98	1.41	113	0.75	87	1.53	114	1.78	100	1.88	95	1.41	102
CICA0915	1.26	104	1.56	123										0	1.41	102
Genesis 079	1.45	120	1.68	132	1.20	96	0.83	97	1.39	104	1.85	104	1.79	90	1.46	105
Genesis 090	1.48	122	1.36	107	1.01	81	0.58	67	1.35	101	1.73	97	1.86	94	1.34	97
Genesis 509	1.23	102	1.37	108								0		0	1.30	94
Genesis 510	1.12	93	1.47	116	1.23	98	0.87	101	1.46	109	1.74	98	1.90	96	1.40	101
Genesis 836	1.21	100	1.27	100	1.25	100	0.86	100	1.34	100	1.78	100	1.98	100	1.38	100
Howzat	1.20	99	1.42	112	1.16	93	0.63	73	1.40	104	1.70	96	1.42	72	1.28	92
PBA HatTrick	1.27	105	1.45	114	1.12	90	0.80	93	1.38	103	1.67	94	1.97	99	1.38	100
PBA Slasher	1.30	107	1.44	113	1.11	89	0.78	91	1.42	106	1.78	100	1.63	82	1.35	98
WACPE2117					1.15	92	0.69	80	1.47	110	1.91	107	1.61	81	1.37	99
WACPE2133					1.15	92	0.79	92	1.48	110	1.70	96	1.89	95	1.40	102
WACPE2136					1.15	92	0.70	81	1.60	119	2.10	118	1.90	96	1.49	108
WACPE2160					1.17	94	0.91	106	1.27	95	1.68	94	1.91	96	1.39	101
Site mean (t/ha)	1.31		1.43		1.18		0.76		1.38		1.7		1.84			
CV (%)	8.88		11.21		8.15		9.46		10		4.93		6.73			
I.s.d. (t/ha)	0.21		0.32		0.16		0.14		0.26		0.16		0.22			

A tool for identifying problems in wheat paddocks

Ben Curtis and Doug Sawkins, Department of Agriculture and Food, Western Australia

KEY MESSAGES

A diagnostic tool for wheat will be available later this year which will considerably improve crop diagnostics and information accessibility.

AIMS

To produce a web based diagnostic tool for wheat for agronomists and farmers. The tool will provide simple steps to diagnose crop and paddock problems and then offer remedial solutions.

METHOD

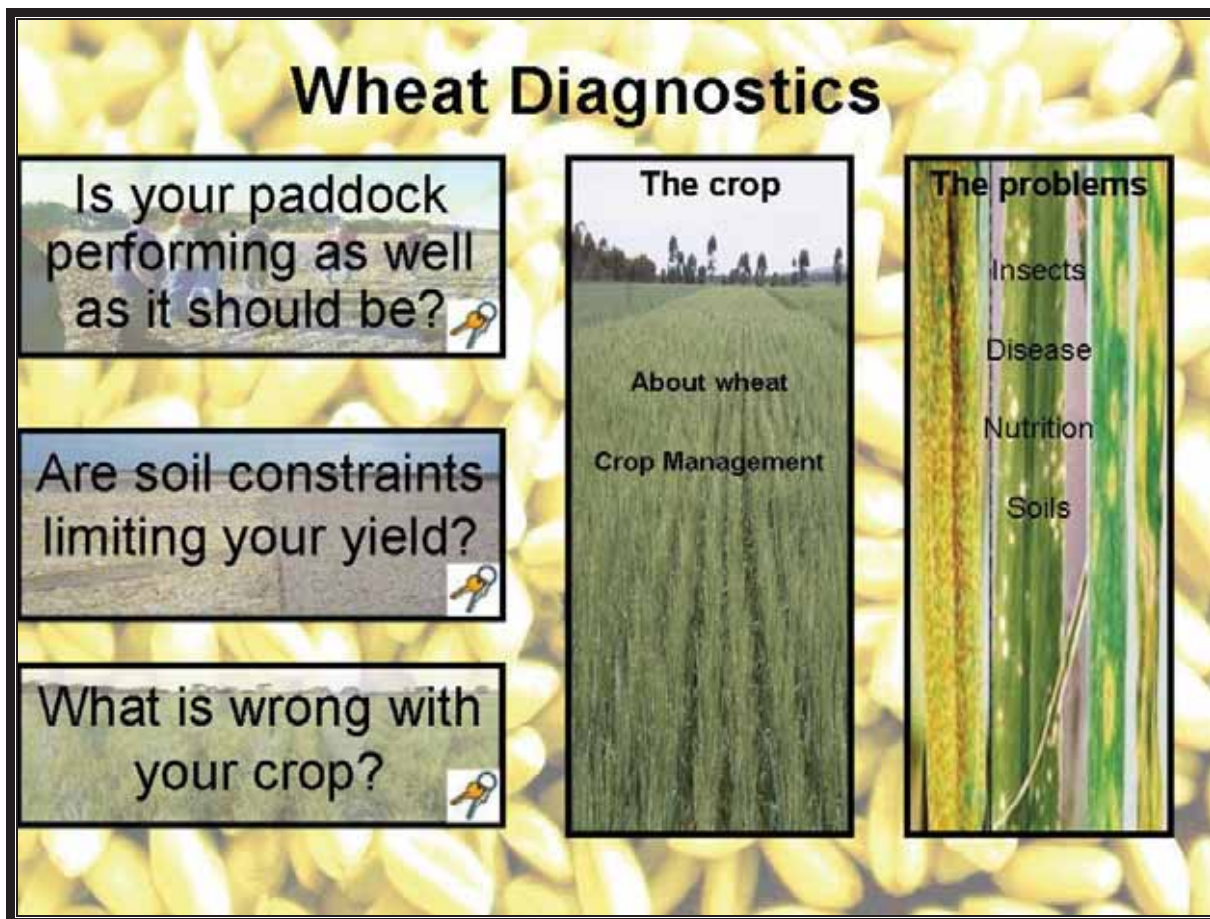
Problem diagnosis in paddocks is a complex task and with the advent of yield mapping and precision agriculture more detailed information is required before useful solutions can be provided.

Some paddocks often have sections which are consistently performing badly. Agronomists are increasingly looking at a number of paddock zones and attempting to determine the causes of poor yields and their potential remedies. This has brought an increasing level of intensity to diagnostic interrogation and the required agronomic advice. Accurate symptom diagnosis most often relies on field experience and expertise. Younger agronomists and growers gain this experience over time by working with more experienced professionals and by accessing the vast amount of information that is available.

A range of decision aids have been produced to help with this process for several discreet parts of agronomy. They are not however always easy to find or readily available. There is nothing that comprehensively covers all potential paddock and crop symptoms in one resource. With this wheat diagnostic tool we are bringing together previously developed soil and crop diagnostic tools and using them within a logical electronic framework. Delivery options can be CD, web delivery or PDA. This means images and information can be taken into the field for comparison and visual identification.

Some paddocks or zones may not be meeting their water limited yield potential. We are producing a simple process which will allow the user to determine paddock/zone yield potential by using a modified French and Schultz model, this will be easy to use and will assist the user to determine if further diagnosis is needed. Paddock records can be used to compare yields against yield potential. If a paddock has been consistently underperforming then it is likely that soil or landscape constraints exist and should be identified.

There are two entry points in our diagnostic process. One is to determine if the constraints are paddock/soil related and the other to determine what in-crop symptoms there are. Crop and soil diagnostics are obviously closely linked, however soil diagnostics can be conducted at any stage of the year and crop diagnostics are seasonal.



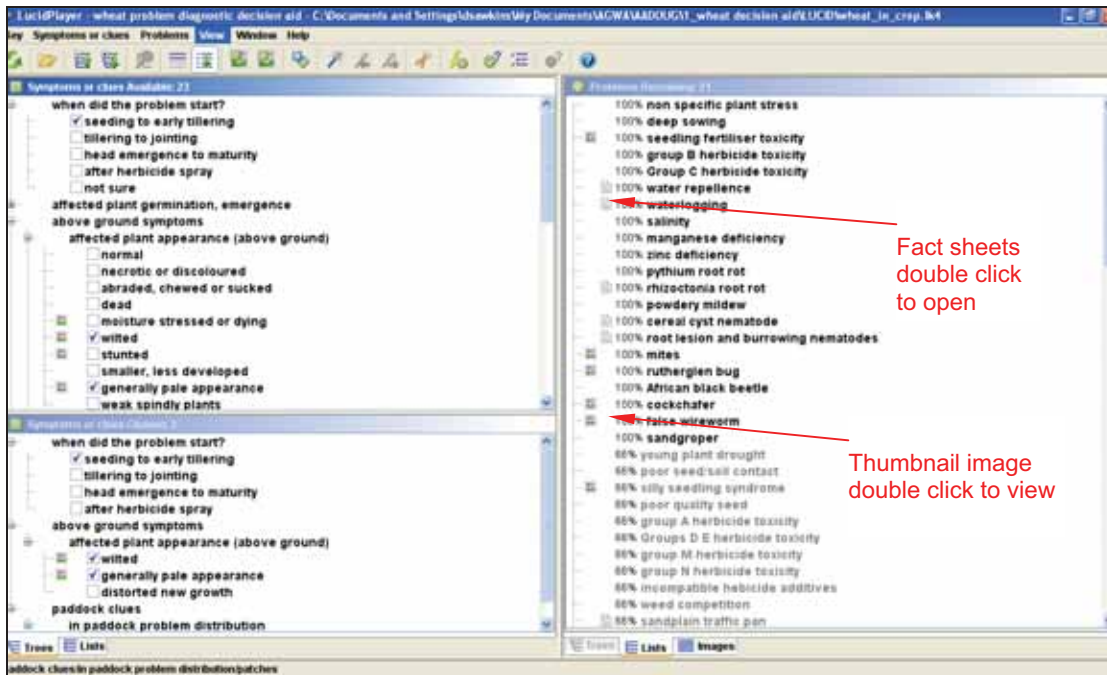
Example: Web based front page which will allow access to the diagnostic keys and a range of information about wheat and its problems.

This tool will allow the user to:

- determine if their paddocks/zone are meeting yield potential
- conduct diagnostics on paddocks or zones that are consistently performing badly (This being the case they could start by either conducting soil or crop diagnostics depending on what time of the year it is.)
- identify the causes to symptoms within a crop
- access a comprehensive amount of information relating to the problems.

LUCID Diagnostics

We are using a software package developed by the Queensland University called LUCID. Lucid tools are powerful and highly flexible knowledge management software applications designed to help users with identification or diagnostic tasks. The beauty of this diagnostic software is the user does not need to answer all of the questions relating to the problem. Unlike most dichotomous or polychotomous keys, LUCID will narrow down the potential problems depending on how much can be answered about the symptoms. You will not reach a dead end if you can't answer everything but you might be left with more than one potential problem. Once potential problems have been defined the software will link to a comprehensive fact sheet data base which will allow you to read about potential problems and their remedies (if there are any). This will help the user to again narrow down the potential problems. This will also allow us to link users to the most up to date information, bulletins and models relating to the identified issues.



Lucid player window.

The Lucid player comprises a main window presenting three lists to the user:

Symptoms or Clues Available (above left)—Lists all symptoms and clues and their states that may be used to describe the specimen to be identified. When you select a state by left clicking on a checkbox, a blue arrow appears. To remove it, left click again.

Symptoms or Clues Chosen (below left)—Displays symptoms and clues that have been chosen.

Problems Remaining (right)—Lists all problems in the key by percentage match with the symptoms and clues that have been chosen in descending order.

By choosing more and more symptoms and clues, the list in *Problems Remaining* will be gradually reduced until, perhaps, a single problem remains.

CONCLUSION

LUCID has the potential to change the way diagnostics are delivered in the wheat industry in Australia. It also has great potential for expansion into other grain crops. It is not only a simple and effective delivery mechanism for crop and paddock symptom diagnosis but it also is a logical and easy to use way of delivering agronomic information.

KEY WORDS

LUCID, diagnostics

ACKNOWLEDGMENTS

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Paper reviewed by: Nicole Witham

DAFWA Seasonal Forecast for 2010

Stephens, D, Department of Agriculture and Food, Western Australian, Climate and Modelling Group

KEY MESSAGES

1. The present El Nino in the central equatorial Pacific is expected to breakdown slowly with a high chance of neutral conditions being established by mid-year.
2. There is a tendency for May to October rainfall to be average to above average following an El Nino year. However, 1977 and 2007 were exceptions to the rule and show that there is still risk to yield potentials.
3. The DAFWA long range forecasting model ESS is predicting average to above average rainfall for southern parts of the WA wheatbelt between May-October. Skill testing of the model at this time of the year shows that there is significant skill only in the southern half (except far south-east coast). In the northern wheatbelt average rainfall is indicated, however only low confidence can be attributed to this outlook as a low level of skill is found in past ESS predictions for this area.
4. In addition to taking into account climate variability, farmers need to take into account climate change. The main issue to be aware of is the shift in recent climatology to later and drier starts to the crop season.
5. These late starts have coincided with strengthening high pressures and weaker long wave troughs off the WA coast since the mid-1970s in the April-July period.
6. Consequently, farmers should manage their cropping programs carefully on the basis of stored soil moisture, sowing opportunities and other information released in DAFWA AgTactics.
7. In 2010 DAFWA is expected to trial the integration of soil moisture and seasonal forecasts in shire level crop yield forecasts. A new regional forecasting system is expected to provide increased skill on a seasonal timeframe.

KEY WORDS

climate variability, forecasting, ENSO, seasonal outlook

ACKNOWLEDGMENTS

Dr Fiona Evans (skill maps), Phil Goulding (mapping analogue rainfall).

Project No.:

Paper reviewed by: Dr Ian Foster, Dr Art Diggle, Dr Fiona Evans, Dr David Bowran

REFERENCES

ENSO Summary: http://www.agric.wa.gov.au/PC_93764.html?s=1870216794

Growing Season Outlook http://www.agric.wa.gov.au/PC_90647.html?s=1870216794

Enhancement of black spot resistance in field pea

Kedar Adhikari, T Khan, S Morgan and C Boyd, Department of Agriculture and Food, Western Australia

KEY MESSAGES

1. Progress towards enhancing black spot resistance in agronomically desirable lines in field pea is making progress.
2. More adapted resistant lines have been developed and these will be incorporated into crosses by the Australian Field Pea Improvement Program (AFPIP); selected lines will be tested in national yield trials

BACKGROUND

Black spot (*Ascochyta blight*), caused by *Mycosphaerella pinodes*, is the most important disease of field pea across southern Australia. Development of resistant germplasm will be slow because of the low level of resistance found in the available germplasm collections and polygenic inheritance of the resistance. However, considerable progress has been made in the last few years towards this goal in Western Australia and many breeding lines with a moderate level of resistance have been developed. Consequently, WA has been identified as a primary site for genetic enhancement of black spot resistance by the AFPIP of Pulse Breeding Australia (PBA).

AIMS

1. Screen field pea germplasm developed by the PBA against black spot.
2. Identify new sources of resistance to black spot and incorporate this into agronomically suitable background.
3. Contribute enhanced germplasm to the national program for crossing, further evaluation and selection.

METHODS

About 250 breeding lines from the AFPIP and 15 lines from the Australian Temperate Field Crops Collection (ATFCC) at Horsham were screened at Medina where black spot epidemic occurs naturally every year. In addition more than 150 lines developed by the Department of Agriculture and Food, WA (DAFWA) were screened at the same site. Medina has been identified as a 'hot spot' for black spot screening in Australia.

Seventy-two crosses were made in 2009 between agronomically suitable lines and the best black spot resistant lines. The early generations are advanced using the single seed descent (SSD) method in glasshouses and single plants are selected at the F₄–F₅ stage subjecting to high black spot disease pressure in the field at Medina. Genetically stable lines are screened for resistance and for agronomic desirability over two years before being advanced to the yield trials. We report here results from the advanced yield trials conducted at Bolgart, Dalwallinu, and Bindi Bindi and the black spot resistance evaluated at Medina in 2009. Each yield trial had three replications and plot size was 1.2 x 10 m. The black spot evaluation nursery at Medina had 3 m row plots and was replicated 2 or 3 times depending upon the trial. The disease nursery at Medina was sown in the second week of May 2009; black spot epidemic developed naturally.

RESULTS

The disease developed later at Medina than in the previous years. Nevertheless all the susceptible lines, such as Dundale and Helena were heavily infected with almost the whole plant covered with black spots.

Fifteen lines obtained from ATFCC at Horsham which showed some resistance in 2008 were again evaluated in 2009. Accessions ATC 6927, 6950, 7086 and JO 7633 were found to have resistance similar to that of WAPEA2211. WAPE2211 is the first germplasm developed in an agronomically suitable background with a moderate level of resistance and this level of resistance has been used as

a benchmark in the program. All ATFCC lines are landraces and very late flowering. ATC 7086 has been used in crossing in 2009 to transfer its resistance into agronomically suitable lines. Majority of the lines developed by AFPIP had better resistance than Kaspera and eight lines had similar level of resistance to WAPEA2211, but none exceeded WAPEA2211 level.

Over 70 DAFWA bred F6 lines were screened against black spot and about two thirds of them were found to have equal to or better resistance than WAPEA2211. Selected lines will be tested for yield potential, agronomic traits and black spot resistance in 2010. Four lines were found to have significantly better resistance than WAPEA2211 and were also early flowering.

A number of DAFWA bred lines in the advanced breeding trial were found to show moderate resistance. Of these, 98P795-4 showed the best resistance with an overall yield of 93 per cent of Kaspera. Other lines with significantly higher level of resistance than WAPEA2211, had lower yields. Variation in the black spot resistance of WA bred germplasm is presented in Figure 1; showing many lines with higher level of resistance than WAPEA2211.

In Stage 2-1 trial, there were at least 20 lines with equivalent or better level of resistance than WAPEA2211. Selected lines with moderate level of resistance along with their yield and agronomic features are presented in Table 1. Eight lines yielded similar to or higher than Kaspera and they had significantly better resistance than Kaspera. Line 05P803-BSR-701 yielded more than 6 per cent of Kaspera and was one of the most resistant lines. All these lines had good standing ability similar to Kaspera, semi leaflessness and early flowering. It appears that combining various sources of resistance has led to higher level of resistance.

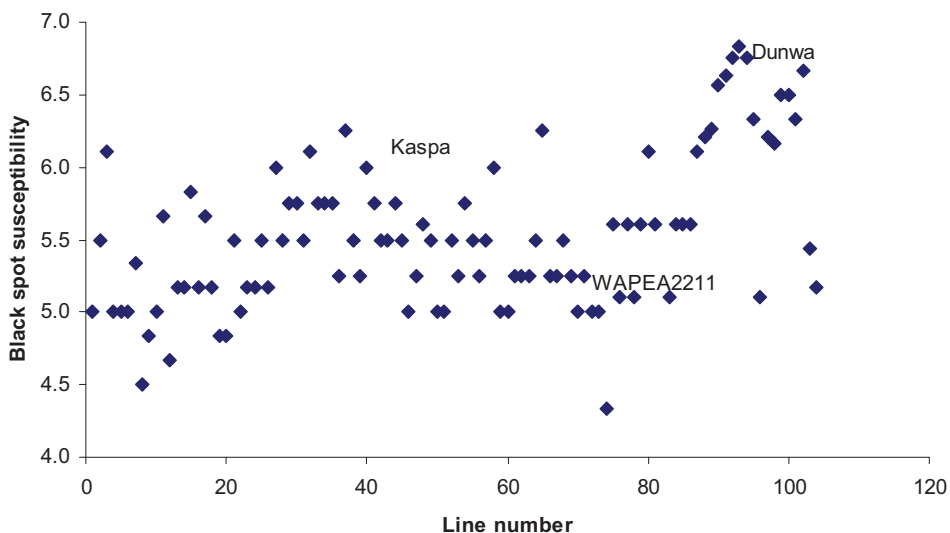


Figure 1 Distribution of black spot resistance (0-9, 0 = immune and 9 = extremely susceptible) in WA bred field pea lines at Medina disease nursery in 2009.

CONCLUSIONS

New lines with moderate resistance to black spot in an agronomically suitable background continue to be developed. More promising resistance has been identified at earlier stages of the breeding cycle supporting the breeding strategy currently in practice.

KEY WORDS

field pea, black spot, *Mycosphaerella pinodes*, resistance breeding, yield

ACKNOWLEDGEMENTS

We thank Research Support Unit Manager at Medina. We also thank Mr Jeff Ludemann (Bolgart) on whose property a yield trial was conducted. Financial support from GRDC is gratefully acknowledged.

Table 1 Overall and mean yield (kg/ha) at Bolgart (BG) and Dalwallinu (DW), development score (DS, 0–9, 0 no flowering, 3 flowering, 4 pod initiation, 9 fully developed seed), standing ability (St, 1–9, 1 totally lodged and 9 all plants upright), black spot reaction (BS, 0–9, 0 immune and 9 extremely susceptible) and flower colour (FC, w white, p purple, pk pink) in selected WA bred lines

Genotype	Grain yield						DS	Standing ability	BS	FC
	Overall	% Kaspa	BG	% Kaspa	DW	% Kaspa				
05P803-BSR-701	2550	106	3196	104	1795	103	2	5	5.0	PK
05P770-BSR-703	2328	97	3214	105	1448	83	3	4	5.0	PK
05P807-BSR-703	2287	95	3126	102	1442	83	3	3	5.0	P
00P040-BSR-705	2092	87	2601	85	1600	92	2	4	5.0	PK
05P773-BSR-704	2079	87	2807	92	1530	88	3	5	5.0	PK
05P801-BSR-702	2074	87	2746	90	1530	88	3	5	5.0	PK
05P765-BSR-703	2000	83	2562	84	1482	85	3	4	5.0	P
00P040-BSR-708	1992	83	2538	83	1523	87	2	5	5.0	PK
05P773-BSR-703	1940	81	2561	84	1530	88	3	5	5.0	PK
00P040-BSR-707	1782	74	2292	75	1390	80	2	5	5.0	PK
05P773-BSR-705	2404	100	3386	111	1399	80	4	4	5.2	PK
04P762-BSR-704	2397	100	3130	102	1530	88	4	4	5.2	P
05P770-BSR-705	2258	94	2956	97	1530	88	4	4	5.2	PK
04P762-BSR-701	2211	92	2877	94	1530	88	5	3	5.2	P
05P785-BSR-703	2192	91	2910	95	1530	88	2	4	5.2	PW
05P765-BSR-704	2080	87	2536	83	1563	90	1	3	5.2	PK
05P794-BSR-701	1978	83	2669	87	1410	81	3	5	5.2	PK
05P773-BSR-708	1934	81	2560	84	1530	88	3.5	4	5.2	PK
05P770-BSR-710	1924	80	2764	90	1316	76	2	5	5.2	P
05P785-BSR-702	1871	78	2408	79	1530	88	3	4	5.2	PK
05P773-BSR-706	1863	78	2428	79	1530	88	2	5	5.2	PK
05P801-BSR-703	1410	59	2313	76	817	47	2	5	5.2	PK
WAPEA2211	2404	100	3020	99	1690	97	3	5	5.4	PK
04P762-BSR-707	2548	106	3447	113	1551	89	3	5	5.5	P
05P765-BSR-706	2546	106	3287	107	1755	101	3	5	5.5	PK
05P770-BSR-704	2302	96	3000	98	1530	88	2	4	5.5	P
05P765-BSR-701	2159	90	2869	94	1397	80	1	4	5.5	PK
05P778-BSR-701	2123	89	2774	91	1530	88	3	5	5.5	PK/P
05P770-BSR-707	2087	87	2829	92	1370	79	2	5	5.5	P
04P762-BSR-703	2026	85	2640	86	1530	88	3.5	5	5.5	P
04P756-BSR-701	2007	84	2601	85	1530	88	3	5	5.5	PK
05P789-BSR-701	1804	75	2352	77	1530	88	3.5	5	5.5	P/PK
00P040-BSR-703	1786	74	2331	76	1530	88	3	4	5.5	PK/P
05P770-BSR-712	1579	66	2057	67	1530	88	3	5	5.5	W
Bundi	2486	104	3235	106	1741	100	4	4	6.2	W
Kaspa	2397	100	3060	100	1741	100	3.5	5	6.2	PK
Dunwa	2441	102	3054	100	1810	104	5	2	6.7	P
Helena	2223	93	2835	93	1581	91	4	2	6.7	P

Project No.: DAV00071

Paper reviewed by: Dr Peter White

Fungicide management of yellow spot in wheat

Ciara Beard, Kith Jayasena, Kazue Tanaka and Anne Smith, Department of Agriculture and Food, Western Australia

KEY MESSAGES

- In 2009, yellow spot in Correll wheat (rated VS) grown on wheat stubble was effectively reduced by a range of fungicides at Eradu in the NAR and Gibson on the south coast. Under intense disease pressure at Eradu, yield was significantly increased with fungicide application by on average 0.3 t/ha (21 per cent). At Gibson, where disease pressure was low, fungicide application significantly increased yield by 0.8 t/ha (24 per cent) on average.
- At Eradu, a single application of a range of fungicides at Z39 significantly reduced disease and increased yield. A single application of *propiconazole* 250 g/ha at Z31 also significantly reduced disease and increased yield however *flutriafol* in-furrow 250 g/L did not significantly reduce yellow spot.
- At Gibson, applications of a range of fungicides at Z33 and Z55, significantly reduced disease and increased yield.
- Registered fungicides should be used in an integrated management strategy along with using crop rotation and avoiding VS-S wheat varieties in favour of MS-MR varieties.

AIMS

To assess the activity of new and existing fungicides for control of yellow spot disease in wheat.

METHOD

In 2009, two trials were established, one at the Northern Sandplain Research Annex (Eradu) in the northern agricultural region, and one at Esperance Downs Research Station (Gibson) on the south coast of Western Australia (WA). The variety used in both trials was Correll which is rated S-VS for yellow spot and both trials were sown onto wheat stubble to increase disease risk. The Eradu trial was sown on 2 June at the rate of 85 kg/ha and the Gibson trial on 28 May at the rate of 60 kg/ha. At the Gibson site, in addition to sowing the trial on wheat stubble, yellow spot infected stubbles were introduced @ 300 g/plot on two occasions (7 and 28 July).

Although both trials used similar fungicide treatments, application timings and frequency were different to suit site specific disease development. Ten fungicide treatments were replicated four times at each site and are listed in the results tables. The active ingredients tested included currently registered fungicides: *propiconazole* 250 g/ha (Tilt® 250EC), *azoxystrobin* 200 g/L + *cyproconazole* 80 g/ha (Amistar® Xtra), and *prothioconazole* 210 g/L + *tebuconazole* 210 g/L (Prosaro® 420SC); and fungicides that are not currently registered for yellow spot control in WA: *epoxiconazole* 125 g/ha (Opus® 125), *pyraclostrobin* 133 g/L + *epoxiconazole* 50 g/L (Product A), *propiconazole* 125 g/L + *fenpropidin* 500 g/L (Product B), and *flutriafol* in-furrow 250 g/L (Intake® Combi). The latter was tested at Eradu only. Amistar® Xtra and Prosaro® were used with Adigor® at 2 per cent v/v and Hasten® at 1 per cent v/v respectively. The full control treatment was included to simulate yield potential under minimal disease conditions and not as a potential management recommendation.

For simplicity, fungicide treatments will be referred to by product name (or active ingredient in the case of unregistered products), however, no reference to trade name should be taken as a preference or recommendation of that product over similar products with different trade names which are currently, or may in the future, be available and registered for the recommended use.

Necrotic leaf area on the top 3 leaves was assessed regularly from Z31 until Z69 and disease confirmed as yellow spot by AGWEST plant labs. Fungicides were applied in 80 L/ha water by boom sprayer and plots were harvested for yield. At the time of publication, grain quality had been assessed on the Eradu plots but not on the Gibson plots.

RESULTS

Yellow spot (*Pyrenophora tritici repentis*) developed at both sites. At the Eradu site, disease development commenced early and due to favourable conditions throughout the season it reached very high levels (83 per cent necrotic leaf area on untreated at Z69). Disease levels were low at Gibson (20 per cent necrotic leaf area on untreated at Z69). Herbicide damage, rhizoctonia, poor weed control and poor nutrition were a problem at the Gibson site. Growing season (May to November) rainfall was 180 mm at Eradu, and 312 mm at Gibson. In the 8 weeks after flag leaf emergence 79 mm/rain fell at Eradu, and 69 mm/rain fell at Gibson.

Table 1 Effect of fungicides on control of yellow spot, yield and quality of wheat cv. Correll at Eradu in 2009. LAD = leaf area diseased at Z69 (anthesis complete), average on the top 3 (Flag, F-1 and F-2) leaves

Treatments *	LAD Z69 (21 Sept.)	Yield		Protein (%)	Screenings (%)	Gross Income ** (\$/ha)	Returns net of treatm't cost *** (\$/ha)
	Av. Flag, F-1 and F-2	t/ha	% Nil				
1. Untreated	83	1.7	100	11.4	5	376	376
2. Intake® Combi IF @ 800 mL/ha+ Tilt 250EC @ 500 mL/ha at Z31	71	2.0	118	11.3	4	442	399
3. Intake® Combi IF @ 800 mL/ha + Tilt 250EC @ 500 mL/ha at Z39	61	2.1	124	10.8	4	459	416
4. Tilt® 250EC @ 500 mL/ha at Z39	65	2.1	124	10.9	4	459	436
5. Product B @ 500 mL/ha at Z39	70	1.9	112	11.1	4	420	NA
6. Amistar® Xtra @ 400 mL/ha at Z39	72	2.1	124	10.7	4	459	399
7. Opus® 125 @ 500 mL/ha at Z39	69	1.9	112	11.1	4	420	390
8. Product A @ 1000 mL/ha at Z39	62	2.1	124	10.8	4	459	NA
9. Prosaro® 420SC @ 150 mL/ha at Z39	69	2	118	11.1	4	442	422
10. Full control—Tilt® 250 EC @ 500 mL/ha at Z31, Z39 and Z55	55	2.3	135	10.7	4		
I.s.d. (5%)	5.8	0.3		0.4	0.4		

Bold font indicates value is significantly different from untreated.

* Product A = pyraclostrobin 133 g/L + epoxiconazole 50 g/L, Product B = propiconazole 125 g/L + fenpropidin 500 g/L.

** Assuming APW wheat price of \$216/t and increments applied for protein (10.5% = \$2.5/t, 11% = \$5/t).

*** Assuming fungicide cost for the rates used: Intake® Combi in-furrow @ 800 mL = \$20; Tilt® 250EC @ 500 mL = \$15; Product B @ 500 mL = NA, Amistar® Xtra @ 400 mL = \$51; Opus® 125 @ 500 mL = \$22; Product A @ 1000 mL/ha = NA, Prosaro® 420SC @ 150 mL = \$11; Adigor® @ 2% = \$1; Hasten® @ 1% = \$1; and Application cost = \$8. NA = not available.

At Eradu, Intake® Combi in-furrow 250 g/L did not significantly reduce disease levels (as assessed at Z31), so we took the opportunity to modify the treatments and test an early (early stem elongation, Z31) foliar spray of Tilt®. This early foliar spray was as effective in terms of yield improvement as a single foliar spray at flag leaf emergence (Z39).

At both sites, by the final disease assessment all the fungicide treatments significantly reduced yellow spot but not all treatments significantly improved yield. At Eradu, all fungicide treatments, except Product B and Opus®, significantly increased yield (Table 1). Of the treatments that significantly improved yield none stood out as significantly better than the others, the average increase in yield was 0.3 t/ha (21 per cent) above the untreated. All fungicide treatments at Eradu significantly increased hectolitre weight (results not shown) and significantly reduced screenings (Table 1). At Gibson, all

fungicide treatments, except Tilt® and low rates of Opus® and Product A, significantly increased yield (Table 2). Of the treatments that significantly improved yield at Gibson, the average increase in yield was 0.8 t/ha (24 per cent) above the untreated.

Table 2 Effect of fungicides on control of yellow spot, and yield of wheat cv Correll at Gibson in 2009. LAD = leaf area diseased at Z69 (anthesis complete), average on the top 3 (Flag, F-1 and F-2) leaves

Treatments*	LAD Z69 (12 Oct.)	Yield		Gross income** (\$/ha)	Returns net of treatm't costs*** (\$/ha)
	Av. Flag, F-1 and F-2	(t/ha)	(% Nil)		
1. Untreated	20	2.3	100	490	490
2. Product A @ 500 mL/ha at Z33 and Z55	8	2.7	117	575	NA
3. Opus® 125 @ 250 mL/ha at Z33 and Z55	11	2.7	117	575	537
4. Tilt® 250EC @ 500 mL/ha at Z33 and Z55	13	2.6	113	554	508
5. Product B @ 500 mL/ha at Z33 and Z55	13	2.8	122	596	NA
6. Amistar® Xtra @ 400 mL/ha at Z33 and Z55	7	3.1	135	660	542
7. Opus® 125 @ 500 mL/ha at Z33 and Z55	11	3.2	139	682	622
8. Product A @ 1000 mL/ha at Z33 and Z55	6	3.0	130	639	NA
9. Prosaro® @ 150 mL/ha at Z33 and Z55	6	2.9	126	618	580
10. Full control—Tilt® 250EC @ 500 mL/ha at Z21, Z33, Z55 and Z65	12	2.6	113		
l.s.d. (5%)	4	0.5			

Bold font indicates value is significantly different from untreated.

* Product A = pyraclostrobin 133 g/L + epoxiconazole 50 g/L, and Product B = propiconazole 125 g/L + fenpropidin 500 g/L.

** Assuming APW wheat price of \$213/t and protein assumed to be 10% for all treatments.

*** Assuming fungicide cost for the rates used: Products A and B = NA, Opus® 125 @ 250 mL/ha = \$11, Tilt® 250EC @ 500 mL = \$15; Amistar® Xtra @ 400 mL = \$51; Opus® 125 @ 500 mL = \$22; Prosaro® 420SC @ 150 mL = \$11; Adigor® @ 2% = \$1; Hasten® @ 1% = \$1; and Application cost = \$8. NA = price not available.

CONCLUSION

Yellow spot risk can be effectively reduced by using crop rotation, avoiding VS or S varieties in favour of MS-MR varieties, and using fungicide in an integrated management strategy.

In 2009 at Eradu and Gibson, yellow spot levels and associated yield loss were significantly reduced by a range of fungicides containing various active ingredients. These findings show that there is a wide choice in fungicide chemistry for managing yellow spot, which may help to minimize the risk of fungicide resistance developing. At Eradu the most profitable treatment was treatment Tilt® at 500 mL/ha at Z39, followed by Prosaro® at 150 mL/ha at Z39. Although not included as a potential management recommendation, the full control treatment (Tilt® at 500 mL/ha at Z31, Z39 and Z55) was in fact highly profitable (returns net of treatment costs \$434/ha) which shows how intense the disease pressure was at the Eradu site in 2009. At Gibson the most profitable treatment was Opus® at 500 mL/ha at Z33 and Z45, followed by Prosaro® at 150 mL/ha applied at Z33 and Z55.

Stubble-borne leaf diseases such as yellow spot are a higher risk in a continuous wheat system and as shown in these trials can significantly reduce yield if a susceptible variety is sown. Severe disease will also cause grain quality reductions as was observed at Eradu, and these can add to economic loss.

When a susceptible variety is sown after wheat, and disease pressure prior to stem elongation is high, as it was at Eradu, it can be economical to apply fungicide at early stem elongation (Z31, first node). A second spray may be required at or after flag leaf emergence (Z39) depending on the disease development and season.

Although Tilt®, Product B (*propiconazole* 125 g/L + *fenpropidin* 500 g/L), and Opus® significantly reduced disease levels at both sites, their effect on yield was not consistent across both sites and may be attributed to regional differences.

Despite some weed and root disease problems and a fairly dry spring, the impressive yield responses to many of the fungicide treatments at Gibson shows the value of multiple fungicide applications in long season, high yielding environments such as the south coast.

KEY WORDS

yellow spot, foliar fungicide spray, wheat

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Resistance to infection by *Beet western yellows virus* in four Australian canola varieties

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KEY MESSAGES

- *Beet western yellows virus* (BWYV) is spread by green peach aphids from infected wild radish weeds to canola crops. Yield losses of up to 46 per cent occur and oil content and quality is reduced when canola plants become infected early in the life of the crop.
- Twenty two of 28 canola and both of the Indian mustard varieties and breeding lines became infected when exposed to BWYV in the field.
- Plants of Tranby and Trigold remained uninfected and so were resistant to BWYV infection.
- Plants of Stubby and Banjo were also resistant to BWYV with only 2–5 per cent of plants infected, while plants of Tanami and Jade ranked as moderately resistant with 14–23 per cent BWYV infection incidences.

AIMS

To screen Australian canola and Indian mustard (*Brassica juncea*) varieties and breeding lines for their susceptibility and sensitivity responses to infection with *Beet western yellows virus*.

BACKGROUND

Beet western yellows virus (BWYV) is spread from infected wild radish weeds to canola crops predominantly by the green peach aphid (*Myzus persicae*). In surveys in the wheatbelt, BWYV reached high incidences within individual canola crops. Yield losses of up to 46 per cent occurred when most canola plants became infected early, this also led to oil content and quality being diminished. The susceptibility of Indian mustard varieties to field infection with BWYV and the effect infection has on their seed yield and oil quality had not yet been investigated.

METHOD

Two field experiments which evaluated different varieties, or advanced breeding lines, for their responses to infection with BWYV were done at Medina Research Station. Expt 1 was sown in July 2006 with 14 canola varieties and 4 advanced breeding lines, and Expt 2 in July 2009 with 13 canola and 2 Indian mustard varieties. In both experiments, single test row plots 6 metres long with 3 replicates were sown in randomised block designs. The distances between the ends and sides of each plot were 1 and 2 metres, respectively. 'Infector' plants of canola infected with BWYV and infested with green peach aphids in the glasshouse were transplanted at both ends of each test row. This experimental design ensured a high and uniform initial BWYV inoculum source for spread by naturally-occurring aphid vectors of BWYV (principally the green peach aphid). Test rows were thinned to 60 plants each once all had germinated. The plots were irrigated.

For Expt. 1, at 98 days after sowing (DAS), a petiole sample was taken from every plant within each test row and tested serologically for BWYV by the TBIA technique. At 112 DAS, all plants in any test rows in which no BWYV was found previously were resampled and these samples tested in the same way. For Expt. 2, at 126 DAS, leaf samples were taken from 30 plants within each test row and tested serologically for BWYV by the ELISA technique. Data for percentage of plants in which BWYV was detected were recorded for each plot.

At 112 DAS for Expt. 1 and at 121 DAS for Expt. 2, for each variety or breeding line tested, the types of viral symptoms caused were recorded, and susceptibility and sensitivity rankings assigned. The different susceptibility rankings used relate to the relative ease with which plants of a given genotype became infected when exposed to virus infection by aphid vectors, while different sensitivity rankings refer to the intensity of the reactions in plants (symptom severity) after they became infected. Susceptibility rankings were based on the percentage of plants that became infected, and there were five categories ranging from HS, highly susceptible to HR, highly resistant. Sensitivity rankings were on a 1–5 scale: 1, symptomless infection, to 5, severe symptoms.

RESULTS

In Expt. 1, at 98 DAS, BWYV infection incidence for the different varieties and breeding lines ranged from 0 per cent to 63 per cent (Table 1). Tranby and Trigold ranked as highly resistant (0 per cent incidence), while Stubby and Banjo ranked as resistant (2–5 per cent incidence) and Tanami and Jade as moderately resistant (14–23 per cent incidence). The other 12 varieties or breeding lines tested were ranked as susceptible (45–63 per cent incidence). At 112 DAS, Tranby and Trigold plants were re-sampled and tested again but both remained without infection. The varieties and breeding lines that became infected ranged in sensitivity from 1 to 4 (Table 1). There was no relationship between the susceptibility and sensitivity rankings of varieties ranked moderately resistant or susceptible as their sensitivity rankings ranged from 2–4. No symptoms were seen in the few BWYV-infected plants of Stubby or Banjo, while infected plants of Tanami, Thunder, Tornado and TR006-03W08 had very mild symptoms (2 ranking). All others had moderate symptoms (3 ranking), except for Rocket in which the symptoms were severe (4 ranking). The predominant symptoms found were plant stunting and reddening of older leaves.

In Expt. 2, at 126 DAS, BWYV infection incidence for the different varieties ranged from 0 per cent to 87 per cent (Table 2). Tranby and Trigold still remained uninfected but all other varieties tested were infected with BWYV. The other canola varieties were 55–87 per cent infected, while the 2 Indian mustards, JR049 and Dune, were 38 per cent and 53 per cent infected, respectively. As Tranby and Trigold remained uninfected they again showed a high level of resistance. The canola varieties that became infected ranged in sensitivity from 2 to 4. Rottnest, 46C76, Argyle and Trilogy had mild symptoms (ranking 2), while 45Y77, Garnett and Comet had the most severe symptoms (ranking 4). As in Expt 1, the predominant symptoms were stunting and reddening of the older leaves. No symptoms were seen in mustards JR049 and Dune, despite plants being infected with the virus

CONCLUSION

This study used field exposure to reveal that resistance to BWYV transmission by aphid vectors (infection resistance) is present in canola varieties Banjo, Stubby, Tranby and Trigold. Varieties Jade and Tanami were ranked as moderately resistant on field exposure while the 24 other canola varieties or breeding lines evaluated were ranked as susceptible. Those that became infected varied widely in sensitivity following infection with BWYV.

Management of BWYV in canola crops requires an integrated disease management (IDM) approach incorporating a number of diverse control measures that operate in different ways. These measures include removal of BWYV reservoir hosts (especially wild radish weeds) by herbicide application before and after sowing; manipulating sowing dates to avoid exposure of young canola plants to peak aphid vector flights; and insecticide application to control aphid vector populations. The work reported here showed that Australian canola varieties with useful infection resistance to BWYV are also available. Host resistance can therefore be added to the IDM control measure package for BWYV. However, it should not be used alone as, when deploying varieties with resistance to infection, there is a need to also limit the numbers of colonising aphid vectors as with high inoculum pressure this type of virus resistance is likely to be less effective.

Indian mustard has not been screened in the field previously for its reaction to BWYV infection, but both Dune and JR049 were susceptible to BWYV infection, although this infection was symptomless.

KEY WORDS

virus, aphids, control, host resistance

ACKNOWLEDGMENTS

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Table 1 Susceptibility and sensitivity of canola varieties and advanced breeding lines to field infection with *Beet western yellows virus* (Expt. 1, 2006)

Genotype	% infection ¹	Significance (from % infection) ²	Susceptibility ranking ³	Sensitivity ranking ⁴	Predominant symptoms ⁵	
Tranby	1.8	0	a	HR	–	NI
Trigold	1.8	0	a	HR	–	NI
Stubby	9.0	2	ab	R	1	SI
Banjo	12.8	5	ab	R	1	SI
Tanami	21.6	14	bc	MR	2	MLR, S
Jade	28.9	23	cd	MR	3	LR, S
Bravo	42.4	45	de	S	3	LR, S
TR006-03W30	44.6	49	de	S	3	LR, S
TR006-03W08	44.8	50	de	S	2	LR, S
Boomer	46.5	53	e	S	3	LR, S
Beacon	47.9	55	e	S	3	LR, S
Warrior	48.8	57	e	S	3	MLR, S
Tornado	50.6	60	e	S	2	MLR, MS
TR002-03M09	50.9	60	e	S	3	LR, S
TR004-03M02	51.5	61	e	S	3	LR, S
Thunder	51.6	61	e	S	2	MLR, MS
Rocket	52.1	62	e	S	4	LR, S
Trilogy	52.5	63	e	S	3	MLR, S
<i>P</i>	< 0.001					
l.s.d.	16.11					
d.f.	34					

¹ All percentage BWYV data were angular transformed before analysis. Back transformed percentage infection data are in bold.

² Varieties or breeding lines followed by the same letter were not significantly different at $P < 0.05$.

³ Susceptibility rankings: HR, highly resistant; R, resistant; MR, moderately resistant; S, susceptible.

⁴ Sensitivity rankings: 1, symptomless infection to 5, severe symptoms.

⁵ Symptom descriptions: SI, symptomless infection; LR, leaf reddening; MLR, mild leaf reddening; S, plant stunting; MS, mild plant stunting; NI, not infected.

Table 2 Susceptibility and sensitivity of canola and Indian mustard varieties to field infection with *Beet western yellows virus* (Expt 2, 2009)

Genotype	% infection ¹		Significance (from % incidence) ²	Susceptibility ranking ³	Sensitivity ranking ⁴	Predominant symptoms ⁵
Trigold	0.6	0	a	HR	0	
Tranby	0.6	0	a	HR	0	
JR049*	37.8	38	b	S	1	
Dune*	46.6	53	b	S	1	
Rottnest	47.9	55	bc	S	2	MST, MRD
45Y77	48.4	56	bc	S	4	ST, RD
Garnett	49.8	58	bcd	S	4	ST, RD
Comet	53.5	65	bcd	S	4	ST, RD
Marlin	54.3	66	bcd	S	3	ST, RD
Flinders	54.9	67	bcd	S	3	ST, RD
46C76	60.2	75	cd	S	2	MST, MRD
44C73	62.2	78	cd	S	3	ST, RD
Argyle	64.4	81	cd	S	2	MST, MRD
Trilogy	64.4	81	cd	S	2	ST, MRD
Cobbler	65.3	83	cd	S	3	ST, RD
Trilogy	69.2	87	d	S	2	ST, MRD
<i>P</i>	< 0.001					
l.s.d.	19.92					
d.f.	46					

* Varieties of Indian mustard.

1–5 footnotes as described for Table 1.

Yellow spot carryover risk from stubble in wheat-on-wheat rotations

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KEY MESSAGES

Stubbles from moderately resistant wheat varieties (such as Wyalkatchem) tend to have a lower yellow spot carryover risk compared with more susceptible varieties. Very susceptible to moderately susceptible varieties, such as Correll (VS-S), Yitpi (S) and Calingiri (MS) have a high yellow spot carryover risk and are not suited to continuous wheat cropping.

Fungicide application to the growing crop reduces yellow spot carryover risk on the stubble in the following season. The reduction is greatest in moderately resistant wheat varieties but is less so in susceptible varieties.

There is little to no carryover risk associated with 18-month old wheat stubbles. A single, non-cereal break crop significantly reduces the risk of yellow spot carryover in subsequent wheat crops.

AIMS

To determine which disease management options (e.g. fungicide application to the growing crop, use of varieties with disease resistance and break crops) in the growing season effect the development of fruiting bodies on wheat stubble in the following season.

METHOD

Wheat stubbles infected with yellow spot during the previous growing season were collected after harvest. In 2008, a range of wheat stubbles from 2007 non-fungicide treated plots of varieties with differing levels of yellow spot resistance were used—Correll (S-VS), Yitpi (S), Arrino (S), Calingiri (MS), Ruby (MR) and Wyalkatchem (MR). In 2009, 18-month old stubbles of the varieties Correll, Yitpi and Wyalkatchem from the previous year's stubble trials were re-assessed. In addition, wheat stubbles from fungicide treated and non-fungicide treated plots of varieties Yitpi and Wyalkatchem from DAFWA 2008 wheat-on-wheat trials at Meckering were used.

Each year, stubbles were placed on the soil surface at cleared sites at the Centre for Cropping Systems in Northam where they were left to weather under natural environmental conditions. At fortnightly intervals from early-May onwards, sub-samples of stubble from each treatment were collected and inspected for sexual fruiting bodies (pseudothecia). The potential for yellow spot infection was quantified by counting the numbers of fruiting bodies that developed on the stubble and rating the maturation stage microscopically.

RESULTS

Of the wheat varieties tested in 2008, stubble from Correll produced the highest number of yellow spot fruiting bodies (Figure 1). Yitpi and Calingiri stubbles had similar carryover risks while stubbles from the MR varieties Ruby and Wyalkatchem had the lowest carryover risk. A surprise was the variety Arrino, the stubble of which had a carryover risk similar to the MR varieties tested. In 2008 mature fruiting bodies were present on the untreated stubbles of Correll from mid-May; Yitpi and Ruby from late May; Calingiri and Arrino from mid June, and Wyalkatchem from late June.

On 18-month old stubbles from the varieties Correll and Yitpi a small number of new fruiting bodies formed and produced mature spores (Figure 2). On 18-month old stubble from the variety Wyalkatchem no new fruiting bodies formed.

In 2009 the stubble from the variety Yitpi produced significantly more mature yellow spot fruiting bodies than Wyalkatchem. Fungicide treatment of Yitpi in the growing season did not significantly reduce the development of fruiting bodies on the stubble. However, fungicide treatment of Wyalkatchem in the growing season reduced the development of fruiting bodies by 91 per cent

(Figure 2). Mature fruiting bodies were present on untreated stubbles of both Yitpi and Wyalkatchem from mid-July onwards. Fungicide treatment in the growing season delayed the maturation timing of the fruiting bodies by 4 weeks for Yitpi and 8 weeks for Wyalkatchem.

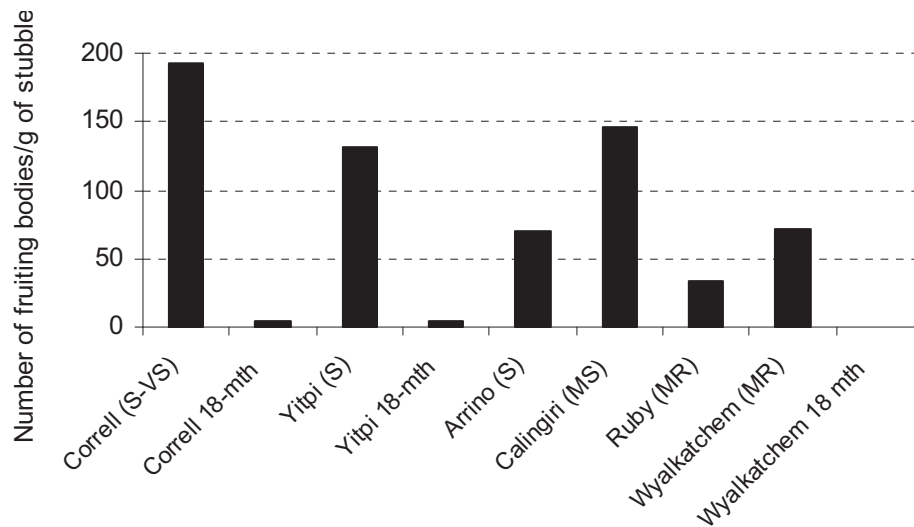


Figure 1 Effect of stubble age and variety on the development of yellow spot sexual fruiting bodies on untreated wheat stubbles. The level of yellow spot resistance is indicated in parenthesis after the variety name.

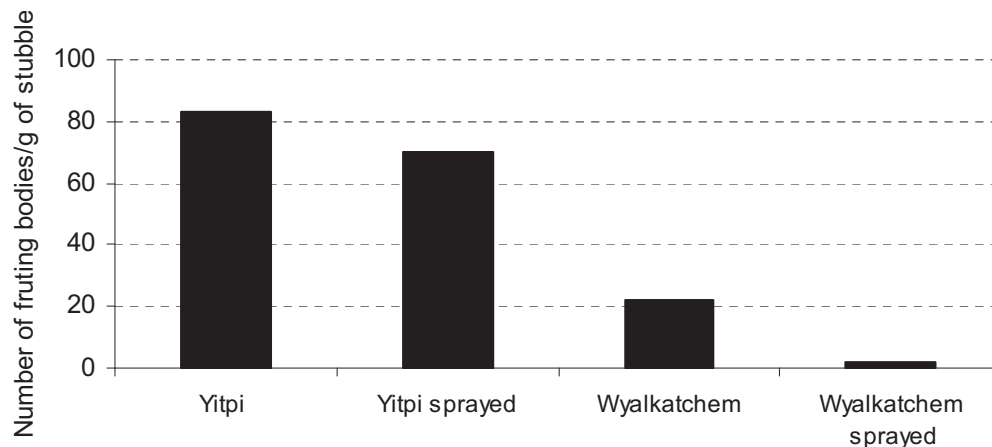


Figure 2 Effect of variety and in-season fungicide application ('sprayed') on the development of yellow spot sexual fruiting bodies on wheat stubbles.

CONCLUSION

Stubbles from different wheat varieties have differing yellow spot carryover risks. There is a general trend for stubbles from more resistant varieties to have a lower disease carryover risk than stubbles from more susceptible varieties. Stubble from the very susceptible variety Correll had a high disease carryover risk due to the early maturation of the high numbers of sexual fruiting bodies that form on this stubble. Yitpi also displayed a higher disease carryover than more resistant varieties in both 2008 and 2009. This suggests that these varieties are not suited to either phase of a wheat-on-wheat rotation. The susceptible variety Arrino had a lower disease carryover risk and may be more suitable for use in the 1st year of continuous wheat cropping. As a general rule very susceptible to moderately susceptible varieties are more likely to have high levels of yellow spot carryover and are unlikely to be suited for use in wheat-on-wheat rotations.

Spraying moderately resistant varieties with fungicides to reduce yellow spot levels during the crops growing season reduces the yellow spot carryover risk. Fungicide application to susceptible varieties during the crops growing season delayed the maturation timing of the fruiting bodies but did not significantly reduce the numbers of fruiting bodies that formed. The yellow spot carryover risk for the sprayed susceptible variety was higher than the risk for the unsprayed moderately resistant variety.

This suggests that spraying a susceptible variety for yellow spot in the growing season will not reduce their carryover risk sufficiently for their use in a wheat-on-wheat system.

There is only a very small risk of yellow spot carryover associated with 18-month old wheat stubbles. This supports current recommendations to observe a minimum of a one year rotation with a non-cereal break crop to reduce the risk of yellow spot.

KEY WORDS

yellow spot, wheat, stubble

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Fungicides for the future: Management of Barley Powdery Mildew and Leaf Rust

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KEY MESSAGES

- 'Currently registered products' for broadacre crops, Amistar® XtraAZ® (*azoxystrobin* + *cyproconazole*), Tilt Xtra® (*propiconazole* + *cyproconazole*), Prosaro® 420SC (*prothioconazole* + *tebuconazole*), Tilt® 250EC (*propiconazole*), Opus® 125 (*epoxiconazole*) and Folicur® 430SC (*tebuconazole*) were all effective in controlling powdery mildew and leaf rust but their efficacy varied.
- Under moderate leaf rust pressure, fungicides increased yield by 6 to 45 per cent at South Stirling and 7 to 44 per cent at Gibson under moderate powdery mildew and leaf rust pressure.
- When selecting registered products, consideration should be given to the spectrum of diseases present in the crop and also the price of the product.
- Development of fungicide resistance, particularly in barley powdery mildew, is an ongoing concern in WA. These trials have shown that fungicides with different modes of action (MOA) can provide effective disease control and therefore facilitate rotation of fungicide MOA to minimise the risk of developing fungicide resistance.

BACKGROUND

Barley is widely grown along the south coast of Western Australia (WA); 40 per cent of barley is delivered as malt. This is mainly due to high returns for malt barley compared to feed barley. Currently grown malt varieties in the region are susceptible to many foliar diseases including leaf rust and powdery mildew. Barley leaf rust caused by *Puccinia hordei* is a difficult disease to control and occurs from time to time depending on survival of summer barley regrowth. Severe leaf rust infections can cause up to 45 per cent yield loss on susceptible barley varieties. Barley powdery mildew occurs more frequently on the south coast. Early powdery mildew infection can cause more than 20 per cent yield loss whereas late infection causes around 20 per cent loss. The lack of genetic resistance of current malting barley varieties to leaf rust and powdery mildew and the reduction in prices of some of the registered fungicides, has led growers to use fungicides more frequently (two to three times per season). It has been reported in Europe that repeated use of single mode of action fungicides such as some DMI and strobilurin base group of fungicides can lead to a decrease in pathogen sensitivity. This would have very serious implications to barley growers in Australia. A good example for this is powdery mildew cause by *Blumeria graminis* f. sp. *hordei* which falls into a high risk category for developing resistance to fungicides. Therefore it is important to evaluate the efficacy of new and old foliar fungicides with different or combinations of modes of action (MOA) against leaf rust and powdery mildew with the aim of identifying fungicides that are effective against both diseases.

AIMS

To evaluate unregistered and currently registered fungicide products against leaf rust and powdery mildew on Baudin barley.

MATERIALS AND METHODS

In 2009, two trials were established at South Stirling and Gibson on 4 June and 27 May respectively. The susceptible barley cv. Baudin was used at both locations. The trial design was a randomized block with 20 m x 1.8 m wide plots with similar size alternating wheat buffers. The treatments consisted of two seed dressings: Baytan® T (*triadimenol*); Jockey® (*fluquinconazole*) and ten foliar fungicides: Tilt® 250EC (*propiconazole*); Tilt Xtra® (*propiconazole* + *cyproconazole*); Amistar® XtraAZ® (*azoxystrobin* + *cyproconazole*); Opus® 125 (*epoxiconazole*); Folicur® 430 SC (*tebuconazole*); Prosaro® 420 SC (*prothioconazole* + *tebuconazole*); Product A (*quinoxifen*); Product B (*spiroxamine*); Product C (*cyproconazole*) and Product D (*epoxiconazole* + *pyraclostrobin*). Control treatments were: Untreated (no fungicide) for maximum disease development and full control (Jockey® with three applications of Amistar® XtraAZ®) to measure yield potential under minimal disease conditions. Amistar Xtra and Prosaro were used with Adigor® at 2 per cent v/v and Hasten at

1 per cent v/v respectively. The individual fungicide rates used is shown in the footnote of Table 1 and their application timing are shown in Table 1 and Table 2.

RESULTS

At South Stirling and Gibson, rainfall of 370 mm and 342 mm was received from April to December respectively. June was the wettest month with 105 mm at South Stirling and 96 mm at Gibson.

South Stirling

Leaf rust was the only disease at this site. Moderate levels were found. The disease first appeared around early stem extension. Of the many fungicides tested, there were several that were effective in controlling leaf rust. At flowering stage, the average leaf rust severity ranged from 9 to 27 per cent on the top four leaves (Table 1). Either Baytan followed by two foliar applications of Folicur, Prosaro, Tilt Xtra, Opus, Amistar Xtra, Product C (*cyproconazole*), Product D (*epoxiconazole + pyraclostrobin*) or Jockey seed dressing with Tilt or Amistar Xtra significantly reduced the leaf rust compared to the other treatments. There were no significant treatment differences among untreated, Baytan only and Baytan with foliar application of Product A (*quinoxifen*). Product A is specific for powdery mildew control, hence the poor control of leaf rust. Combined use of Jockey with Tilt had significantly less leaf rust than Baytan with Tilt, however, there were no significant treatment differences between Baytan with Amistar Xtra and Jockey with Amistar Xtra in leaf rust control.

Grain yield varied from 2.7 to 4.0 t/ha (Table 1). All treatments except Baytan alone and Baytan plus Product A significantly increased yield above the untreated. Grain quality parameters such as screenings varied from 5 per cent (Jockey with Amistar Xtra) to 16 per cent (untreated and Baytan only), protein 10 to 11 per cent, hectolitre weight 63 (untreated) to 66 (Jockey with Amistar Xtra) and colour from 53 to 54 (data not shown). Grain colour and protein differences were not significant but there were significant improvements in hectolitre weight and reduced screenings. Based on the 2009 Grain Pool receival standard, the colour of the grains was low (< 55) and categorised as feed grade. The gross income for each treatment is shown in the Table 1 and ranged from \$399 (untreated) to \$593 (Jockey with Amistar Xtra). Most profitable applications were Baytan with Prosaro (\$513) followed by Baytan with Tilt Xtra (\$504), Jockey with Tilt (\$490) and Baytan either with Tilt or Folicur (\$488) respectively.

Gibson

Powdery mildew and leaf rust were the dominant diseases and were found at moderate levels. Powdery mildew was apparent at late tillering stage and leaf rust started to appear during the mid stem elongation stage but later became the dominant disease during spring. The average powdery mildew severity on the top four leaves ranged from 3 to 32 per cent (untreated) at flowering (Table 2). By this growth stage Baytan alone was ineffective, all foliar fungicides significantly reduced powdery mildew although Baytan with Folicur was less effective than other treatments.

Leaf rust severity, measured as the average of the top four leaves, varied from 4 to 33 per cent (Table 2). Combined use of Baytan with Prosaro, Tilt Xtra, Opus, Amistar Xtra, Product C (*cyproconazole*) and Jockey either with Tilt or Amistar Xtra was significantly better than other treatments in leaf rust control. There were no significant differences between Baytan with Amistar Xtra and Jockey with Amistar Xtra. Product A provided effective powdery mildew control but as occurred at South Stirling did not control barley leaf rust.

Application of foliar fungicides increased the yield between 7 to 44 per cent depending on the treatment (Table 2). All foliar fungicides significantly increased the yield compared to untreated and Baytan only. Yield with Product A was significantly lower than other foliar fungicides reflecting control of only one disease. There were no significant yield differences between Baytan used with Folicur, Prosaro, Tilt Xtra or Opus and Jockey used with Tilt (Table 2). Treatments containing applications of Amistar Xtra had the highest yield (5.5 t/ha) although the treatment differences were not significant. There were significant grain quality improvements with use of foliar fungicide. Screenings ranged from 7 to 51 per cent, protein 11 to 12 per cent, hectolitre weight 63 to 69 and colour 56 to 60 among the treatments (data not shown). Grain from untreated and Baytan only plots was feed quality due to high screenings, 51 and 38 per cent respectively whereas Baytan with Product A (*quinoxifen*) was malt 2 based on reduced screenings (30 per cent). Grains from other treatments were malt 1. The gross income for each treatment is shown in the Table 2 and ranged from approximately \$570 (Baytan) to

\$1267 (Baytan with Amistar Xtra). Most profitable applications were Baytan with Prosaro (\$1189) followed by Baytan with Folicur (\$1173), Jockey with Tilt (\$1165) and Baytan with Tilt Xtra (\$1164) respectively.

CONCLUSIONS

Only leaf rust was present at South Stirling whereas both powdery mildew and leaf rust were observed at Gibson. The disease levels were moderate at both sites. At Gibson powdery mildew was first evident in trace levels at early tillering in untreated (control) plots followed by late tillering on Baytan treatments and at mid stem elongation on Jockey treated plots. Additionally, it is interesting to note that use of Jockey as seed dressing with foliar Tilt improved leaf rust control compared to the combination of Baytan with Tilt at both locations. These observations clearly demonstrate differences between the two seed-dressing fungicides, Jockey provided longer protection against powdery mildew compared to Baytan. At South Stirling Baytan alone increased yield by 6 per cent but did not increase yield at Gibson. The observed differences may be due to the early onset of powdery mildew on Baytan treated plots at Gibson having an impact on yield.

The efficacy of the foliar fungicides used varied against powdery mildew and leaf rust. The registered fungicide products such as Tilt, Prosaro, Opus, Tilt Xtra and Amistar Xtra were highly effective in powdery mildew control whereas Folicur, whilst still reducing mildew, appeared less effective. Prosaro, Tilt Xtra, Opus and Amistar Xtra were the most effective products in leaf rust control. Product A (*quinoxifen*), Product B (*spiroxamine*), Product C (*cyproconazole*) and Product D (*epoxiconazole + pyraclostrobin*) all have the potential to control powdery mildew and the latter two control leaf rust of barley as well but need to be registered by chemical companies.

Use of foliar fungicide applications (two sprays) increased the yield by 10 to 43 per cent at South Stirling and by 7 to 44 per cent at Gibson. Grain quality was also improved with foliar fungicide at both locations. These increases in yield and quality have resulted in significant gross margin improvements over untreated controls.

Products with different MOA were used in these trials. DMI fungicides or mixtures of DMI and strobilurin were very effective. Product A was from a completely different MOA and was highly effective against powdery mildew but not leaf rust. To be effective in mixed infections, MOA specific to only one pathogen will need to be deployed in mixture with other MOAs effective against the remaining pathogens present in the crop to achieve effective disease control. Nonetheless, diversification of the MOA used against each pathogen is required to minimise the risk of them developing fungicide resistance

KEY WORDS

leaf rust, powdery mildew, barley, fungicide

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Table 1 Effect of fungicides on leaf rust severity and yield of Baudin barley, South Stirling 2009

Treatments (Products)	FRAC mode of action code	% leaf area disease (leaf rust) at Z65 (8 Oct.) *ang (avF to avF-3)	Yield		****Gross income (\$/ha)	*****Gross margin (net after product and application cost) (\$/ha)
			(t/ha)	% Nil		
Untreated (Nil)	—	27 ^{a**}	2.7 ^a	100	399	399 ^a
Baytan	3	27 ^a	2.8 ^a	106	423	419 ^a
Baytan + Product A X 2 ^{***}	3 + 13	26 ^a	2.9 ^{ab}	110	440	[∅] na
Baytan + Product B X 2	3 + 5	21 ^b	3.6 ^c	134	534	na
Baytan + Tilt X 2	3+ 3	17 ^c	3.6 ^c	135	537	488 ^b
Baytan + Folicur X 2	3 + 3	13 ^{cd}	3.5 ^{bc}	132	524	488 ^b
Baytan + Prosaro X 2	3 + (3 + 3)	13 ^d	3.7 ^c	140	557	513 ^c
Jockey + Tilt X 2	3 + 3	12 ^d	3.7 ^c	139	553	490 ^b
Baytan + Product C X 2	3 + 3	12 ^d	3.7 ^c	140	559	na
Baytan + Product D X 2	3 + (3+11)	11 ^d	3.8 ^c	142	566	na
Baytan + Tilt Xtra X 2	3 + (3 + 3)	10 ^d	3.8 ^c	145	577	504 ^b
Baytan + Opus X 2	3 + 5	10 ^{de}	3.6 ^c	137	545	481 ^b
Baytan + Amistar Xtra X 2	3 + (11+3)	9 ^e	3.8 ^c	143	568	444 ^{ab}
Jockey + Amistar Xtra X 3	3 + (11+3)	9 ^e	4.0 ^c	149	593	395 ^a
I.s.d. 5%		4	0.6			63

Note: Fungicides were sprayed on Z31 (17 August); Z42 (23 September) and Z69 (12 October)

* Angular transformed data; [∅]na = not available.

** Means followed by the same letter in the same column are not significantly different at $p = 0.05$ level.

*** Number of foliar applications X 2 = Z31 and Z42; X 3 = Z31, Z42 and Z69.

**** Assuming feed barley price = \$150.

***** Assuming fungicide cost for the rates used: Baytan @ 150 mL = \$4; Jockey @ 300 mL = \$18; Tilt 250EC @ 500 mL = \$15; Tilt Xtra @ 500 mL = \$26; Amistar Xtra @ 400 mL = \$51; Adigor @ 2% = \$1; Opus 125 @ 500 mL = \$22; Folicur 430SC @ 290 mL = \$8; Prosaro 420SC @ 150 mL = \$11; Hasten 1% = \$1; Product A @ 100 mL = na; Product B @ 144 mL = na; Product C @ 400 mL = na; Product D @ 500 mL = na and Application cost = \$8.

Table 2 Effect of fungicides in control of powdery mildew, leaf rust and on yield of Baudin barley, Gibson 2009

Treatments (Products)	% leaf area disease		Yield		Gross income (\$/ha)	Gross margin (net after product and application cost) (\$/ha)
	Powdery mildew	Leaf Rust	(t/ha)	% Nil		
	at Z69 (30 Sept.) *ang (avF to avF-3)		(t/ha)	% Nil	(\$/ha)	
Untreated	32 ^{a**}	33 ^a	3.8 ^a	100	572 [†]	572 ^a
Baytan	29 ^a	30 ^a	3.8 ^a	100	570 [†]	566 ^a
Baytan + Product A X 2 ^{***}	3 ^d	25 ^b	4.1 ^b	107	860 ^{†††}	[∅] na
Baytan + Product B X 2	5 ^d	16 ^c	4.8 ^{cd}	127	1120 ^{††}	na
Baytan + Tilt X 2	5 ^d	11 ^{de}	5.0 ^d	133	1170 ^{††}	1121 ^{bc}
Baytan + Folicur X 2	13 ^b	13 ^{cd}	5.2 ^e	137	1210 ^{††}	1173 ^{cd}
Baytan + Prosaro X 2	3 ^d	6 ^f	5.3 ^{ef}	140	1233 ^{††}	1189 ^d
Jockey + Tilt X 2	4 ^d	8 ^{ef}	5.3 ^{ef}	139	1228 ^{††}	1165 ^{cd}
Baytan + Product C X 2	5 ^d	5 ^f	5.2 ^e	136	1202 ^{††}	na
Baytan + Product D X 2	9 ^c	9 ^e	5.1 ^{de}	135	1189 ^{††}	na
Baytan + Tilt Xtra X 2	4 ^d	6 ^f	5.3 ^{ef}	140	1237 ^{††}	1164 ^c
Baytan + Opus X 2	4 ^d	5 ^f	5.2 ^e	137	1211 ^{††}	1147 ^c
Baytan + Amistar Xtra X 2	5 ^d	5 ^{fg}	5.5 ^f	144	1267 ^{††}	1143 ^c
Jockey + Amistar Xtra X 3	3 ^d	4 ^g	5.5 ^f	144	1266 ^{††}	1069 ^b
I.s.d. 5%	3	3	0.2			56

Note: Fungicides were sprayed on Z31 (29 July); Z39 (7 September) and Z55 (26 September).

*Angular transformed data; **Means followed by the same letter in the same column are not significantly different at $p = 0.05$ level; ***Number of foliar applications X 2 = Z31 and Z39; X 3 = Z31, Z39 and Z55; Assuming [†]feed barley price = \$150; ^{††}malt barley 1 = \$232 and ^{†††}malt barley 2 = \$211.

[∅]na = not available.

2009 canola disease survey and management options for blackleg and *Sclerotinia* in 2010

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KEY MESSAGES

- The results of canola disease survey indicated that *Sclerotinia* stem rot was widespread in the northern agricultural region in the 2009 growing season, however, average *Sclerotinia* incidence across all samples was down by 2 per cent from that seen in the 2008 survey.
- Severity of blackleg was very high in the southern areas. Averaged over all samples, both the incidence and severity of blackleg was up by 22 and 18 per cent respectively in 2009 compared with the 2008 season.
- Mild infections of club root were detected from the northern region only, however, average incidence of club root in the northern region was double that seen in last year's survey.
- No powdery mildew was detected in any samples collected for the survey in 2009.
- Yield losses in various canola varieties under moderate to high disease pressure situations in medium rainfall areas ranged between 13–35 per cent.

AIMS

- To monitor root and stem diseases in canola crops to provide timely feedback to the industry about the fungal diseases which need to be considered in establishing and managing canola crops.
- Assessment of yield loss from blackleg in new canola varieties under moderate disease pressure.

METHOD

Canola disease survey

Samples were collected from canola crops across the low, medium and high rainfall zones of the Western Australian grainbelt. About 100 stems were collected in each sample along a 200 m transect. Stems were washed and rated for severity of internal infection of blackleg on a 0–4 scale (0 = no disease, 4 = more than 75 per cent stem cross section showing internal necrosis). Disease incidence (% plants with crown cankers) and disease severity expressed as per cent disease index (PDI) for each sample were calculated. Plants were also assessed for the incidence of *Sclerotinia* stem rot (SSR), club root caused by *Plasmodiophora brassicae* and powdery mildew caused by *Erysiphe cruciferarum*

Yield loss from blackleg in canola varieties under moderate disease pressure

Trials were conducted to determine the yield loss from blackleg in Clearfield (CL) and Triazine tolerant (TT) varieties at Wongan Hills, Mt. Barker and Katanning. Ten canola varieties including 5 varieties each from CL and TT herbicide tolerance groups were sown with and without maximum fungicide protection in a paddock containing two year old canola residues. The fungicide treatment included fluquinconazole seed dressing @ 2 g a.i./kg, Impact in Furrow @ 400 mL/ha and 3 sprays of Impact @ 400 mL/ha foliar application. The first fungicide spray was applied at 4 weeks after sowing and followed by two more sprays at the same rate at 4 week intervals.

Trial design was a split split plot design (Fungicides as main plots, herbicide groups as sub plots and varieties as sub sub plots) with four replications. Blackleg assessments were made three weeks before swathing. All plots were harvested for yield. In this paper only yield loss data from the Wongan Hills trial is presented.

RESULTS

Canola disease survey

A total of 95 samples were collected from canola crops in 2009. About 30 per cent samples were cultivar (cv) Cobbler, 20 per cent Thunder, 13 per cent Tanami, 7 per cent Tornado, 5 per cent Beacon, 4 per cent each Barra and Bravo and 2 per cent cv Rocket. A majority of the crops were sown in paddocks where there had been at least a three year break since the previous canola crop. Prevalence of disease (percentage crops affected) was highest (100 per cent) for blackleg followed by Sclerotinia stem rot followed by club root. No powdery mildew was detected in any samples assessed (Figure 1). When averaged across all samples, the incidence of blackleg was highest compared with that of other diseases (Figure 1). Average severity of internal infection of blackleg was 41 per cent. The range of incidence within a sample, across all samples, was 1–100 per cent for blackleg, 0–79 per cent for Sclerotinia stem rot and 0–65 per cent for club root. Club root was detected only from samples collected from the northern region as the samples from the southern areas were very dry and symptoms of club root were not visible. Average incidence of club root in northern areas was 25 per cent.

In comparison with the survey undertaken in 2008, the average incidence (across all samples) of SSR was down by 2 per cent, and that of blackleg and club root was up by 22 and 2 per cent respectively. The average internal infection (severity) of blackleg crown canker was also up by 18 per cent in 2009 season. Likewise, average incidence of club root was up by 14 per cent in the northern region.

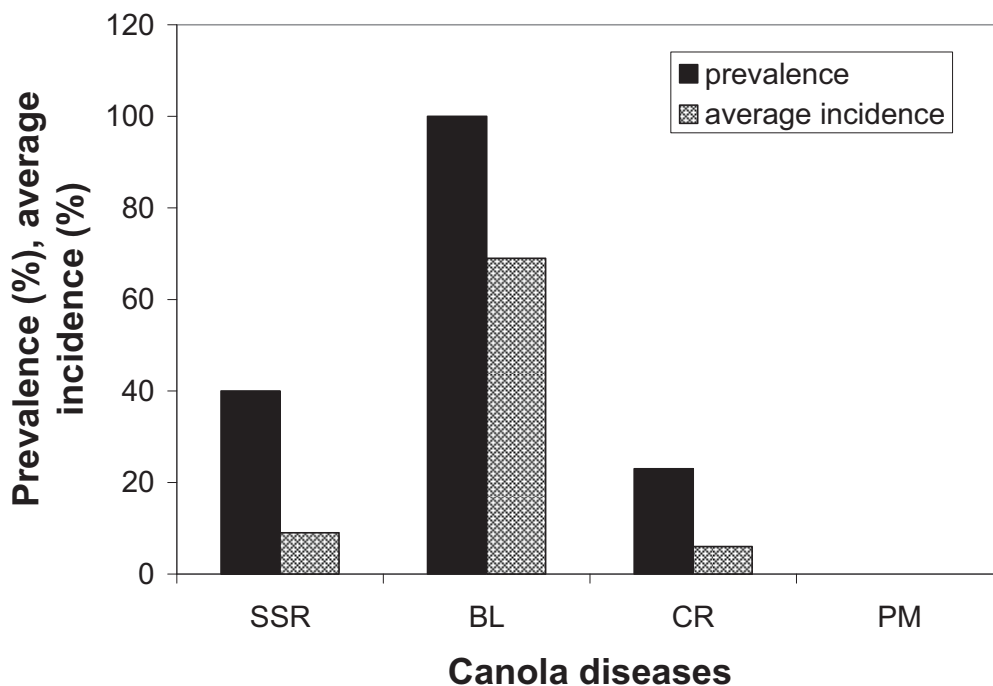


Figure 1 Prevalence (%crops infected) and average incidence (% plants infected) across all samples of various canola diseases in Western Australia during 2009 (SSR = Sclerotinia stem rot, BL = Blackleg, CR = club root, PM = powdery mildew).

High levels of blackleg in the southern areas could be due to conducive environmental conditions favouring early spore release from stubble and sowing canola in tight rotations without any fungicide protection. Likewise, high levels of Sclerotinia stem rot particularly in the northern region could be attributed to a gradual build up of sclerotia of Sclerotinia in conjunction with favourable environmental conditions for spore release coinciding susceptible flowering stage of the crop.

Yield loss from blackleg in canola varieties

Maximum fungicide treatment significantly reduced the crown canker severity in all varieties compared with the nil treatments. Likewise, seed yield was significantly improved with fungicide treatment in all varieties except for 45Y77 and 46Y81 (Table 1). Maximum fungicide protection treatment gave an increase in seed yield from 14–54 per cent and yield losses in various canola varieties ranged between 13–35 per cent.

Table 1 **Blackleg severity (per cent disease index or PDI) and yield (kg/ha) of canola varieties with and without full fungicide protection under moderate disease pressure at Wongan Hills in 2009**

Variety	BRR	PDI		Yield (kg/ha)		% increase
		Nil	Fungicide	Nil	Fungicide	
43C80CL	MS	41	4	784	933	19
45Y77	MR	52	6	685	784	14
46Y81	R-MR	32	2	675	784	16
Hyola 571CL	R	23	1	893	1042	17
Warrior	MR-MS	45	2	476	734	54
Stubby	S	75	14	384	585	52
Boomer	MS-S	71	9	655	923	41
Cobbler	MS	48	6	635	814	28
Thunder	MR-MS	20	4	496	685	38
Tornado	MR	28	1	536	734	37

BRR = Blackleg resistance rating.

%inc. = % increase in yield over control.

I.s.d. ($P < 0.05$) for PDI: Herbicide group*Fungicide*Variety = 9.

I.s.d. ($P < 0.05$) for Yield: Herbicide group*Fungicide*Variety = 136.

Management options for the control of blackleg

- Sow resistant varieties.
- Reduce residue carryover by raking, burning or grazing.
- Crop rotation—do not sow canola in the same paddock for at least three to four years.
- Increase distance from last year's canola stubble—ensure at least 500 m between this year's canola crop and last year's canola stubble.
- Use fungicide where disease pressure is high. Growers are advised to refer to Canola Blackleg Disease risk forecast that can be accessed at <http://www.agric.wa.gov.au>.

Management options for the control of Sclerotinia

- Crop rotation with non-host crops is important to curtail the build up of Sclerotinia inoculum.
- Increase distance from last year's canola crop to reduce the risk of air-borne ascospores from apothecia of the pathogen.
- Several iprodione and procymidon based fungicides are registered for the control of Sclerotinia stem rot. Fungicide protection in high risk paddocks is warranted. However, it is important that the fungicide sprays should be targeted at the critical stage of spore release by the pathogen in order to successfully control Sclerotinia in canola. The DAFWA team are planning to conduct trials to determine the effectiveness of various fungicide products to control Sclerotinia under WA conditions in the 2010 growing season.

CONCLUSION

Survey results highlight that both in 2008 and 2009 growing seasons, Sclerotinia stem rot was most prevalent in the northern agricultural region whereas, blackleg was very severe in the southern areas. These two diseases warrant good management practices in order to reduce yield losses. Moreover, our trial results indicate that yield losses from blackleg can vary from 13 to 35 per cent in different canola varieties under moderate to high disease pressure situations in medium rainfall areas. In 2010, canola growers in all areas need to carefully manage blackleg in their canola crops given there is an accumulation of infected canola residues. These disease sources, if coupled with conducive weather conditions for the development of the disease, may pose a serious risk of developing blackleg epidemics in canola crops. Although club root didn't emerge as a serious problem, its prevalence,

particularly in the northern region, means that growers are required to maintain good hygiene practices and avoid movement of soil between paddocks on machinery, in order to prevent the spread of this pathogen. Other options to prevent the spread of club root are the control of Brassica weeds, long rotations and sow club root free seed. This disease is recognised as a key disease in Alberta, Canada as it has spread rapidly and caused significant losses of yield in canola crops.

KEY WORDS

blackleg, Sclerotinia stem rot, canola, club root, disease management

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Impact of variety and fungicide on carryover of stubble borne inoculum and yellow spot severity in continuous wheat cropping

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KEY MESSAGES

In environments favourable for yellow spot, stubble borne inoculum poses a significant threat for early season infection. For wheat-on-wheat cropping in these environments, the yellow spot resistance status of the current season variety and in-season fungicide management have a far greater impact on disease levels and yield losses than the variety of the stubble sown over.

Varieties susceptible to yellow spot, such as Yitpi, are at high risk of infection regardless of the stubble variety and should not be sown into wheat stubble. Yellow spot susceptible varieties increase disease carryover and should not be grown consecutively in any cropping environment.

AIMS

To examine the impact of variety sequencing and fungicide management on yellow spot disease severity in continuous wheat crops and to determine whether the level of yellow spot in the first year influences the choice of variety (resistant vs. susceptible) in the second year.

METHOD

Field trials were conducted at Eradu (2007–2008) and Meckering (2008–2009). The trials were conducted over two years. In the first year they examined the impact of variety resistance and standard fungicide application on disease development and subsequent stubble borne inoculum. In the second year they examined how the changes in stubble borne inoculum impacted on yellow spot infection levels in susceptible or moderately-resistant wheat varieties sown into the stubble.

In year 1, plots were sown to a yellow spot susceptible (S) variety and a yellow spot moderately-resistant (MR) variety. Fungicide was applied at Z39 to manage yellow spot infection.

In year 2, S or MR plots were sown across year 1 plots to achieve all combinations of S or MR in year 1 oversown with S or MR in year 2, plus both varieties with or without fungicide in year 1 and year 2. Regular disease assessments were made to track disease development and machine harvest carried out to determine treatment effects on grain yield.

Samples of year 1 stubble were taken from all plots for laboratory measurement of timing and amount of spores released. Stubble from the 2007 Eradu treatments was removed and placed into micro-plots at South Perth. Yitpi wheat was grown through the stubble and this was assessed for yellow spot.

Eradu

In year one (2007), Wyalkatchem (YS – MR, SNB – S) and Tammarin Rock (YS – S, SNB – S) plots were sown over Bonnie Rock stubble. At flag leaf emergence, half of the plots were treated with fungicide (propiconazole 62.5 g a.i./ha). Rainfall: May–October = 179 mm, post flag leaf = 48 mm.

In year 2 (2008), year 1 plots were over-sown with Wyalkatchem and Tammarin Rock. Half of all plots were sprayed with fungicide (propiconazole 62.5 g a.i./ha) at flag leaf emergence. Rainfall: May–October = 271 mm, post flag leaf = 130 mm.

Meckering

In year one (2008), Wyalkatchem (YS – MR, SNB – S) and Yitpi (YS – S, SNB – MR/MS) plots were sown over Calingiri stubble. At flag leaf emergence, half of the plots were treated with fungicide (propiconazole 62.5 g a.i./ha). Rainfall: May–October = 243 mm, post flag leaf = 92 mm.

In year 2 (2009), year 1 plots were over-sown with Magenta (YS – MR, SNB – MR/MS) and Yitpi. Half of all plots were sprayed with fungicide (propiconazole 62.5 g a.i./ha) at three times (Z30, Z32, Z39) to determine yield potential. Rainfall: May-October = 232 mm, post flag leaf = 46 mm.

RESULTS

Year 1 (Eradu 2007, Meckering 2008)

Eradu-2007: Moderate-high levels of yellow spot were evident in the trial. Wyalkatchem had significantly lower levels of disease than Tamarin Rock. Laboratory examination of infected leaves showed that disease was predominantly yellow spot. Small responses to fungicide application were evident on the flag leaf, however yield responses did not correspond, there was no yield difference in Tamarin Rock and a small response in Wyalkatchem with no associated quality responses (Table 1).

Meckering-2008: Moderate-high levels of yellow spot were evident in the trial from an early stage. Wyalkatchem had significantly lower levels of seedling disease than Yitpi. Laboratory examination of infected leaves indicated that the dominant disease was yellow spot (85 per cent) however septoria nodorum blotch (SNB) was also present (15 per cent), particularly in Wyalkatchem. At growth stage Z39, when fungicide was applied, heavy disease levels were evident in the lower canopy of Yitpi, with significantly less in Wyalkatchem. During grain fill, green leaf retention was lower in Yitpi than in Wyalkatchem, however disease levels in Wyalkatchem increased with late season rain. Small reductions in leaf disease in response to fungicide were evident in both varieties. By the end of the season YS was most prevalent on Yitpi and SNB most prevalent on Wyalkatchem. Fungicide increased yield by about 0.2 t/ha in both varieties and increased test weight in Wyalkatchem from 72 to 74 kg/hL although neither response was statistically significant. Wyalkatchem yield was poor, possibly due to frost damage (Table 1).

Table 1 Effect of variety and fungicide (Tilt 250 EC @ 500 mL/ha) on control of yellow spot and yield of wheat in year 1 at Eradu in 2007 and Meckering in 2008

Site (year 1)	Variety	Fungicide	% leaf area affected (L1-3)			Yield t/ha
			Z32/39	Z65	Z75	
Eradu (2007)	Tamarin Rock	Untreated	16.3	69.5		1.87
		Tilt @ Z39	–	64.4		1.87
	Wyalkatchem	Untreated	6.1	37.6		1.96
		Tilt @ Z39	–	35.2		2.11
	I.s.d. (5%)		3.4	6.9		0.15
Meckering (2008)	Yitpi	Untreated	40.7		84.7	1.66
		Tilt 500 mL/ha	–		75.6	1.85
	Wyalkatchem	Untreated	14.7		72.6	0.88
		Tilt 500 mL/ha	–		55.0	1.09
	I.s.d. (5%)		14		5.1	n.s.

Year 2 (South Perth 2008, Eradu 2008, Meckering 2009)

South Perth-2008: Stubble from the 2007 Eradu treatments was removed and placed into micro-plots at South Perth. In Yitpi wheat grown through the 2007 stubble, significant responses were evident from both stubble variety and fungicide treatment. However, moderate levels of disease were evident in all stubble plots, including fungicide treated Wyalkatchem (Table 2).

Table 2 Effect of variety and fungicide treatment of stubble from the 2007 Eradu field trial on yellow spot of Yitpi wheat (at Z14) grown in small plots at South Perth in 2008

Stubble variety	Stubble fungicide	% leaf area affected (L1-3)
Tamarin Rock	Untreated	22.8
	Tilt @Z39	11.5
Wyalkatchem	Untreated	14.6
	Tilt @Z39	9.3
l.s.d. (5%)		5.1

Table 3 Effect of stubble variety and fungicide treatment from year 1 on yellow spot and yield of wheat grown in year 2 at Eradu in 2008 and Meckering in 2009

Site (year 2)	Stubble treatment (year 1)	% leaf area affected (L1-3)			Yield t/ha
		Z24	Z31/32	Z61/65	
Eradu (2008)	Variety				
	Tamarin Rock	7.2	10.5	33.1	2.95
	Wyalkatchem	8.6	12.1	33.9	2.99
	l.s.d. (5%)	0.6	ns	ns	ns
	Fungicide				
	Untreated	9.3	13.6	36.3	2.90
	Tilt @Z39	6.6	9.0	30.6	3.03
	l.s.d. (5%)	1.0	2.4	ns	ns
Meckering (2009)	Variety				
	Yitpi	27.7	49.8	34.3	2.25
	Wyalkatchem	24.1	45.8	30.3	2.26
	l.s.d. (5%)	ns	ns	2.5	ns
	Fungicide				
	Untreated	28.2	46.7	31.4	2.29
	Tilt @Z39	23.7	48.8	33.1	2.21
	l.s.d. (5%)	ns	ns	ns	ns

Eradu-2008: In the field at Eradu, the differences exhibited in micro-plots were also evident, however the degree of difference was smaller and became less important as the season progressed, resulting in no significant yield response. Interactions between stubble variety and fungicide were not significant (Table 3). Yellow spot was the dominant pathogen in both varieties, Tamarin Rock (94–100 per cent) and Wyalkatchem (65–100 per cent). Current season variety and fungicide had the greatest impact on disease severity. Less disease was apparent in Wyalkatchem and the Z39 fungicide reduced diseased leaf area in both varieties. Again, despite significant disease responses, significant yield and quality responses were not achieved (Table 4).

Table 4 Effect of year 2 variety and fungicide (Tilt 250 EC @ 500 mL/ha) on control of yellow spot and yield of wheat at Eradu in 2008 and Meckering in 2009

Site (year 2)	Variety	Fungicide	% leaf area affected (L1-3)			Yield t/ha
			Z24	Z31/32	Z61/65	
Eradu (2008)	Tammarin Rock	Untreated	11.3	16.2	52.9	2.53
		Tilt @ Z39			37.2	2.68
	Wyalkatchem	Untreated	4.5	6.4	26.6	3.39
		Tilt @ Z39			17.3	3.26
	I.s.d. (5%)		1.9	1.5	2.5	ns
Meckering (2009)	Yitpi	Untreated	50.8	53.2	51.1	1.89
		Tilt @ Z39			29.7	2.37
	Magenta	Untreated	32.5	42.4	29.2	2.25
		Tilt @ Z39			19.1	2.50
	I.s.d. (5%)		8.1	3.5	2.5	ns*

* I.s.d. (10%) = 0.2.

Meckering-2009: Magenta replaced Wyalkatchem in 2009 to better synchronise maturity of varieties. Five weeks after sowing, (three leaf stage) significant levels of disease were evident on seedlings, severity was greater in Yitpi than Magenta (Table 4). Stubble variety had little effect and 2008 fungicide treatment only marginally reduced disease severity (Table 3). Both yellow spot (60–82 per cent) and septoria nodorum (17–40 per cent) were present on leaves with yellow spot being most common, particularly in the Yitpi on Yitpi plots (82 per cent). This trend continued throughout the season with small non-significant effects of both stubble variety and previous fungicide on current season disease. The major effect on disease levels was from current season variety and fungicide treatment (Table 4). Disease levels in Yitpi were consistently greater than in Magenta and fungicide application reduced diseased leaf area throughout the season. Assessment of pathogen proportions indicate that YS was the dominant pathogen on Yitpi regardless of the stubble variety, however in Magenta following Wyalkatchem, SNB was the dominant pathogen.

Stubble variety or fungicide treatment from year 1 had no impact on grain yield. Fungicide application in year 2 increased yield in both varieties however yield response in Yitpi (0.48 t) was almost twice the response in Magenta (0.25 t). Grain quality assessments were not available at time of publication.

CONCLUSION

At both sites significant levels of yellow spot developed in year 1 of the trials. Early disease assessments showed small differences between stubble variety and fungicide treatment on disease levels in year 2. This was further evident in the micro-plot results with stubble from Eradu. However, these small early differences did not persist throughout the season and did not result in significant yield differences. In both trials the most significant impact on crop disease levels were the year 2 variety or fungicide treatment.

Early season weather conditions were favourable for yellow spot development in year 2 at both sites and high levels of disease were evident. At Meckering, yellow spot was the dominant pathogen, particularly following Yitpi, indicating that the carryover on this stubble was probably greater than on Wyalkatchem. Wyalkatchem is susceptible to SNB and it should be noted that the level of this disease was higher following Wyalkatchem. These results indicate some differences in disease carryover between varieties, dependant on susceptibility.

In disease conducive environments, yellow spot susceptible varieties such as Yitpi or Tammarin Rock should not be grown in a wheat-on-wheat system because even MR type stubble provides enough YS inoculum for significant disease to occur in the second year. MR varieties will have significantly lower levels of disease, however under heavy disease pressure can still suffer significant yield loss.

Even in less disease favourable environments (lower rainfall zones), susceptible varieties such as Yitpi are unsuitable for use in wheat-on-wheat rotations. These experiments have shown that susceptible varieties have increased disease carryover on stubble and a lower threshold for infection compared to a moderately resistant variety such as Wyalkatchem.

KEY WORDS

yellow spot, wheat, stubble, variety resistance, fungicide

ACKNOWLEDGMENTS

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Limitations to the spread of *Wheat streak mosaic virus* by the Wheat curl mite in WA during 2009

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KEY MESSAGES

- *Wheat streak mosaic virus* (WSMV) is spread by the wheat curl mite (WCM), a tiny, wingless airborne mite, which cannot be controlled by insecticide.
- Mortality of volunteer cereal and grass plants, especially resulting from pre-seeding knockdown herbicide, triggers mass dispersal of WCM onto germinating crops within or bordering virus source paddocks. Mass dispersal is also triggered by rapid WCM build-up at temperatures above 25°C.
- WCM and WSMV were present in 7 of 18 paddocks found to contain volunteer cereals during May-June 2009 in the central and southern agricultural areas.
- No spread of WSMV was detected to emerging wheat crops bordering two separate paddocks containing WCM and WSMV within advanced self-sown wheat that were grazed heavily by sheep.
- No spread of WSMV was detected in a sown wheat crop that adjoined a field of advanced self sown wheat plants containing high levels of WCM and WSMV. The self sown infected wheat was left undisturbed throughout the growing season.
- These studies on commercial scale properties help to explain why there have been relatively few outbreaks of WSMV in Western Australia since its introduction into the State in 2005.

AIMS

To investigate high risk situations for potential WSMV outbreaks in commercial paddocks in the Western Australian grainbelt where volunteer cereals hosted both WCM and WSMV prior to time of sowing.

BACKGROUND

WSMV transmission in wheat requires living cereal or grass host plants, the presence of WSMV in the host plants (either from previous WCM transmission or seed borne sources), and the presence of WCM to vector the virus. Even then, the mites must disperse aerially from the infected host to infest another crop.

The aerial dispersal of WCM from a host plant is dependent on:

- ✓ mite population levels (i.e. overcrowding of mites triggers dispersal)
- ✓ host plant condition (i.e. dying and severely stressed host plants, e.g. natural senescence or death of plants with herbicide use, triggers dispersal)
- ✓ environmental factors such as temperature and wind speed.

The presence of advanced volunteer cereals prior to and during cereal seeding and crop emergence (April, May and June) is the ideal situation for WSMV carryover onto germinating crops. The presence of advanced volunteer cereals in paddocks prior to autumn sowing is dependent on summer/autumn rainfall allowing for germination and sustainability of self-sown plants. An increase in WCM populations on these volunteer plants is encouraged by warm weather as their optimal temperature range is 24–27°C.

The possibility of a WSMV outbreak occurring assumes that early sown wheat crops in the presence of advanced volunteer cereals would provide a high level of risk. The virus is most damaging to seedling crops where it is introduced to young plants within the first 10 weeks of growth. Current recommendations are that the volunteer crop should be destroyed by herbicide or heavy grazing at least two weeks prior to sowing crops, as WCM can survive 4–6 days without a green host.

This paper reports on situations where the above risk was present yet no outbreak of WSMV occurred.

METHODS AND RESULTS

Volunteer cereal survey (May-June 2009)

A survey of the central and southern areas of the WA grainbelt was undertaken from May to June 2009. Some of these regional areas experienced late summer/early autumn rainfall and were suspected to harbour advanced self sown cereals at the head formation growth stage. Widespread rains occurred around 22 May which created the main 'break of season' event.

Regional roads were used to transect the study region and areas with green vegetation were inspected. Eighteen random properties were found to contain volunteer cereal plants. The abundance of green roadside weeds in some areas was suggestive of likely areas for volunteer cereal however only barren paddocks were found. This indicates previous spraying with herbicides or paddocks heavily grazed with stock. The paddocks found with advanced cereal plants were all in head (flowering to dough development stage), which is the growth stage that WCM are most detectable.

The main factor contributing to the presence of volunteer cereals was summer and autumn rainfall. In the areas found to contain advanced volunteer cereals, the rainfall data indicates sufficient soil moisture to sustain the plants over summer and through to May-June (Table 1).

Table 1 Summer/autumn rainfall data (mm) in the central and southern agricultural regions of WA containing WCM/WSMV infested volunteer cereals. Source: Bureau of Meteorology sites closest to cereal volunteer paddocks

Rainfall (mm)	Nov. 2008	Dec. 2008	Jan. 2009	Feb. 2009	Mar. 2009	Apr. 2009	Nov.- Jan.	Feb.- Apr.	Total
Cunderdin	21	2	21	3	23	23	45	49	93
Brookton	22	4	61	9	18	6	87	33	120
Corrigin	16	19	37	4	39	1	71	43	114
Ongerup	66	32	16	13	34	11	114	58	172
Munglinup	66	33	43	10	38	21	142	69	211
Esperance	58	23	102	8	12	50	183	70	253

The presence of WSMV in paddocks was tested for by enzyme-linked immunosorbent assay (ELISA) using 50 leaf tip samples of wheat, barley and grasses (separately) collected at random up to 100 m into the paddock and WSMV-specific antiserum. Thirty random cereal or grass heads per site were taken to assess for the presence of WCM. The number of WCM per wheat or grass head was identified by placing 20 of these heads onto sticky contact material. As the wheat heads dried out, the mites crawled onto the sticky contact which was inspected under a stereo microscope. Voucher specimens were extracted from the remaining 10 heads and slide mounted for species identification.

Of the 18 volunteer cereal sites chosen, seven properties contained paddocks (5 wheat; 2 barley) with WCM and WSMV, while four others contained paddocks with WCM without WSMV. No mites or virus were detected on the other seven properties sampled (Figure 1).

More paddocks are assumed to have contained advanced volunteer cereals during May-June given that many areas were not investigated during the survey, some of which would have received similar rainfall. It is also assumed, given the number of WSMV and WCM source paddocks found, that some of those volunteer cereal sites would also have had the same potential for WSMV infection.

Of the seven paddocks containing WCM and WSMV, three properties in the central agricultural area were chosen and followed throughout the growing season to monitor transfer of WSMV by WCM onto cereal crops sown either into, or adjoining, the source paddock. These paddocks were near Cunderdin, Brookton and Meckering and are the topic of the following report. Plants were sampled for WSMV and WCM as described above, but with 2–4 sampling sites per paddock, chosen according to highest risk of transfer onto bordering wheat crops.

One biotype of WCM has been shown to not vector WSMV in Australia (Schiffer et al. 2009). The Meckering population of WCM was screened by the Centre for Environmental Stress and Adaptation Research (CESAR) and shown to be a WSMV-vectoring biotype. The other sites containing WCM with WSMV are assumed to be able to vector the virus given the presence of the mite/virus complex.

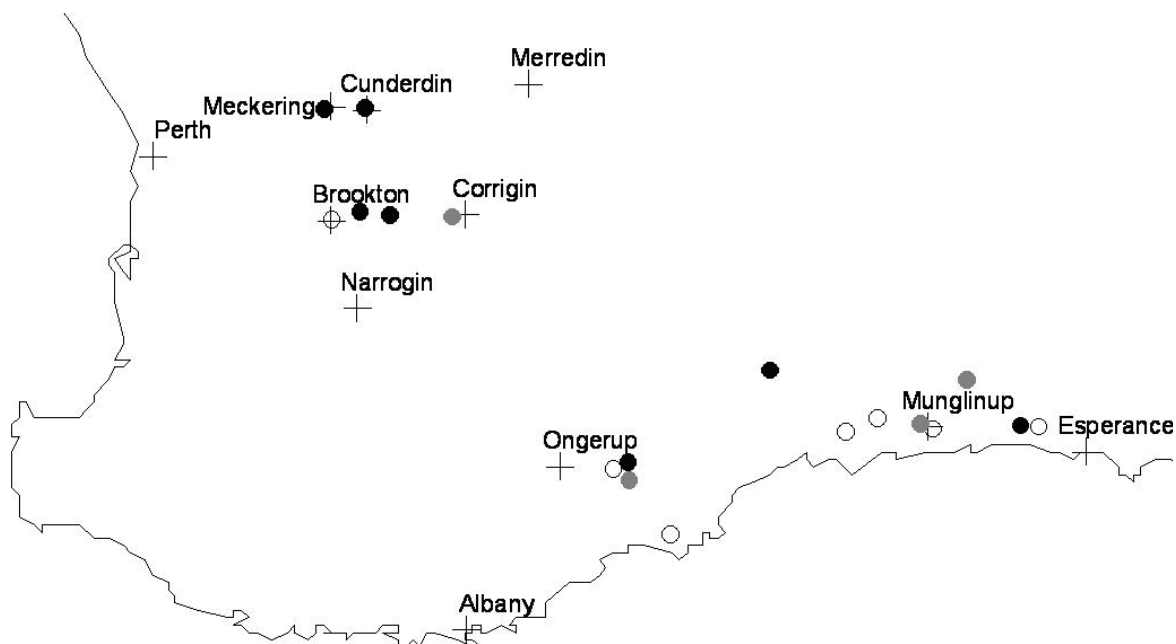


Figure 1 Paddocks of volunteer cereals found in the central and southern agricultural regions during May-June 2009 displaying no detections of WCM or WSMV (○), WCM present with no WSMV detected (●) and WCM present on WSMV-infected cereal plants (●+) (+ indicates town site).

Cunderdin Site

Volunteer wheat and grasses were sampled from a paddock (approx. 45 ha) near Cunderdin on 11 June 2009. The wheat growth stage then ranged from early head emergence to milk development and volunteer wheat was scattered throughout the paddock at 0–20 wheat heads/tillers per m² with most areas having 0–5 heads per m². Ryegrass and barley grass, which are hosts for WSMV and WCM, were present throughout the paddock covering 40–80 per cent of ground area.

WSMV was detected (2 per cent incidence) in a sample of 50 wheat leaf tips collected at random up to 100 m into the paddock from the NE corner. Low numbers of WCM (4) were also found on 20 random wheat heads collected from this area. WSMV and WCM were not detected in the ryegrass or barley grass.

Sheep were introduced into the paddock the following week. At one and three months after this introduction (14 July and 15 September), no remaining, reshooting or other self-sown wheat was found in the paddock, indicating that intensive grazing by the sheep eliminated the previous wheat volunteers. Ryegrass and barley grass persisted through the 3-month grazing period.

WSMV and WCM were undetected in grass samples taken at 11 June, 14 July and 15 September. WSMV and WCM were also undetected at 15 September on bordering roadside wild oats and wheat volunteers, and wheat and ryegrass samples from a wheat paddock 500 m north of the infected paddock.

Brookton Site

Volunteer wheat and grasses were sampled from a paddock (approx. 40 ha) near Brookton on 18 May 2009. At this time, WSMV incidence was > 13 per cent of wheat plants and contained over 100 WCM per head. The wheat volunteers ranged from late flowering to soft dough growth stage and were scattered throughout the paddock at 0–30 wheat heads/tillers per m² with most areas having 1–4 heads per m². Annual ryegrass, barley grass, capeweed and subclover were also present in the paddock covering 50–95 per cent of ground area.

The paddock was sampled again on 9 June. WSMV was detected in > 11 per cent of leaf tip samples taken from 4 paddock sites of volunteer wheat (north, central-west, south-west and south-east areas of the paddock). WSMV was not detected in annual ryegrass and barley grass samples. Over 100 WCM were found on each of 20 random soft dough stage wheat heads at each paddock site. Approx. 10–100 WCM were found within each ryegrass and barley grass head in these areas.

Sheep were introduced to the infected paddock about 12 days after the initial sampling. Newly sown wheat crops were also planted during this time on both sides of the infected source paddock and to the east (across a creek).

Grazing continued on the paddock and on 7 October, no volunteer wheat and very little ryegrass and barley grass plants were present in the paddock as capeweed and subclover dominated the plant composition.

WSMV and WCM were not detected in any samples taken on the 7 October including from barley grass or ryegrass in the source paddock or the adjoining wheat crops which were at the flowering to early grain fill growth stage.

Meckering Site

Volunteer wheat and grasses were sampled from a paddock (approx. 25 ha) near Meckering on 11 June 2009. The wheat growth stage ranged from flowering to soft dough and volunteers were scattered throughout the paddock at 0–40 wheat heads/tillers per m² with many one-hectare sized patches having 20–40 per m². Apart from volunteer wheat, 60–100 per cent of the ground surface was covered with annual ryegrass, barley grass, wild oats, wild radish, Patterson's curse and capeweed. WSMV was detected in 2 per cent of advanced wheat volunteers sampled 100 m into the paddock from the SE corner. WCM were found within a 20 head sample of soft dough stage wheat heads varying from nil on 12 heads, to over 100 WCM on each of 3 heads and a total of 81 on 5 heads. This indicates that the presence of WCM within a small area can be sporadic and dispersal may be limited even between nearby plants.

The infected source paddock was surrounded by crops sown in late June. A barley crop was sown to the east, a wheat crop bordering the NW fenceline and a wheat crop across a road to the south.

All adjoining sown crops were sampled for WSMV presence on 14 July, 12 August and 15 September. Although WSMV continued to be detected in wheat plants in all four corners of the source paddock at incidences of 4–13 per cent, no transmission was found in the bordering crops at these times.

WCM continued to be found within advanced wheat volunteers within the source paddock on 14 July, 12 August and 15 September. However, WCM were not sampled in the bordering crops because WSMV was not detected and WCM are very difficult to find in the vegetative parts of cereal plants when in low numbers.

Bordering wheat and barley crops were sampled for the presence of WCM at the soft dough growth stage (22 October) when they are most detectable. WSMV transmission was not tested at the October sampling period as no green leaf material was present. The barley crop to the east of the source paddock had 10 WCM on 6 of 20 heads collected. Seven WCM were found on 3 of 20 heads in the wheat crop to the north-west. Fifty four WCM were found on 10 of 20 heads from the wheat crop across the road to the south. Most cereal heads sampled had no WCM detected, and most of the heads infested with WCM had only one mite per head. The low levels found suggest that a late dispersal of WCM resulted from the source paddock (or elsewhere) to the surrounding crops. The higher numbers of mites found within some wheat heads are likely to have resulted from an increase in population parthenogenetically (non sexual reproduction) from the earlier arrival of a single mite.

CONCLUSION

The survey for paddocks containing volunteer cereals and case study of three WSMV-infected sites helps to explain, to some extent, why there have been relatively few outbreaks of WSMV since it was first detected in Western Australia in 2005. Major factors that contributed to low occurrence of WSMV has been the limitation of volunteer cereal 'source' paddocks resulting from unsustainable summer rainfall or farmer management of volunteer cereals by use of herbicide, animal grazing or tillage.

Eighteen properties throughout the surveyed areas were found to contain advanced volunteer cereals and were chosen for inspection during May-June 2009. Although relatively few volunteer cereal paddocks were found, 7 out of 18 (39 per cent) of the paddocks investigated revealed the presence of WSMV and its mite vector. This is significant as it showed a potential risk for a WSMV outbreak where the 'green bridge' was left uncontrolled. Four out of 18 (22 per cent) of the properties revealed the presence of WCM on cereals not infected with WSMV, which would have been of no consequence given the lack of virus inoculum.

Surrounding areas had no self sown cereals present indicating that any self sown plants had been controlled either by natural death (i.e. lack of rainfall) or by herbicide application and or grazing.

Monitoring of the Cunderdin and Brookton paddocks along with bordering crops showed that grazing to control volunteer cereals and grasses containing WCM and WSMV was effective at minimising the spread of WSMV onto bordering cereal crops via its mite vector. Importantly, the previous recommendation of a two week interval between destroying a 'green bridge' and sowing the crop was not required. The mites did not disperse from volunteer wheat crops as they, along with the infected plant material, were consumed by sheep.

The study at Meckering (along with previous trials) has shown that WCM have very limited dispersal when the green host plants on which they are living are left undisturbed and survive. This contrasts with the death of plants by natural senescence or as a result of herbicide use which is well known to cause a mass dispersal of WCM in response to their host plants dying. Although WSMV transmission was not detected in bordering crops and a late dispersal of WCM from the Meckering paddock occurred, the current recommendation of controlling the volunteer cereals in advance of sowing is to be encouraged given the capacity of advanced volunteers to senesce naturally and trigger a dispersal of WCM.

REFERENCES

Schiffer M, Umina P, Carew M, Hoffmann A, Rodoni B & Miller A 2009, The distribution of wheat curl mite (*Aceria tosichella*) lineages in Australia and their potential to transmit wheat streak mosaic virus. *Annals of Applied Biology*, **155**: 3, 371–379.

KEY WORDS

wheat curl mite, *Aceria tosichella*, Wheat streak mosaic virus, WSMV

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Viable solutions for barley powdery mildew

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KEY MESSAGES

- Barley powdery mildew caused by the obligate biotroph *Blumeria (Erysiphe) graminis hordei* (Bgh) is estimated to be the most important disease of barley in Western Australia resulting in ca. \$33m in losses (Murray and Brennan, 2010). At present the strategies for management include the use of resistant cultivars and the application of fungicides.
- Bgh exists in numerous races each of which has a specific set of avirulence (*Avr*) genes. Knowledge of the frequency of *Avr* genes in the population can be used to decide which major resistance (*R*) genes should be deployed to control the disease. But as Bgh is notorious for mutating to confer resistance, new methodologies are needed to exploit this information.
- Recessive alleles on the barley *Mlo* gene (*mlo*) confer resistance to almost all known isolates of Bgh. The resistance mediated by *mlo* is independent to that conferred by the *R* genes. Since the 1970s *mlo* resistance alleles have been used extensively in cultivar development (Tacconi et al. 2006). The durability of *mlo* provides an advantage over the often short-lived resistance conditioned by *R* genes. Currently *mlo* continues to provide long-lasting protection against colonisation by all known Bgh pathotypes.
- Fungicides have been used to control Bgh in the absence of *mlo* and effective *R* genes. Bgh is deemed to be of high inherent risk of developing fungicide resistance (Brent and Holloman, 1998). Hence, close monitoring of fungicide effectiveness is central in the management of barley powdery mildew. Surveying field isolates can detect early stages of fungicide resistance before it becomes severe enough to cause practical problems. Several different chemical classes of fungicides are examined for their *in vivo* control of Bgh. Triazoles continue to be effective although we have preliminary indications of reduced efficacy of these and other fungicides.

AIMS

- Perform a pathotype survey to determine which *R* genes could be utilised in the control of WA's Bgh population.
- Develop a robust and high throughput method to screen large numbers of Bgh isolates for putative fungicide resistance—the sentinel test.
- Establish fungicide resistance benchmarks and survey levels of fungicide sensitivity within WA's Bgh population.

METHODS

Isolate collection

The 64 isolates of Bgh used in these studies were collected from barley crops in southern WA. All isolates were purified as single spore isolates on untreated leaf segments (barley cv. Baudin) on water agar containing benzimidazole. Isolates were subcultured at 10 day intervals.

Pathotype survey

Each Bgh isolate was used to inoculate 25 near isogenic barley Pallas lines, with each line carrying either one or two *R* genes at the *Mla* locus. Current WA cultivars Barque and Dash were also included with Baudin, a highly susceptible cultivar used as a positive control. The cultures were incubated and each isolate and line combination was given a disease score according to the level of pustule development at 7 days, with 1 representing complete resistance and 5 complete susceptibility. Lines consistently scoring 3 and above were considered to be defeated.

Fungicide resistance tests

The Sentinel Test

Barley seeds (cv. Baudin) were soaked in calibrated concentrations of fungicides (Azoxystrobin and Fluquinconazole). The seeds were sown at two locations in southern WA into crops with Bgh infections. The number of pustules on plants from both untreated and fungicide treated seeds were counted three weeks after sowing. Isolates from both sets of plants were collected and cultured as above pending *in vivo* testing.

Fungicide Resistance Benchmarks

Three Bgh isolates were randomly selected to infect segments of untreated leaf tissue (cv. Baudin) before being transferred onto benzimidazole agar plates amended with one of seven fungicides. The cultures were incubated and the mean pustule development after 7 days was obtained for each isolate and fungicide combination. The data from three replicates was used to determine the minimum inhibitory concentration (MIC) for each fungicide so that a resistant phenotype could be easily recognised. Fifty-four Bgh isolates were tested at the fungicides' MIC and the scale described previously was used to score the mean pustule development at 7 days post infection. Ratios between the mean pustule development of an isolate on the fungicide plates to that of the control were calculated and used to identify isolates showing fungicide resistance.

RESULTS

Pathotype Survey

We have surveyed 64 Bgh isolates collected from 11 sites in southern WA and so far our results show virulence diversity among the isolates indicating the existence of different Bgh pathotypes in WA (Table 1). The results showed that *mlo* continues to provide a source of resistance along with several other dominant genes. The WA cultivar Barque consistently scored moderately susceptible to susceptible, while Dash was moderately resistant.

Table 1 Differential responses of Pallas lines to powdery mildew isolates

Line description	Albany	South Perth	Katanning	Gairdner	Mount Barker	Broomehill	Medina	Esperence
PALLAS Isoline P2 (Ma3)	2	3	3	3	3	2	3	3
PALLAS Isoline P6 (Ma7+MLG2)	2	3	3	2	2	4	3	4
PALLAS Isoline P10 (Ma12)	1	2	3	3	2	1	2	5
PALLAS Isoline P11 (Ma13+r1Ru3)	2	2	2	2	1	1	1	3
PALLAS Isoline P13 (M1402)	3	4	3	3	2	3	3	4
PALLAS Isoline P14 (M41/145)	1	2	1	3	4/3	1	4/3	1
PALLAS Isoline P15 (MR12)	5	4	3	4	4	3	5	4
PALLAS Isoline P17 (Mk)	4	5	4	5	5	5	2	5
PALLAS Isoline P18 (Mnn)	1	4	1	5	3	3	5	4
PALLAS Isoline P22 (m1c5)	1	3	1	1	1	1	1	2
PALLAS Isoline P23 (MLa)	2	5	2	5	4	5	3	5
Baudin	5	5	5	5	5	5	5	5
Barque	3	3	4	3	2	5	4	4
Dash	2	3	1	2	1	2	2	2

Fungicide resistance

Mutations conferring fungicide resistance occur randomly and at a low rate. Therefore screening an appropriate number of isolates to detect resistance is a large task. Through means of the sentinel test, a total of 9088 pustules were counted on the control plants, denoting the effective number of spores screened. The azoxystrobin treated seeds had 3308 and the fluquinconazole 995, providing candidate isolates for fungicide resistance assessment. Isolates from these collections are being tested as we write.

The MIC was estimated for seven fungicides (Table 2) based on the observations from three isolates. Of the triazoles, triadimefon had the lowest MIC of 1 mg/L and the value for epoxiconazole was also very low at 5 mg/L. Tebuconazole, azoxystrobin and thiabendazole all had MIC's of 15 mg/L followed by prochloraz which only took affect at 100 mg/L. Chlorothalonil was omitted from further testing because of its very high MIC. When screened on the calibrated fungicide MIC's, several isolates showed decreased responsiveness to the fungicides. Currently one isolate has putative resistance to azoxystrobin, another to prochloraz and five more isolates showed low sensitivity to the triazoles tebuconazole, triadimefon and epoxiconazole. Further testing into the level of fungicide resistance of these isolates is being undertaken as we write.

Table 2 **Chemical class and the minimum inhibitory concentration (MIC) of fungicides used**

Fungicide name	Chemical class	MIC (mg/L)
Epoxiconazole	Triazole	5
Triadimefon	Triazole	1
Thiabendazole	Benzimidazole	15
Chlorothalonil	Chloronitrile	> 500
Tebuconazole	Triazole	15
Prochloraz	Imidazole	100
Azoxystrobin	Strobilurin	15

CONCLUSION

Powdery mildew is a widespread disease on Western Australian barley crops. It has been demonstrated that *mlo* remains fully effective against all Bgh isolates surveyed. It would therefore seem useful for all barley cultivars to carry *mlo*; however breeders resist its incorporation into cultivars as it is linked to yield penalties. A second means of protecting against Bgh colonisation is to include one or more undefeated *R* genes. This strategy requires extensive and continual field surveys of Bgh *Avr* genes in order to deploy cultivars with appropriate *R* genes. A new strategy based on minor gene resistances may therefore be the most promising route (Yu et al. 2001).

As the trend for more frequent fungicide application continues, the evolutionary potential of the pathogen population increases, where those individuals with reduced sensitivity to the fungicide may have an advantage. It was found in this experiment that the Western Australian Bgh population was on the whole highly responsive to the triazole, strobilurin and benzimidazole classes of fungicides but 7 isolates displayed reduced sensitivity. The application rate of prochloraz and chlorothalonil would possibly be considered too high for practical purposes.

For the effective protection of barley from powdery mildew disease, an integrated approach including the use of resistant cultivars and fungicide application is required. Constant monitoring of the changes in the population is essential for ensuring longevity of control.

KEY WORDS

Blumeria graminis hordei, fungicide resistance, genetic resistance

REFERENCES

- Brent KJ & Hollomon, DW 1998, Fungicide resistance: The assessment of risk. In: Fungicide Resistance Action Committee Monograph No. 2. Crop Life International, Brussels, Belgium.
- Murray GM & Brennan JP 2010, Estimating disease losses to the Australian barley industry. *Australasian Plant Pathology* **39**: 85–96.
- Tacconi G, Baldassarre V, Collins NC, Bulgarelli D, Stanca AM & Vale G 2006, Haplotype characterisation and markers at the barley *Mlo* powdery mildew resistance locus as tool for marker-assisted selection. *Genome* **49**: 864–872.
- Yu DZ, Yang XJ, Yang LJ, Jeger MJ & Brown JKM 2001, Assessment of partial resistance to powdery mildew in Chinese wheat varieties. *Plant Breeding* **120**: 279–284.

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The importance of varietal accreditation in a post-deregulation barley marketing environment

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INTRODUCTION

The deregulation of the barley market has brought about some profound changes to the way in which barley is bought and sold in Australia. This has affected all players through the grain supply chain including growers, bulk handlers, traders, domestic end users and exporters.

Prior to deregulation, growers were faced with one bulk handling company, one buyer, and usually a choice of cash or pool when selling their crop. There are now many buyers from which to choose, each offering a range of selling options, and growers can select the one which they believe suits them best, or will offer them the best opportunity to maximise their returns. In addition, they have the option of retaining grain on farm, or storing their grain in one of the major bulk handling company facilities and can sell it at either location or warehouse it and sell it later at a time of their choosing.

Buyers must now ensure that their prices and selling options are attractive to growers, and that they offer flexibility, transparency and payment security. They must also offer prices which enable them to accumulate the barley varieties most in demand by the market, or those which satisfy the quality requirements of specific markets they are supplying. When the supply and demand balance alters for any particular variety in any one season, this is now reflected in the prices being offered for that variety. Varietal based prices may also be different for different barley producing areas.

Breeders must also produce varieties which satisfy the malting and brewing quality requirements of buyers as well as the grower requirements for high yielding drought tolerant and disease resistant varieties which satisfy protein screenings and test weight requirements to enable classification into malting grades. There are now a range of new varieties available to growers, each suited to different growing regions, each with its own disease resistance profile, and each with varying degrees of suitability to specific end uses. There are now 12 malting barleys on the Barley Australia preferred list.

EFFECTS ON PRICING

The deregulated market has significantly affected the way in which marketers offer prices for malting barley, and highlights the importance of barley quality. These prices are offered by many different marketers or direct end users, and are now expressed on a variety-by-variety basis as a premium over feed.

Currently, there is a strong trend to pricing barley through cash rather than pools, however straight malting forward cash prices are relatively rare on a long-range basis due to the uncertainty of quality achievable by the grower until harvest.

As a result, the multigrade contract has become popular although the malting price is almost always discounted in this sort of contract as the buyer of the barley needs to mitigate their risk of contracting malting barley and procuring feed barley at harvest time.

Growers are now exposed to a suite of malting barley cash prices in any one region in any season.

The prices on offer reflect the fluid state of the global barley market (as shown in Figure 1) and this fluidity is directly affected by:

- global supply and demand of all grains
- underlying supply and demand for feed barley (influenced significantly by Saudi Arabian demand and Black Sea supply)
- malting barley quality and impact from competitor supplies.

Figure 1 Real example of cash price change in 18 months from one marketer

Port Adelaide	Flagship 1	Baudin 1	Sloop 1	Feed 1
March 2008	380.00	380.00	380.00	315.00
October 2009	170.00	165.00	140.00	130.00

* All prices quoted net of GST and standard receival fee.

There are still pools available around Australia, and many grain acquirers offer a feed pool and a malting pool (while perhaps, but not necessarily, paying small premiums for one malting variety over another on entry into the pool). However, different marketers' pools will be structured differently in terms of payment schedule, and the proportion schedule of pool returns paid to pool participants over the life of the pool.

There is no true benchmark price for 'malting barley' per se in the new environment. The price of any particular variety of malting barley will depend on the individual acquirer of the grain, their customer base (or trading position in the market if they are not a direct marketer of barley to an end user) and how much of any variety they are willing to buy.

The differential of a malting barley price over a feed barley price will vary greatly between seasons, and even during the course of a growing season. The differential of a price of a new variety over an established variety will reflect the market demand for that variety in the market.

Australian malting barley varieties are now competing for market share in the export malting barley market *with each other*, as well as generically. Australian malting barley is also competing with Canadian, EU, Black Sea and Chinese malting barley. Because of this, the industry must ensure that our barley quality is competitive or even superior to that being offered by these other suppliers.

THE ROLE OF BARLEY AUSTRALIA

In a deregulated market, it is important that the industry is provided with a suitable mechanism for adapting the demands of the market to the requirements of both end users and barley growers. The two sets of requirements can best be brought together through management of barley breeding and accreditation programs to produce varieties acceptable to both parties, and which take into account the pricing signals provided by the marketplace.

Barley Australia was established to forge stronger linkages across all industry sectors to drive plant breeding goals and industry strategy, to develop new varieties more suitable to both farmer and end user needs, to more effectively utilise national resources and technology, and to enhance the superior quality reputation of Australian barley through varietal accreditation, trade marking and whole of supply chain quality assurance programmes. By achieving these objectives, Barley Australia is able to enhance the free market system.

Varietal accreditation is a key mechanism for constantly improving barley quality, as new varieties will only be considered if they are of better quality (agronomic and/or malting) than the varieties they replace. By providing this continuous improvement system, the full benefits of deregulation can be realised both by growers and by marketers and traders.

Similar accreditation systems also exist in competitor countries, so it is important that we maintain and improve our efforts to improve barley quality in the future. Only then can our reputation as a supplier of quality barley be maintained in future seasons.

THE FUTURE

Deregulation will continue to drive innovation and change in the barley industry. This will be observed through:

- continued trends to cash pricing
- greater choice of buyers/traders
- a wide range of contract types from which to choose
- more varieties of superior yield with better malting and brewing quality

- direct pricing signals more rapidly transmitted to growers regarding which varieties are in demand in the marketplace and at what time
- more efficient supply chain from producer to consumer
- greater flexibility offered in delivery options to central storage locations or to domestic end users.
- continued expansion of on farm storage
- rapid development of marketing expertise by growers.

The future also presents a number of challenges, among them price volatility due to events beyond our control, rising input costs for producers such as fuel and fertiliser, rapidly changing market demands, the lack of a rapid test to accurately identify specific varieties on delivery, fragmentation of stored product pest control programs, and global climate change and associated droughts to name a few. However, a coordinated industry approach to such problems involving all barley marketers will secure the success of the industry, indeed this is essential in the new deregulated market operating paradigm.

Can Australian wheat meet requirements for a new middle eastern market?

Robert Loughman, Larisa Cato, Department of Agriculture and Food, Western Australia and **Ken Quail**, BRI Australia

KEY MESSAGES

A decision by Saudi Arabia to phase out wheat production and instead rely on imported wheat has opened up new market opportunities for Australian wheat. The policy is being implemented rapidly and in 2009 wheat imports were 1.9 Mt of an estimated 2.5 Mt consumption.

Bread is an important traditional food in Saudi Arabia and wheat flour is subsidised as a staple food ingredient. Saudi's baking sector has become accustomed to domestic wheat production and low cost but consistently high protein flour with very strong stable dough characteristics suitable for a range of bread types.

Australian Premium White is already very suited to producing flat breads, the major segment of the Saudi industry. It may also be suitable for other products or in blended flour, subject to flour milling infrastructure.

However, wheat import requirements for Saudi Arabia have specified 12.5 per cent protein wheat (at 11 per cent moisture) to match Saudi production. This is generally above that available through major Australian export grades such as APW.

Australia's international reputation as a major and reliable supplier of large-grained, clean, white wheat with good milling characteristics and predictable processing properties will assist the Australian industry meet the requirements of this new market. However suitable price and quality factors, as well as milling and processing experience with Australian wheat, will ultimately be required to establish a regular and large volume market with Saudi Arabia.

As Australian wheat will often be measured against versatile higher protein wheat available in the international market, achieving excellent processing properties with our varieties at our protein levels becomes an industry priority for ongoing competitiveness.

AIMS

The aim of this study was to understand the general quality properties of current wheat and wheat flour use in Saudi Arabia, to identify the range and production emphasis of wheat end products in Saudi Arabia and to determine how the potential for wheat trade may be built on through further interaction / exchange.

METHOD

To understand wheat use in Saudi Arabia a delegation representing the Department of Agriculture and Food visited flour mills, bakers, manufacturers and retail outlets in Saudi Arabia in July 2009. To better understand wheat quality requirements a two stage testing program to compare Saudi and Australian flour is being undertaken. Commercial flour samples collected in Saudi Arabia were compared with Western Australian commercial flour samples in standard baking tests in a preliminary comparison of end product performance. After promising results a more detailed comparison is being undertaken using wheat samples imported under quarantine and milled under standard milling conditions for direct comparison to a range of Australian wheat quality grades from Western and Eastern Australia.

A delegation from Saudi Arabia has been invited to Western Australia to determine how the potential for wheat trade may be built on through further understanding / exchange to help establish a new export market for Australian wheat with enhanced food security and market diversity for Saudi Arabia.

RESULTS

Market visit

Until recently Saudi Arabia produced between two and three million tonnes of wheat per year under irrigation—with yields ranging from 5–8 tonnes per hectare.

Dominated by one major wheat variety with excellent bread baking quality and grown under high fertility, Saudi's baking sectors have become accustomed to consistently high protein flour with strong stable dough characteristics suitable for a range of bread types. A large range of bread styles are produced.

Three major baking sectors were identified. Traditional bakers, operating in numerous shop-front bakeries, consume the majority of Saudi's flour production. A range of flat bread styles are manufactured in either bench hearths or pizza style ovens. This type of baking is done continuously with convenience and freshness the main requirements. Customers typically receive breads directly from the oven, to be taken home and eaten either warm or very fresh.

A growing sector in the Saudi baking industry is the small to medium semi-automated bakeries typically operating within large or specialty supermarkets. These bakeries produce a large range of flat breads, buns, bread sticks and sliced loaves as well as other baked products such as croissant. The key emphasis in this sector is product variety and freshness.

Larger mechanised bakeries are operating in major centres supported by effective distribution networks. The availability of low cost energy, flour and immigrant labour has enabled large well run factories with high operating standards to supply both local and export markets with a range of fresh sliced breads, buns and cakes, sweet biscuits, long life cake, snack and convenience foods. The sector is characterised by modern, mechanised, efficient and quality controlled production systems.

Overall, 60–70 per cent of flour is used in traditional flat breads, 20–25 per cent of flour is used in western style breads and 5–10 per cent is used in cakes and biscuits.

Preliminary analysis of Saudi flour quality

Two commercial flour samples milled from Saudi Arabian wheat had long dough development times and produced strong dough with very good stability. A third commercially milled flour sample was wheat imported into Saudi Arabia which also produced strong dough with very good stability and was comparable in quality to Saudi grown wheat flour. Saudi flour was generally higher protein than two WA flour samples. The development time, strength and stability of these doughs from Saudi flour samples were generally higher than doughs produced with two Western Australian commercial flours, indicating a different balance of properties.

The three flour samples obtained in Saudi Arabia and two commercial flours from Western Australia were used in standard tests for flat bread and rapid dough baking. All samples produced flat breads with even golden brown colour without blisters. Flat bread from Western Australian flour performed well and compared favourably for folding/rolling evaluation, softness and also tearing / chewing scores. In rapid dough baking all flours produced good, even golden brown crust colour. Oven spring score (height after baking and smoothness / evenness of the loaf sides) was greater for Saudi Arabian samples. Two of the three flour samples obtained in Saudi Arabia had the highest loaf volumes while the third sample was at or below the loaf volumes achieved with two commercial WA flour samples. The preliminary conclusion from this work suggested Saudi processors would be able to produce good quality flat breads with WA wheat which could also be satisfactory for use either blended or unblended in rapid dough baking. The different balance of properties may require bakers to adjust some of their processes, for example to compensate for lower protein content.

Three wheat samples have now been imported from Saudi Arabia under quarantine for more direct comparisons under standardised milling and baking tests. These are being compared to six samples of APW, AH or APH wheat from either Western Australia, South Australia, Victoria, or New South Wales.

CONCLUSION

Australia has potential to become a major wheat supplier to Saudi Arabia. Our reputation as a major, reliable exporter of wheat with climatically distinct production environments (e.g. Western and eastern Australia) and proximity to market highlight export potential. Over the past five years, 25 per cent of WA wheat exports were shipped into other Middle East markets.

The Kingdom is now buying wheat on the international market and in 2009 bought 1.87 million tonnes from four markets—Canada, the European Union, the USA and Germany. Despite the potential suitability, Australian wheat has not been purchased by Saudi Arabia to date. Current tenders to supply Saudi are requiring high protein wheat, similar to local production. The current requirement is for a minimum 12.5 per cent grain protein (measured as at 11 per cent moisture equivalent). This places major Australian grades such as Australian Premium White, outside of the specifications required by Saudi wheat importers. Information exchange resulting from this research will improve bilateral understanding so that Saudi import authorities have the technical confidence to specify quality characteristics in wheat tenders that can be met by traders of Western Australian and other Australian wheat grain. A significant and positive sign is that recent tender specifications indicate that Saudi authorities will seek limited shipments of 11.1 per cent protein wheat in 2010 to gain experience with other quality types and examine price dynamics in international markets.

The Saudi market opportunity provides clear signals to the Australian wheat industry for the longer term. International markets like versatile wheats that can be used for a range of products. The Australian industry needs to continue to improve quality for flexible end uses. As our wheat will often be measured against higher protein wheat available in the international market, achieving excellent processing properties at our protein levels becomes an industry priority.

KEY WORDS

wheat quality market intelligence

ACKNOWLEDGMENTS

This services of BRI Australia in understanding Saudi market requirements and for milling wheat samples imported under quarantine protocols is greatly appreciated. The assistance of staff in the Department of Agriculture and Food's Grain Products Laboratory in dough rheology and baking evaluation is greatly appreciated. Western Flour Mills provided flour samples for preliminary quality comparisons. This research would not have been possible without the cooperation and assistance of Australian grain handling companies in providing representative wheat grade samples. This research is supported by the Grains Research and Development Corporation.

Project No.: DAW00192

Paper reviewed by: Janet Paterson

Sowing rate and time for hybrid vs open-pollinated canola

Mohammad Amjad and Mark Seymour, Department of Agriculture and Food, Western Australia

KEY MESSAGES

During 2009, hybrid canola out-yielded the open-pollinated canola by around 18 per cent across five target plant densities and two times of sowing (May and June) both in the medium rainfall zone (MRZ) at Meckering and in the high rainfall zone (HRZ) at Gibson.

AIMS

To investigate the effect of plant density and sowing times on grain yield and oil content of hybrid canola in comparison with open-pollinated canola in medium and high rainfall environments

METHOD

During 2009, open-pollinated (44C79 CL) and hybrid (45Y82 CL) cultivars of canolas (cultivars of Clearfield Imididazolinone tolerant (CL)) were sown at 5 target plant densities and two times of sowing (TOS). Trials were located at Meckering (annual rainfall 350–450 mm) and Gibson (annual rainfall above 450 mm). The trial design was a split plot design, with TOS as main plots and cultivars x seeding rates (plant densities) as sub plots. There were four replicates. The treatments are listed in Table 1. Seeding rates were adjusted to target plant density (plant population) on the basis of seed size of cultivars (45Y82 CL, 6.13 g/1000 seeds and 44C79 CL, 3.47 g/1000 seeds), germination percentage (90 per cent) and the seedling in-field survival rate (80 per cent).

The trial sites were sown into cereal stubbles treated with knockdown herbicide prior to seeding. A basal fertilizer was applied at a rate of 100 kg/ha at Meckering (Agras, 16 kg N/ha, 9 kg P/ha and 14 kg S/ha) and at Gibson (Whitstar, 15 kg N/ha, 14.3 kg P/ha and 10 kg S/ha). Urea was topdressed at a rate of 100 kg/ha (46 kg N/ha) 4 to 6 weeks after sowing at Meckering, whereas Flexi N was applied at a rate of 62 L/ha, 4 to 6 weeks after sowing at Gibson. Intervix at 0.6 L/ha (active constituents: 33 g/L imazamox and 15 g/L imazapyr) was applied to control weeds at 4–6 leaf stage in each time of sowing. Trials were closely monitored for weeds, insects and diseases and were controlled as and when required throughout the growing season.

Table 1 Description of 2009 treatments for trials in the medium rainfall zone (MRZ) at Meckering and in the high rainfall zone (HRZ) at Gibson

Trial treatments	Description	
	Open-pollinated – 44C79 CL	Hybrid – 45Y82 CL
5 target plant densities (plants/m ²)	Seeding rate, (kg/ha)	
21	1	1.8
42	2	3.6
68	4	7.2
126	6	10.6
168	8	14.3
2 Times of sowing	(Meckering)	(Gibson)
TOS1	26 May 2009	19 May 2009
TOS2	17 June 2009	9 June 2009

RESULTS

Crop establishment

Crop germination, emergence, early vigour and growth were visually scored between 6 to 8 (average to good) for both hybrid and open-pollinated canola. Hybrid canola usually established more plants than open-pollinated canola at each target density at both locations (Table 2). Generally more plants established at the later time of sowing than at the earlier time of sowing, particularly at the higher seeding rates and this was the same for both hybrid and open pollinated cultivars.

Table 2 Effect of sowing time and target plant density on plant establishment (plants/m²) of hybrid (45Y82 CL) and open-pollinated canola (44C79 CL)

Location	Meckering				Gibson			
	TOS1 26 May		TOS2 17 June		TOS1 19 May		TOS2 9 June	
	Open-pollinated	Hybrid	Open-pollinated	Hybrid	Open-pollinated	Hybrid	Open-pollinated	Hybrid
21	24	28	31	26	17	19	15	37
42	42	48	62	52	48	43	36	47
84	70	83	89	99	62	82	57	77
126	91	114	132	180	80	108	103	157
168	114	131	139	194	123	141	138	157
Average	68	81	90	110	66	79	70	95

l.s.d. (< 0.05)

Cultivars	8	9
TOS	17	11
Density	12	14
TOS.Cultivars	ns	ns
TOS.Density	21	21
Cultivars.Density	17	ns
Cultivars.Density.TOS	ns	ns
CV	20%	26%

Grain yield

At Meckering the grain yield of open pollinated canola increased when plant density increase from 24 to 42 plants/m² but did not increase beyond that (Figure 1). This is consistent with previous research that shows open pollinated canola typically produces similar yields at plant densities ranging from 40 to 90 plants/m² in Western Australia. In contrast, the yield of hybrid canola continued to increase up to the highest plant density (131 plants/m²). Research studies on the Canadian prairies have shown that established plant densities for *Brassica napus* (consisting of both hybrid and open pollinated canola) ranging from 40 to 200 plants/m² often result in similar yields, with the exception of a small number of cases where densities outside this range (lower or higher) have resulted in highest yield. Hybrid canola established at the lowest density (28 plants/m²) produced similar yield (1.2 t/ha) as achieved by open-pollinated canola at higher plant densities. Both hybrid and open pollinated canola produced similar yield of less than 0.5 t/ha when sown in June, and there was no effect of plant densities ($P > 0.05$).

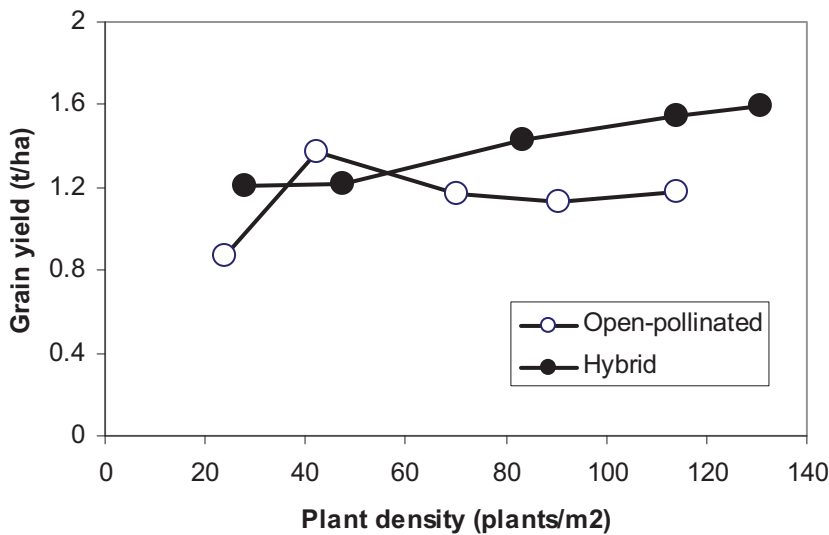


Figure 1 Effect of plant density on yield of hybrid and open-pollinated canola sown in May at Meckering

At Gibson, there was no yield penalty with delayed sowing, but again hybrid canola produced about 18 per cent higher yield ($P > 0.05$) than open pollinated canola. The response of the different cultivars to increasing plant density was also similar to that observed at Meckering. The yield of open pollinated canola increased with increasing plant density up to about 50 plants/m² and then remained flat (Figure 2). Whereas the yield of hybrid canola tended to respond to higher plant densities (above 80 plants/m²). These differences however are not statistically significant using the simple analysis of variance used here and further regression analysis is required.

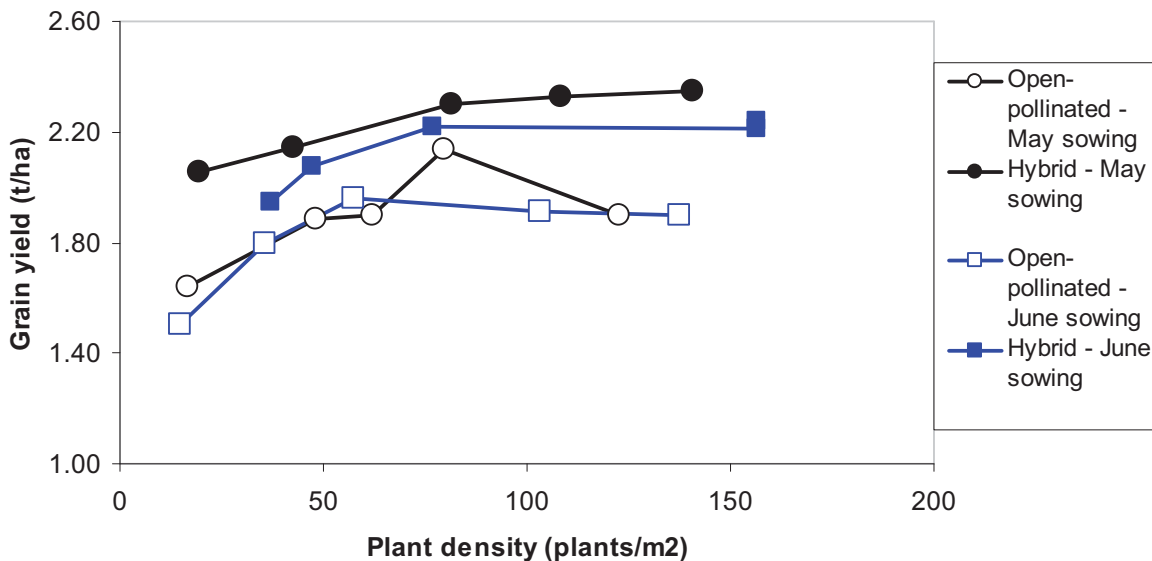


Figure 2 Effect of plant population on yield of hybrid and open-pollinated canola in May and June sowing at Gibson, 2009.

CONCLUSION

Hybrid canola produced similar or higher yields to open pollinated canola in 2009.

In the high rainfall area both open pollinated and hybrid canola responded similarly to changes in sowing times whereas in the medium rainfall area sowing in June had reduced yield for both hybrid and open pollinated.

Hybrid canola sown at low plant densities produced similar yields to open pollinated canola sown at high plant densities; however hybrid canola may produce even higher yields at high plant densities.

KEY WORDS

Brassica napus, herbicide tolerant canola, seeding rate, times of sowing, grain yield, oil content

ACKNOWLEDGMENTS

This research was jointly funded by the Department of Agriculture and Food, Western Australia (DAFWA) and the Grains Research and Development Corporation (GRDC). Thanks to WANTFA committee for approving and endorsing the canola research trial in the medium rainfall zone at Meckering. The research support staffs at Northam and EDRS provided the technical support for managing these trials throughout the growing season. The contributions of the break crop technical staffs Andy Sutherland, Mike Baker, Reg Lunt and Pam Burgess for collecting plant count and flower data are acknowledged.

Project No.: DAW 161

Paper reviewed by: Peter White

HYOLA® National Hybrid vs OP Canola Hybrid F1 vs Retained Seed Generation Trial Results and recommendations for growers

Justin Kudnig, Mark Thompson, Anton Mannes, Michael Uttley, Chris Fletcher, Andrew Etherton, Nick Joyce and Kate Light, Pacific Seeds Australia

TAKE HOME MESSAGE

Canola growers, consultants, agronomists and advisors should now be able to have the confidence that the extensive research conducted throughout Australia on Hybrid F1 versus retained F2 seed shows that the F2 segregates out for all observable and measurable traits to different extents depending the Hybrid parent combination and environmental conditions.

There is considerable reason for concern regarding the variability in the F2 segregates for observed and measured changes in agronomic traits and their negative effects on plant vigour, plant height uniformity, flowering uniformity, blackleg resistance, lodging resistance and their combined effects on reducing yields.

This research shows significant yield losses when retaining a leading Conventional or Clearfield Hybrid variety into the F2 generation and calculated figures of between \$178/ha to \$256/ha are extremely significant losses on the potential returns from a canola crop.

BACKGROUND

Hybrid seed production is where there is cross pollination of two distinctly different pure lines can produce a hybrid (F1 seed) that exhibits a marked improvement in performance over either parent.

Hybrid performance traits such as grain yield, disease resistance, herbicide resistance, relative maturities, lodging resistance, oil content and meal quality are the result of hybrid vigour.

However, seed from the next generation (F2 or retained seed) and subsequent ones is not hybrid and it will not have the heterosis of the original purchased hybrid canola seed and may have lost some useful agronomic and physiological traits.

PREVIOUS FINDINGS

Farmer retained hybrid seed will segregate for different traits depending on how physiologically and agronomically different the parents are and this affects successive progeny or generations by exhibiting:

1. Early flowering to late flowering plants and at windrowing time a mixture of plants flowering, podding and shattering which is a result of the different flowering maturities of the two parents in the hybrid. Other than machinery operational difficulties, seed yields and oil contents could be significantly affected.
2. Mixture and variable levels of taller and shorter plants due to the segregation process. This could lead to difficulties with spraying, windrowing and harvesting operations.
3. Some plants are resistant or tolerant to chemical and some susceptible depending on the specific herbicide tolerance trait. With Clearfield hybrids, due to the dual gene interaction, some of the plants may not be fully tolerant in subsequent generations. Roundup Ready hybrids have the herbicide tolerance usually coming from only one parent so following generations will segregate for the tolerance and some will become susceptible.
4. Some plants remain resistant to adult blackleg canker and some become susceptible. Grain yields could be significantly affected and it would be much more difficult to manage blackleg levels in the crop using seed treatments and crop rotations.
5. Some plants (up to a quarter) are 'male sterile' (no pollen) and some remain fertile. The effect of this on potential grain yield is affected by rainfall events, insect activity, temperatures and relative humidities during the canola flowering cycle.

6. Early hybrid seedling vigour can be lower in some plants from the next generation and it has been observed in retained seed from Clearfield and Conventional hybrids as shown below with marked differences in early plant seedling vigour and growth rates.

Australian research on hybrid purchased seed versus farmer-retained seed from hybrids (Eyre Peninsula and Struan in South Australia) has shown 20 to 30 per cent yield decline on Conventional hybrids.

International research has shown 8 to 15 per cent yield decline, and it has been determined that this decline is due to a combination of factors which vary between hybrids due to the different parents in the hybrid breeding.

TRIAL DETAILS

This research involved leading Hybrids vs OP's varieties from all major companies within 3 herbicide technologies being evaluated in 11 replicated trials 3 states.

The aim was to evaluate Hybrid F1 versus F2 retained seed grown out in plot trials for a range of agronomic traits and the anticipated negative impact on associated grower gross returns.

This research is regarded as novel research for evaluation of such varieties under Australian conditions in the low to medium and medium-high rainfall environments.

- Harvested Mean Trial Yields ranged from 1.93 MT/ha to 3.33 MT/ha
- CNV/CL—F1 vs F2 (8 sites)
- SA sites included Cummins, Clare and Bordertown
- VIC sites included Lake Bolac, Glenorchy and Greenlake
- NSW sites included Walbundrie and Parkes
- Harvested Mean Trial Yields—1.47 MT/ha to 2.08 MT/ha
- CNV—F1 vs F2 vs F3 (3 sites)—NE Victoria

Trial measurements and summary of results

Canola variety	Sowing rate kg/ha	Mean analysed plant pop p/m ²	Actual plant est. %	Mean seedling vigour
HYOLA 571CL	2.0	27	78%	8.0
HYOLA 571CL	4.0	46	62%	8.1
HYOLA 571CL	6.0	66	64%	8.1
CLEARFIELD F2	2.0	24	64%	7.2
CLEARFIELD F2	4.0	41	47%	7.4
CLEARFIELD F2	6.0	59	47%	7.4
HYOLA 50	2.0	24	76%	8.5
HYOLA 50	4.0	45	73%	8.5
HYOLA 50	6.0	60	65%	8.6
CONVENTIONAL F2	2.0	28	72%	7.6
CONVENTIONAL F2	4.0	49	59%	7.8
CONVENTIONAL F2	6.0	57	51%	7.6

Canola variety	Mean 50% flowering days	Flowering uniformity	Visual lodging %	Visual Blackleg	Mean plant height cm
HYOLA 571CL	117	8.3	0	8.6	108
HYOLA 571CL	116	8.2	1	8.4	111
HYOLA 571CL	116	8.3	4	8.4	114
CLEARFIELD F2	120	5.6	6	6.6	102
CLEARFIELD F2	118	5.6	11	6.6	103
CLEARFIELD F2	117	5.4	17	6.4	104
HYOLA 50	119	8.2	2	8.4	113
HYOLA 50	118	8.6	3	8.3	110
HYOLA 50	118	8.3	3	8.4	113
CONV F2	119	6.1	7	7.1	98
CONV F2	118	6.1	10	7.0	103
CONV F2	117	6.6	12	6.9	94

Treatment	Mean	Mean	Mean	Mean	Mean	Mean
Variety * Ht	2 kg	2 kg	4 kg	4 kg	6 kg	6 kg
	Pop/m ²	Yield	Pop/m ²	Yield	Pop/m ²	Yield
Hyola 50	24	2647	45	2719	60	2782
Hyola 50 F2	28	2202	49	2245	57	2202
Hyola 76	25	2533	40	2569	73	2491
AV-Garnet	32	2484	49	2584	82	2655
HYOLA 571CL	27	2169	46	2448	66	2462
Hyola 571CL F2	24	1609	41	1816	59	1822
44C79	34	1881	60	2039	91	2189
46Y78	26	1939	40	2127	61	2207
Lightning TT	30	1720	52	1786	74	1922
CB Tumby HT	32	1841	54	1950	67	2070
ATR-Cobbler	27	1567	49	1765	64	1901

KEY FINDINGS

1. CNV/CL Hybrid F1 compared to retained F2—lower plants/m² at each sowing rate due to seed count/kg but Hybrids 10 to 15 per cent higher plants established.
2. CNV/CL Hybrid F1 exhibited greater visual biomass seedling vigour over retained F2 generations in all sites.
3. CNV/CL Hybrid F1 showed even 50 per cent flowering within 2 days whereas the CNV/CL F2 retained seed had a 10 day variation in plant segregates across all sowing rates.
4. CNV/CL Hybrid F1 showed 99–100 per cent fertility whereas the CNV/CL F2 retained seed had 25 per cent sterility in plant segregates across all sowing rates.
5. CNV/CL Hybrid F1 measured excellent lodging resistance whereas the CNV/CL F2 retained seed exhibited up to 10 per cent stem lodging in plant segregates increasing with sowing rates.

6. CNV/CL Hybrid F1 height measured within 5 cm whereas the CNV/CL F2 retained seed had a measured height variation of 30 cm within the plant segregates and increasing with sowing rates.
7. CNV/CL Hybrid F1 maintained 'R' rating with low blackleg canker levels whereas the CNV/CL F2 retained seed was observed having up to 15 per cent adult stem cankers across all sowing rates.
8. CL Hybrid F1 yielded significantly higher than the CL F2 retained seed at all 8 sites across all sowing rates.
9. CNV Hybrid F1 yielded significantly higher than the CNVF2 retained seed at all 7 of the 8 sites across all sowing rates.
10. CNV Hybrid F1 Mean yield between 10–17 per cent higher and CL Hybrid 17–26 per cent higher than the CNV/CL F2 retained seed respectively across all sowing rates.
11. CNV Hybrid F1 gross returns \$/Ha ranged between \$178–\$232 higher and CL Hybrid \$237–\$256 higher than the CNV/CL F2 retained seed respectively across the different sowing rates.

FUTURE RESEARCH

Future research will involve the evaluation of all 4 herbicide technologies in new and improved Hybrids comparing Hybrid F1 to retained F2 seed from each of the Hybrid F1's across a range of canola growing environments throughout Southern Australia.

Pacific Seeds' objectives are to provide important information for the industry on the effects of retaining hybrid seed into successive generations and the associated negative influence on yield and gross returns in all four herbicide tolerant groups.

CONTACT DETAILS AND FURTHER INFORMATION

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KEY WORDS

hybrid canola, open pollinated canola, retained seed, F1 vs F2, plant populations, yield, oil, plant height, days to 50 per cent flowering, grower recommendations, retained seed financial loss

HYOLA® National Hybrid vs OP Canola Sowing Rate Trial Results and plant population recommendations for Australian growers

Justin Kudnig, Mark Thompson, Anton Mannes, Michael Uttley, Andrew Etherton, Chris Fletcher, Nick Joyce and Kate Light, Pacific Seeds Australia; **Peter Hamblin**, Agritech Research Young, NSW, **Michael Lamond**, Agrisearch, York, Western Australia

TAKE HOME MESSAGE

Canola growers, consultants, agronomists and advisors are now able to utilise the findings from this research conducted throughout Australia on the effect of different sowing rates on yield, oil and gross returns with leading Hybrid and OP canola varieties.

Optimum Hybrid and OP canola plant populations have been established from the research that maximise yield and potential gross returns across a wide range of environments throughout canola growing districts of Australia

Observed and measured changes in agronomic traits due to the effects of the different sowing rates on plant establishment percentages, plant vigour, plant height uniformity, flowering uniformity, blackleg resistance, and lodging resistance can be used in a more practical sense by growers for overall canola crop growth and agronomic management.

This research discovers the optimum populations for both Hybrid and OP canola varieties in a range of herbicide tolerant groups in both the low to medium (1.5 to 2.0 MT/ha) and medium to high (2.0 to 4.0 MT/ha) rainfall zones.

Agronomists, advisers and canola growers around Australia will now have to develop a new mindset around sowing canola based on target populations per m² instead of the traditional kg/ha sowing rates.

BACKGROUND

Hybrid seed production where there is cross pollination of two distinctly different pure lines can be used to produce a hybrid (F1 seed) that exhibits a marked improvement in performance over either parent.

Hybrid performance traits such as grain yield, disease resistance, herbicide resistance, relative maturities, lodging resistance, oil content and meal quality are the result of hybrid vigour.

However, seed from the next generation (F2 or retained seed) and subsequent ones is not hybrid and it will not have the heterosis of the original purchased hybrid canola seed and may have lost some useful agronomic and physiological traits.

PREVIOUS FINDINGS

Previous research has identified optimum plant populations are 20 to 35 plants per square metre for hybrid canola and 40 to 70 plants per square metre for open-pollinated canola.

Hybrids have generally been sown at lower sowing rates than open-pollinated varieties due to hybrid vigour.

Trials conducted at Cummins and Struan in South Australia as part of the Better Canola project, funded by the Australian Oilseeds Federation (AOF) and Grains Research and Development Corporation (GRDC), showed that sowing rates as low as two kilograms per hectare were adequate for high grain yields from hybrids, provided pests and diseases were controlled.

Improved seeding equipment and good management has allowed some irrigators to sow at two and a half kilograms per hectare using hybrids.

TRIAL DETAILS

This research involved leading Hybrids vs OP's varieties from all major companies with 4 herbicide technologies being evaluated in 15 replicated trials in 4 states.

The aim was to evaluate Hybrids vs OP canola at 2, 4 and 6 kg/ha sowing rates in plot trials for a range of agronomic and performance traits and show the relationship between optimum plant populations, yield, oil and their effects of gross returns (\$/ha).

This research is regarded as original, and necessary for industry to have an evaluation of such a large range of varieties with different herbicide tolerances under Australian conditions in the low to medium and medium-high rainfall environments.

- CNV/CL/TT—Hybrid vs OP—3 sowing rates (9 sites)
- Harvested Mean Trial Yields ranged from 1.93 MT/ha to 3.33 MT/ha
- SA sites included Cummins, Clare and Bordertown
- VIC sites included Lake Bolac, Glenorchy and Greenlake
- NSW sites included Walbundrie and Parkes
- CNV/CL/TT/RR—Hybrid vs OP—3 sowing rates (6 sites)
- VIC sites included Lake Bolac, Glenorchy and Greenlake
- WA sites included York and Kojonup
- NSW sites included Walbundrie

CNV = Conventional (no herbicide tolerance genes), CL = imidazolinone tolerance, TT = triazine tolerance, RR = glyphosate tolerance

Trial measurements and summary of results

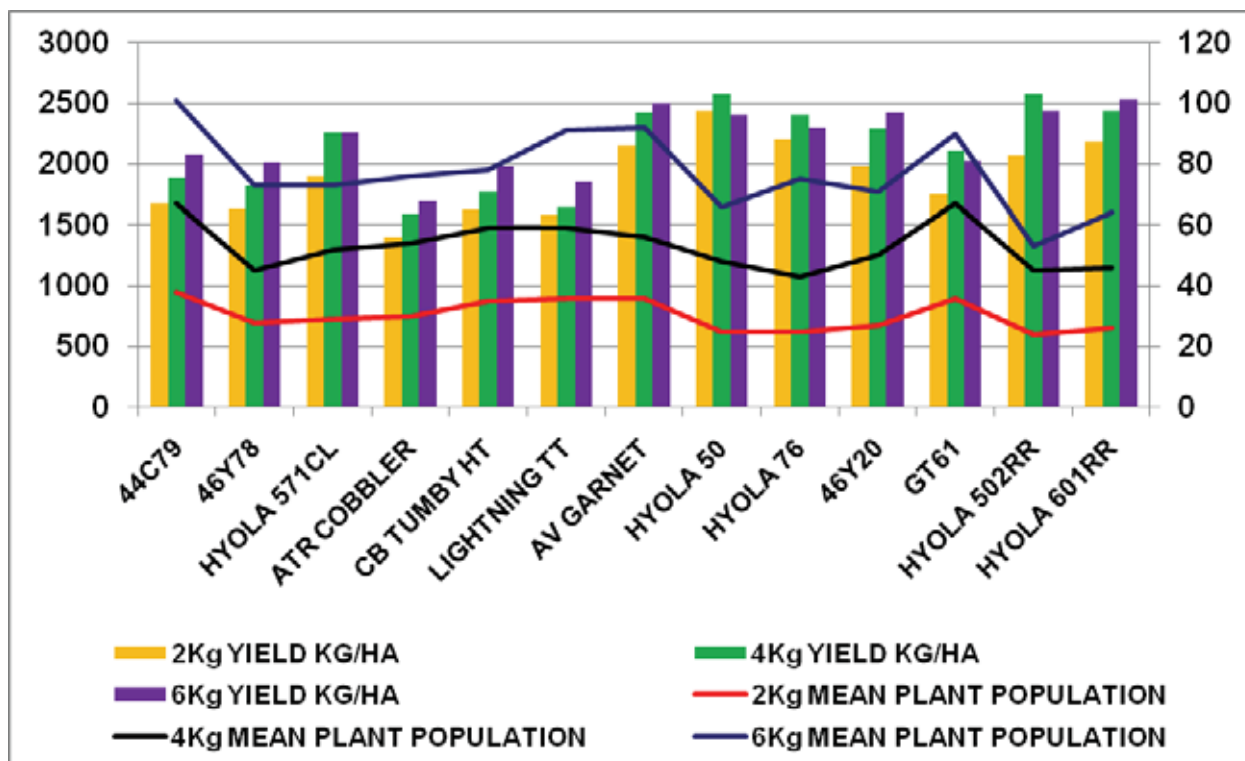
Canola variety	Sowing rate	Flowering uniformity	Visual lodging %	Visual Blackleg	Mean plant height cm	Mean analysed grain yield kg/ha	Mean gross return \$/ha
46Y20	2.0	6.9	13	7.8	134	1981	\$752
46Y20	4.0	7.0	13	7.6	135	2294	\$838
46Y20	6.0	6.7	18	7.6	138	2423	\$849
GT61	2.0	7.3	9	5.8	99	1755	\$682
GT61	4.0	7.5	12	5.6	101	2108	\$803
GT61	6.0	7.3	20	5.6	107	2022	\$749
HYOLA 502RR	2.0	7.5	2	8.1	119	2067	\$787
HYOLA 502RR	4.0	7.4	2	8.0	123	2574	\$949
HYOLA 502RR	6.0	7.7	4	7.9	128	2562	\$905
HYOLA 601RR	2.0	7.9	1	8.8	129	2180	\$832
HYOLA 601RR	4.0	8.3	3	8.5	138	2443	\$949
HYOLA 601RR	6.0	8.1	4	8.5	139	2538	\$895
RR TOTAL	2.0	7.4	6	7.6	120	1996	\$763
RR TOTAL	4.0	7.5	7	7.4	124	2355	\$885
RR TOTAL	6.0	7.4	11	7.4	128	2386	\$850

Canola variety	Sowing rate	Flowering uniformity	Visual lodging %	Visual Blackleg	Mean plant height cm	Mean analysed grain yield kg/ha	Mean gross return \$/ha
AV – GARNET	2.0	6.6	8	6.4	107	2152	\$841
AV – GARNET	4.0	7.3	11	6.3	112	2426	\$930
AV – GARNET	6.0	6.9	13	6.1	114	2498	\$939
HYOLA 50	2.0	8.0	3	8.3	111	2441	\$936
HYOLA 50	4.0	8.4	4	8.2	113	2576	\$950
HYOLA 50	6.0	8.1	5	8.3	116	2650	\$940
HYOLA 76	2.0	7.9	2	8.1	114	2207	\$843
HYOLA 76	4.0	8.1	4	8.0	118	2404	\$882
HYOLA 76	6.0	8.1	5	7.9	119	2302	\$801
CONV. TOTAL	2.0	7.5	4	7.6	111	2267	\$873
CONV. TOTAL	4.0	7.9	6	7.5	114	2469	\$921
CONV. TOTAL	6.0	7.7	8	7.4	116	2484	\$893

Canola variety	Sowing rate	Flowering uniformity	Visual lodging %	Visual Blackleg	Mean plant height cm	Mean analysed grain yield kg/ha	Mean gross return \$/ha
44C79	2.0	6.6	23	4.7	108	1676	\$651
44C79	4.0	6.7	27	4.3	109	1893	\$717
44C79	6.0	6.7	33	4.5	111	2075	\$770
46Y78	2.0	6.4	7	8.2	133	1640	\$616
46Y78	4.0	7.2	10	7.9	135	1821	\$648
46Y78	6.0	7.0	11	7.8	141	2018	\$687
HYOLA 571CL	2.0	8.4	0	8.8	111	1901	\$736
HYOLA 571CL	4.0	8.3	1	8.7	116	2255	\$822
HYOLA 571CL	6.0	8.4	2	8.7	118	2258	\$783
CL TOTAL	2.0	7.1	10	7.2	117	1739	\$668
CL TOTAL	4.0	7.4	13	7.0	120	1990	\$729
CL TOTAL	6.0	7.4	15	7.0	123	2117	\$747

Canola variety	Sowing rate	Flowering uniformity	Visual lodging %	Visual Blackleg	Mean plant height cm	Mean analysed grain yield kg/ha	Mean gross return \$/Ha
ATR – COBBLER	2.0	6.3	18	5.0	87	1399	\$540
ATR – COBBLER	4.0	6.8	20	4.7	91	1592	\$597
ATR – COBBLER	6.0	6.6	30	4.5	97	1697	\$619
^{CB} TUMBY HT	2.0	6.3	8	7.2	116	1627	\$611
^{CB} TUMBY HT	4.0	6.8	11	6.8	118	1770	\$628
^{CB} TUMBY HT	6.0	6.8	18	6.6	121	1984	\$674
LIGHTNING TT	2.0	7.7	3	7.6	97	1586	\$614
LIGHTNING TT	4.0	7.5	5	7.4	99	1651	\$620
LIGHTNING TT	6.0	7.7	10	7.3	102	1857	\$683
TT TOTAL	2.0	6.8	10	6.6	100	1537	\$588
TT TOTAL	4.0	7.0	12	6.3	103	1671	\$615
TT TOTAL	6.0	7.0	19	6.1	107	1846	\$658

2009 HYOLA NATIONAL CNV/CL/TT/RR RESULTS – 6 SITES VARIETY MEAN YIELD KG/HA VS MEAN PLANT POPULATION / M2





Hyola HYBRIDS

ULTIMATE CANOLA PERFORMANCE

OPTIMUM PLANT POPULATION RECOMMENDATIONS

CANOLA VARIETY BREEDING	LOW TO MEDIUM 250–400 mm 1.5–2 MT/ha	MEDIUM TO HIGH 400–600 mm+ 2–4 MT/ha
HYBRID TECHNOLOGY	25–40 PLANTS/M ²	40–60 PLANTS/M ²
OPEN POLLINATED	30–50 PLANTS/M ²	50–75 PLANTS/M ²

KEY FINDINGS

- Hybrids compared to OP—lower plants/m² at each sowing rate due to seed counts/kg, but Hybrids 10 per cent higher plants established.
- Hybrids exhibited greater visual biomass and seedling vigour over OP varieties except TT Hybrids which only showed increased biomass from post 4–5 leaf stage
- All varieties showed a reduction by 1 to 3 days in time to reach 50 per cent flowering from 2 kg/ha to 6 kg/ha sowing rates
- Some varieties more susceptible to lodging and showed increased levels of lodging with increasing seeding rates and plant populations.
- Most varieties plant height increased by up to 5 cm with increasing seeding rates and plant populations.
- Mean ranking of yields—CNV (Hybrid & OP) yield > CL > RR > TT—Significantly higher yields between CL/RR Hybrids and OP canola, with same HT group between the 4 kg/ha and 6 kg/ha sowing rates to the 2 kg/ha rate.
- Some significant differences in yield between CNV/TT Hybrids and OP canola within same HT group with increasing seeding rates.
- CNV/RR/CL in decreasing order showed higher mean per cent yield compared to TT varieties respectively at 2, 4 and 6 kg/ha seeding rates.
- The difference of the higher mean yield per cent of CNV/RR/CL compared to mean TT yield per cent increased between 2 kg/ha to 4 kg/ha and dropped from 4 kg/ha to 6 kg/ha.
- RR/CL/TT Hybrids provided higher gross returns than OP types within 2 kg/ha and 4 kg/ha except at 6 kg/ha—plant populations were too high and the seed price influenced the gross returns.
- CNV Hybrids and OP types showed highest gross returns of all HT groups with minimal differences between Hybrid and OP returns within the CNV group with increasing seeding rates.
- In 2 t/ha to 4 t/ha sites, most Hybrids except TT Hybrids showed Optimum yields achieved at 40–50 plants/m² and OP varieties at 50–75 plants/m².
- In 1.5 t/ha to 2.0 t/ha sites, most Hybrids except TT Hybrids showed Optimum yields achieved at 25–40 plants/m² and OP varieties at 30–50 plants/m².

FUTURE RESEARCH

Future research will involve the evaluation of all 4 herbicide technologies in new and improved Hybrid and OP varieties using four specific target populations per m² for each of the Hybrids and OP's tested across a range of canola growing environments throughout Southern Australia.

Pacific Seeds' objectives are to provide important information for the industry on targeted plant populations per square metre to meet optimum grain yield and also the least variability in yield for hybrid canola.

CONTACT DETAILS AND FURTHER INFORMATION

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KEY WORDS

hybrid canola, open pollinated canola, sowing rates, plant populations, yield, oil, plant height, days to 50 per cent flowering, variety performance comparisons, herbicide tolerance group comparisons, gross returns, grower sowing rate recommendations

Desi Chickpea agronomy for 2010

Alan Meldrum, Pulse Australia and Wayne Parker, Department of Agriculture and Food, Western Australia

KEY MESSAGES

- Ascochyta resistant varieties are available and broadleaf weeds can be managed making desi chickpea a low risk cropping option for the red clay loams of the northern and eastern wheatbelt.
- After a gap of 10 years in chickpea production, a grower update on the principles of sound chickpea agronomy is warranted.

BACKGROUND

Desi chickpea production in Western Australia peaked in 1999 at about 70 000 tonnes from 70 000 hectares. The introduction of the disease Ascochyta Blight in 1999 caused a rapid contraction in production and by 2003 total area was approximately 1 500 hectares. Area has remained low due to a succession of poor seasons and expensive in crop fungicide requirements. In the intervening years, the knowledge of successful chickpea agronomy has been lost or forgotten. This paper sets out to deliver the latest knowledge on chickpea agronomy for new or returning growers of desi chickpea in WA.

2010 – a chickpea renaissance

Ascochyta blight has been the major agronomic problem keeping chickpea unprofitable. Plant breeding has produced chickpea varieties with resistance to ascochyta blight in the last 6 years. Current recommended varieties are rated as Moderately Resistant (MR) or Resistant (R) to the disease. When MR and R varieties are combined with an appropriate fungicide package the risk of yield loss due to ascochyta is low. For the low rainfall regions a MR rating is adequate given the current lack of ascochyta inoculum. R varieties are suited to the medium rainfall zones where ascochyta blight still poses a threat.

Chickpea are less versatile in soil type requirement than field pea and lupin. They are a fine structured plant that provides less competition for weeds than other pulses. Southern regions are generally less suited than the northern regions to chickpea primarily because pod development will only occur after the mean daily temperature has exceeded 15°C.

KEY AGRONOMIC TOPICS

Marketing planning

The majority of marketing options for desi chickpea currently exist with Perth based traders. There will be a requirement to deliver grain to Perth or store on-farm. It is important to liaise with these marketers before planting chickpea to maximise the value of your grain.

Paddock selection

Chickpea grows well on deep fine textured loamy sands and well drained clays where the pH is a minimum of 5.5 (CaCl₂). Chickpea will tolerate a soil at slightly less than 5.5 pH but with reduced vegetative growth, lower yield and the risk of failed nodulation. Chickpea does not tolerate waterlogging.

A clean paddock, free of rocks and sticks is also a requirement. Chickpea have a low harvest height and rolling the paddock after sowing can be beneficial.

To reduce disease risk paddocks selected should not have had a chickpea crop in three years and be 500 m from previous chickpea stubble.

Chickpea is very sensitive to frost and cold temperatures from flowering and early pod development. Avoid paddocks prone to frost damage.

Chickpea is very susceptible to sulfonylurea (SU) herbicides and paddocks must have negligible residual SU.

Variety selection

There are 3 desi chickpea varieties currently available to growers and 1 small kabuli variety. A number of new chickpea varieties are in the final stages of evaluation, both from Pulse Breeding Australia and the COGGO funded WA chickpea breeding program. Varieties to be released during 2010 and 2011 will surpass the disease resistance and agronomic traits of the older varieties Genesis 836 and Genesis 510.

Table 1 **Agronomic traits of chickpea varieties currently available to producers. Source- Pulse Breeding Australia**

Variety	Early vigour	Harvest height	Flower-ing	Maturity	Ascochyta blight rating	Yield under high disease pressure (t/ha)		
						Fortnightly fungicide	Nil fungicide	% Yield loss
PBA Slasher ^A	Poor/Mod	Medium	Mid	Mid	R	2.34	2.37	0
Genesis™ 510	Moderate	Medium	Early/Mid	Early/Mid	R	2.26	2.02	9
Genesis™ 836	Mod/Good	Tall	Mid/Late	Mid/Late	MR/MS	2.00	1.66	15
Genesis™ 090	Good	Medium	Mid	Mid	R	2.29	2.13	5

Sowing

Chickpea should be sown at least 5 cm deep. Research in the 1990s (Siddique, Loss 1998) showed that chickpea plants produced taller and stronger plants when planted at 7 cm than those sown at depths less than 7 cm. Planting deeper also reduces the risk of herbicide damage.

Between 35 and 45 plants/m² is ideal. This corresponds to sowing rates of 80 to 120 kg/ha. Sowing width can be as wide as 50 cm before yield penalties occur. There is evidence of deferred water from wide row sowing during dry seasons (French 2001). This enables plants to fill seed under water limited situations.

Table 2. **Recommended sowing times for chickpea by zone. (from The Chickpea Book)**

Region	April			May				June				
	Week	2	3	4	1	2	3	4	1	2	3	4
Northern region Agzones 1 & 4												
Eastern regions Agzones 4												
Central regions Agzones 2 & 3												
Southern regions Agzones 2, 3 & 5												

As with all pulses, chickpea seed must be inoculated with rhizobium before planting. For Chickpea, Group N is required with peat slurry or dry granular formulations equally effective. Rhizobium and seed dressings are generally incompatible. It is advisable to coat the seed with fungicide days in advance of mixing seed with peat slurry. Seed coated with peat slurry, with or without a fungicide, should be sown within 24 hours of inoculation.

Fertiliser

There is evidence that chickpea is more efficient at extracting phosphorus than other pulse crop species. At soil test levels of greater than 20 ppm, chickpea will rarely respond to added phosphorus. Deep banding the phosphorus is likely to be beneficial, particularly when sown in wide rows where the increased concentration in the row can be toxic.

Provided that the crop is successfully nodulated by the added Group N rhizobia, there is no requirement for added nitrogen.

Weed control

Forward planning for weed control is essential for successful chickpea production.

The majority of broadleaf herbicide applications occur pre-planting and immediately post sowing pre-emergent. There is only one registered broad leaf herbicide, flumetsulam (Broadstrike®), for in-crop application. Flumetsulam has been known to reduce crop yields from herbicide tolerance trials (Table 3). It should also be remembered that flumetsulam is a group B herbicide and it may not work well if weeds have developed resistances to other group B herbicides.

Given these herbicide restrictions, and that chickpea does not compete well with weeds at any growth stage, an Integrated Weed Management (IWM) approach that maintains low soil seedbank is required to keep chickpea in the rotation longer. Initially it is advisable to use paddocks with a low weed burden of both grasses and broadleaf.

The most significant improvement in weed control options in the last ten years is the release of the herbicide Balance® (Isoxaflutole). Balance® shows excellent efficacy on the key broad leaf weed wild radish when applied at 100 g/ha, to a level seed bed post sowing pre-emergent. Like Simazine and Diuron, it is a soil active herbicide that requires moist soil for best results. It is applied to a level seed bed to prevent concentration in furrows after heavy rainfall. Balance® will cause crop damage if concentrated around an emerging chickpea seedling.

Crop topping is not an option for chickpea. Yield loss incurred from crop topping outweighs any benefit in weed control.

Table 3 **Label rate influence of broad leaf herbicides on chickpea yield, as % of untreated control at Mullewa, 2009. Bold numbers indicate significant effect (Harmohinder, data 2009 unpublished)**

Herbicides	Timing	PBA Slasher	Genesis 510	Genesis 836
Untreated Control %		100	100	100
Grain yield (kg/ha)		1918	1798	1077
Simazine 2.0 L/ha(*)	Before Seeding	113	110	129
Balance 100 g/ha	Immediately Post Plant	119	107	115
Metribuzin 280 g/ha		102	108	104
(*) Broadstrike 25 g/ha	4–6 nodes	69	70	60
l.s.d. (0.05) Control vs Herbicides		13	14	23
l.s.d. (0.05) Herbicides vs Herbicides		16	17	29
CV (%)		12	13	21

Disease management

Ascochyta Blight management is still essential to the long term viability of chickpea production. During 2010 and 2011 low levels of inoculum in the environment will restrict the impact of the disease. As chickpea area increases so will background disease levels. Protection against ascochyta blight begins at seeding with a fungicide seed coating.

Seed treatment with P Pickel T (thiabendazole & thiram) provides up to 6 weeks protection against early infection. Follow up foliar fungicides will be required once the seed treatment has worn off. The two fungicides registered for use in chickpea are mancozeb and chlorothalonil.

For Resistant (R) varieties, a single application of fungicide at 6 weeks after emergence keeps background levels of disease inoculum low. For Moderately Resistant (MR) varieties in low rainfall regions a similar single spray is warranted. If a MR variety is grown in a high risk, medium rainfall region, a second application will be required. The second spray should be applied during early pod development.

Pest management

Seedling pests are rarely a problem in chickpea, though they are not immune and monitoring is still required. Native budworm is the principle insect risk. Regular monitoring from the commencement of pod development is necessary. Spray thresholds can be as low as one grub in twenty sweeps. One well timed insecticide spray is usually adequate in most seasons.

Chickpea can suffer from Cucumber Mosaic Virus (CMV), Alfalfa Mosaic Virus (AMV) and Beet Western Yellow Virus (BWYV). These viruses are spread by migratory aphids as aphids generally will not colonise chickpea plants. Cultural management is the most economically feasible form of aphid control.

- Retain standing stubble to minimise aphid landing sites.
- Isolate the crop from other pulses and pastures that harbour aphids.
- Control radish well as radish will attract colonising aphids.

Seed with less than 0.1 per cent virus infection will ensure the crop begins with low background infection.

Harvest and grain handling

Harvester settings are similar to those used for lupin and field pea. Harvest height to the lowest pod can be short, particularly in dry seasons, therefore paddock preparation after sowing for smooth harvest operations may be necessary. Harvest chickpea as early as possible to minimise risk of pod loss through wind damage.

The angular shaped grain of chickpea reduces flow and usually restricts the speed at which it can be moved. Chickpea, especially at low moisture levels, is fragile and prone to damage. Soft handling practices and minimal handling operations are needed to deliver a high quality product to the market.

CONCLUSION

Desi chickpea production is a low risk option for Western Australian growers. The threat of yield loss from ascochyta blight should not be discounted, but it is very low. Gross margin potential with desi chickpea rivals or exceeds that from all other broadacre crops in Western Australia and, aside from the rotational benefits, can be viewed as a cash crop in the first instance.

KEY WORDS

chickpea, agronomy

ACKNOWLEDGMENTS

Producing Pulses in the Northern/Southern Agricultural Region—Bulletin 4656/4645 Editor Dr Peter White et al. DAFWA 2005

The Chickpea Book—Bulletin 1326, Editors—Loss, Brandon, Siddique DAFWA 1998

Chickpea Agronomy Course Manual, Editor—Gordon Cumming, Pulse Australia 2008

Paper reviewed by: Martin Harries

New wheat varieties – exploit the benefits and avoid the pitfalls

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KEY MESSAGES

Performance of Mace and Magenta in 2009 reiterated the high yields achieved by both these varieties in previous seasons and long term yield data.

Performance of King Rock in 2009 justifies consideration as a substitute for Bonnie Rock in the Northern and central regions, however this variety was not as competitive compared to leading varieties on the South Coast.

Yields of Scout were significantly less compared to Mace and Magenta in some instances and more often when compared to Wyalkatchem.

Well adapted mid season varieties yield comparable to the short season varieties Axe, Young and Zippy in most late sown situations, and are likely to be superior when seasonal conditions favour higher yields. Short maturity is not the most important factor when making a variety choice in either a late sowing situation or a shorter season environment.

Yields of Katana have been comparable overall with leading APW varieties in 2008 and 2009. A premium may apply for growers able to meet specifications for Grain Pool private treaty segregations at nominated CBH points.

The propensity of the varieties Fang, King Rock, Magenta and Scout to produce high screenings deserves further investigation.

Sprouting tolerance is highly variable and affected by both temperature and rainfall during grain fill and maturation. Results across a range of sites/ seasons have been inconsistent apart from Eagle Rock which achieves high Falling Number (FN) under adverse conditions.

AIM

To assess the performance of recently released wheat varieties in 2009, and where possible, provide advice on reliability over recent successive seasons.

METHOD

Field based agronomy trials are conducted at up to 11 sites across the state each year. Twenty-four wheat varieties comprising known controls and recent release varieties in at least the second year of evaluation within NVT are sown at 3 times of sowing in a replicated, randomised split plot design. Results from these trials are discussed in this paper with reference to previous season results where pertinent. The full grain yield and quality results from 2009 are published in the Wheat Variety Guide 2010 Western Australia. Please refer to this publication and previous variety guides in conjunction with this paper.

Fifty wheat lines were sown in unreplicated, one metre long rows with three repeated checks on 24 April, 16 May, 3 June and 20 June at Northam, Geraldton and Katanning to assess phenology, or flowering time response to sowing time. The proportion of heads showing anthesis was recorded at 2–3 day intervals to calculate the flowering date (50 per cent of heads showing anthesis).

Falling numbers test were conducted on varieties in the time of sowing trials at Esperance, Grass Patch and Mt Barker in 2008 and at Mingenew in 2009.

RESULTS AND DISCUSSION

Mace and Magenta

Mace and Magenta reinforced their ability to produce high yields in 2009. Both varieties achieved the highest recorded yield within a sowing time on multiple occasions at various sites across the state. Magenta achieved this more often with the early May to early June sowing times, and Mace with mid June to early July sowing times, reflecting the maturity of the two varieties. Mace was within the highest yielding group of varieties for a sowing time in close to 90 per cent of all comparisons, and Magenta was in the highest yielding group in close to 70 per cent of all comparisons.

Katana

Katana is a short season variety that has been released under an arrangement between Australian Grain Technologies and Grain Pool to explore a niche marketing opportunity. The Grain Pool has identified a target area around Geraldton and another that includes Cadoux down through to Kellerberrin, where private treaty segregations at nominated CBH points will enable growers to attract a potential premium (minimum 12.5 per cent protein required). Katana will be eligible for delivery into APW at other CBH points.

Yields of Katana were rarely significantly different from those of Mace, Magenta and Wyalkatchem across all sowing times at all sites in 2009. Katana achieved the highest yield averaged across all sowing times at Newdegate. A yield advantage over Magenta was exhibited at all sowing times at Mullewa. Similar results were recorded in 2008 (data available on request).

Protein levels achieved by Katana at Pithara and Merredin in 2009 were above 12.5 per cent across all sowing times, meeting the minimum requirement for the Grain Pool private treaty segregation. Protein levels were also significantly higher than those of Mace and Magenta in several comparisons across all sites. Katana protein levels across all sowing times at Wongan Hills in 2008 were below 12.5 per cent. However, where the minimum protein requirement for the Grain Pool private treaty segregation is not met the performance of Katana makes it competitive if deliverable as APW.

King Rock

King Rock was included in DAFWA agronomy trials for the first time in 2009. This AH variety is being promoted as 'the Bonnie Rock replacement', offering superior resistance to all three rusts. Phenology observations at Geraldton, Northam and Katanning in 2009 indicate that maturity of King Rock is comparable to Bonnie Rock and slightly earlier than Wyalkatchem (4 days on average when sown between mid May and early June).

Due to absence of Bonnie Rock in some trials direct comparisons to King Rock were only possible at Merredin, Mingenew, Mullewa and Coorow. Yields of King Rock were comparable to Bonnie Rock across all sowing times at all four sites, except when sown on 3 June at Mullewa, where the yield of Bonnie Rock was significantly higher (Table 1).

Overall the yields of King Rock were rarely statistically different from Carnamah, Mace, Magenta and Wyalkatchem at Mingenew, Coorow, Mullewa, Pithara, Merredin, Quairading, Newdegate and Katanning. Mace significantly out yielded King Rock when sown on 20 May at Mingenew, 16 June at Merredin and 2 July at Quairading. Yields of Wyalkatchem and Mace were higher than King Rock at all three sowing times at Grass Patch and some sowing times at Gibson. Magenta also exhibited a yield advantage over King Rock at several sowing times at Grass Patch and Gibson.

Table 1 Comparison of yield and quality of King Rock and Bonnie Rock at four sites in 2009

	Yield t/ha				Av	Protein %			Screenings % (whole and cracked)		
	20 May	3 June	15 June			20 May	3 June	15 June	20 May	3 June	15 June
Mullewa											
Bonnie Rock	4.32	4.15	3.49		3.99	n/a	n/a	n/a	n/a	n/a	n/a
King Rock	4.21	3.66*	3.17		3.68	n/a	n/a	n/a	n/a	n/a	n/a
Coorow											
Bonnie Rock	4.29	3.55	3.03		3.62	12.5	10.6	11.3	4.8	4.6	6.0
King Rock	4.52	3.83	3.11		3.82	12.5	10.6	11.6	3.6	3.3	5.5
Mingenew											
Bonnie Rock	3.13	3.36	2.80		3.10	12.5	11.1	11.7	4.2	4.2	3.7
King Rock	3.15	3.08	2.74		2.99	12.2	10.7	11.8	4.7	4.2	4.2
Merredin											
Bonnie Rock	1.64	1.42	0.61		1.22	16.0	17.1	19.8	3.1	1.4	1.4
King Rock	1.46	1.55	0.59		1.20	15.5	17.1	19.1	3.1	1.2	1.2

* Yield significantly lower than Bonnie Rock sown on 3 June.

Scout

Scout is an APW variety offering high levels of resistance to all three rusts, and was included in some DAFWA agronomy trials for the first time in 2009. Results from 2009 phenology data indicate this variety has medium maturity, approximately 4 days longer than Wyalkatchem and 11 days shorter than Yitpi on average, when sown mid May.

Wyalkatchem yields were significantly higher than Scout when sown in early June to early July in half of the comparisons across all sites. Mace and Magenta yields were significantly higher than Scout when sown in the same period, in around a quarter of the comparisons across all sites.

Screenings in 2009

Screenings (whole and cracked grain) in several varieties, including Fang, Katana, King Rock, Magenta and Scout were above 5 per cent for several sowing times across several sites in 2009, more notably at Mingeneew, Coorow and Pithara. Some of these situations were also associated with the earlier sowing times. Sub-sets of screenings samples from Mingeneew, Katanning and Newdegate were analysed to determine proportion of sample containing cracked grain. In the majority of situations screenings levels dropped below 5 per cent when the cracked grain proportion was removed. This makes it difficult to draw conclusions about varietal propensity to produce relatively high screenings. Trends indicate that the tendency to produce higher screenings is greater in Fang than the other aforementioned varieties. Results also indicate that King Rock, Magenta and Scout deserve further investigation.

Short maturity varieties

Late opening rains and dry finishing conditions in many parts of WA in recent seasons has generated interest and discussion about the merits of newer short maturity varieties. The three short maturity APW varieties Axe, Young and Zippy have been included in many DAFWA trials over the past three seasons. Axe and Zippy very rarely exhibit a significant yield advantage compared to many varieties with a range of maturities when sown on or after 15 June in 2007 to 2009 (Table 2). When the longer maturity varieties Calingiri, Fortune, Magenta and Yitpi are ignored Axe and Zippy have a significant yield advantage over the remaining varieties in less than 5 per cent of situations. The performance of Young is better but all other varieties achieve either comparable yields, or a yield advantage, in the majority of comparisons.

Well adapted mid season varieties yield comparable to these short season varieties in most late sown situations, and are likely to be superior when seasonal conditions favour higher yields. While some short season varieties have exhibited competitive yield performance in WA (e.g. Westonia and

Tammarin Rock and Katana) their competitiveness can be attributed to adaptation. Short maturity is not the most important factor when making a variety choice in either a late sowing situation, or a shorter season environment.

Table 2 Yield performance of Axe, Young and Zippy compared to several varieties when sown on or after 15 June at various locations throughout WA in 2007 to 2009. In each comparison Axe, Young and Zippy have been rated as either significantly higher yielding, not significantly different (similar) or yielded significantly lower than the variety being compared to.

	Axe			Young			Zippy		
	Higher	Similar	Lower	Higher	Similar	Lower	Higher	Similar	Lower
Arrino	0	12	1	3	10	0	0	5	1
Binnu	1	17	3	6	10	0	1	10	3
Bonnie Rock	1	16	3	2	12	1	0	11	2
Calingiri	4	19	4	5	11	1	4	11	5
Carnamah	3	22	4	5	12	2	3	12	7
Espada	0	18	3	2	6	2	1	13	8
Fortune	0	12	1	0	5	0	1	7	5
Gladius	1	24	4	1	17	1	1	15	6
Mace	1	15	6	1	6	3	1	13	8
Magenta	2	24	3	3	13	2	2	15	5
Tammarin Rock	2	12	3	2	10	1	0	9	1
Wyalkatchem	1	21	7	4	13	2	1	18	3
Yandanooka	2	14	5	3	9	1	2	9	3
Yitpi	5	17	2	3	14	1	4	10	3

Harvest weather damage assessments and Sprouting tolerance

Varieties vary in their inherent or undamaged FN due to differences in dough viscosity and dough chemistry. Sprouting is influenced by dormancy, but there is no useful variation in dormancy in any of the current commercial wheat cultivars. Most differences in sprouting tolerance are due to phenotypic differences such as the presence of awns and glume compaction. Eagle Rock is an awnless variety, with tight glumes (difficult to thresh) which helps to keep water away from the grain. Awns funnel water into the ear, making it wetter and holding moisture in over a greater period of time. Tight glumes keep grain drier, and assist in drying out more quickly following rain events as the diffusion rate is higher than a loosely glumed, easy threshing variety. Final FN is also affected by a complex interaction involving the timing and amount of rainfall following mid-dough, length of time the head stays wet and temperature effects during grain filling. Falling number data tends to be highly variable with large l.s.d.s, generally in the order of 50–70, due to the nature of the test, particularly for badly damaged varieties. An acceptable FN doesn't mean the variety will pass the CBH receival test for other parameters such as field fungi or head scab. Generally, the higher falling number wheat samples in 2008 were better in appearance.

Wet weather at harvest caused sprouting at Gibson, Grass Patch and Mt Barker in 2008 and Mingenew in 2009. At both Mt Barker and Gibson in 2008 large amounts of rainfall, up to 200 mm during harvest, caused significant damage to earliest sown crops (TOS1). These were the most mature when the rain started and accumulated the most damage by harvest. Later sown treatments were progressively less damaged. In the earlier sown treatments varieties with a FN greater than 200 were Eagle Rock, Fang and Derrimut. Severely damaged varieties included Carnamah, Lincoln, Katana, Wyalkatchem and Magenta. Mace had a high FN at Gibson (270) but was only feed grade at Mt Barker (116). The response of Yitpi, Endure and Carinya also significantly differed between the two sites, indicating the interaction of an additional factor such as temperature which was not accounted for by varietal maturity or rainfall amount and timing.

At Grass Patch only 5 varieties in TOS1 failed to reach GP grade (FN 200). Carnamah had the (149) lowest FN and Eagle Rock the highest (422). At Mingenew only 20 May and 2 June sown treatments were assessed for FN as the 15 June sown treatments showed no visual signs of sprouting, attributable to later maturity. Eagle Rock, Bonnie Rock, King Rock, Fang and Scout made milling grade (FN > 300). Gladius (190), Carnamah (187), Axe (186), Espada (176) and Katana (159) were only eligible for Feed grade (i.s.d. 65). Mace (242) and Wyalkatchem (239) showed an identical FN response averaging 240 for both times of sowing. While largely there were no significant differences between 20 May and 2 June sowing times at Mingenew. The mid maturity variety Carnamah showed a significant decrease in FN (236–137) while the longer maturing varieties Calingiri (224–297), Fang (303–380) and Fortune (179–271) significantly increased FN, indicating a possible interaction of varietal maturity and rainfall timing.

Over all sites and years Carnamah and Katana appear very susceptible to low FN. Eagle Rock has a consistently high FN. Due to the variable responses between sites and years we would conclude that Mace is not worse than Wyalkatchem, but there is not evidence to say that it is better. Other factors affecting final FN are involved and further work evaluating FN of varieties under field conditions is required. In a consistently dry harvest (Gibson 2009) all varieties tested showed FN exceeding 300 and many FN > 400.

South Coastal Agricultural region

Time of sowing trials have been conducted on the sandplain at Esperance Downs Research Station (EDRS) and on Mallee duplex soils at Mt Madden (2007) and Grass Patch (2008 and 2009). At EDRS, a site with little frost risk, earliest sowing leads to highest yields. Delaying sowing reduces yields for all varieties. In years of high yield potential (2007 and 2008) this may be as much as 60 kg/ha/day lost yield. In theory, long season varieties will achieve high yield potential when sown early but experience disadvantage if sown too late. Mid-season varieties may not achieve such high yields due to a shorter vegetative growing phase. Short season varieties (quick or early maturing) would be disadvantaged if sown too early as they will mature too early in spring (frost risk) and suffer weather damage and lower yield potential, but may be able to finish well when sown late in the season, and hence have an advantage for late sowing opportunities.

However, the theory is not supported by the data. Part of the problem for researchers (and a great advantage to growers) is that there exist very well adapted mid-season varieties which are well suited to reasonably early sowing opportunities (*not* false break situations in late March or early April) but also perform well even when sown at the very end of the seeding opportunities, and can do this across a broad range of environments and soil types. Wyalkatchem is the leader of this pack although the closely related recent release Mace exhibits similarly broad adaptation. Across a range of sowing dates over three seasons at EDRS there have been no trends based on variety maturity length. The main effect is that well adapted varieties perform relatively well at all times of sowing in all seasons, and poorly adapted varieties perform poorly almost always. This continues to hold true even for the newest released varieties. No real trends based on maturity are evident. The main effect is local adaptation.

Varieties which have consistently high yields, equal to or exceeding the mean for each time of sowing at a particular site, demonstrate effective plasticity of the variety. At EDRS in 2009 the highest yielding and most consistent varieties (the 'winners') were Mace, Wyalkatchem, Magenta, Katana, Bullaring, Bumper and Calingiri. This was consistent with 2008. Eagle Rock had good, consistent, above average yields in 2007 and 2008 but was only about average in 2009, a drier and less favourable season where average site yields were lower overall, and is less suited to transitional or mallee soils.

Varieties to avoid on the deep sandy soils of the sandplain appear to include the boron tolerant, mallee soil adapted varieties such as Derrimut which is consistently below average and Gladius which has similar adaptation. However, in contrast to their relatively poor performance on the sandplain, Derrimut and Gladius achieved high yields and demonstrated good environment specific adaptation on the mallee duplex soil at Grass Patch in 2009, and Mt Madden in 2007 (Derrimut only). Other varieties that show consistent performance at Grass Patch in 2009 include Espada, Fang, Mace, Magenta, Katana, and Wyalkatchem.

The inclusion of Mace, Magenta, Katana, Wyalkatchem as highest yielding and most consistent over a range of sowing dates and sites indicates their broad adaptation.

Quality

As with yield, it may reasonably be expected that grain quality would vary with sowing date and maturity. However the interaction of maturity by sowing date effect is generally masked by the magnitude of the main effects of season and variety. Difficult seasons tend to damage most varieties and varieties with quality defects tend to display these even in reasonable seasons.

In a wet harvest season such as 2008, almost all varieties were damaged by high rainfall at maturity with the notable exception of Eagle Rock. Where there are no major seasonal effects, varietal differences are more apparent. In 2009 grain quality was generally excellent with high hectolitre weight and low screenings. However 8 varieties had higher screenings for the last time of sowing, reflecting the stress of finishing grain late in the season, particularly among the longer season types.

Southern Agricultural region

The 2009 season generally started late in May with Newdegate receiving below average rainfall throughout the growing season while Katanning had a very wet June followed by below average rainfall during grain fill. The growing season rainfall (May to October) was 180 mm at Newdegate Research Station and 332 mm at Katanning. Only 13 mm fell late in October at Newdegate and even less at Katanning with only 8mm (in contrast Newdegate recorded 90 mm and Katanning recorded 45mm for the month of October in 2008).

Average yields at Katanning declined by 0.41 t/ha (22.8 kg/ha/d) from 25 May to 11 June and then levelled at the later 23 June sowing with yields for individual varieties either increasing or decreasing compared to the previous sowing time. The yield penalty with delayed sowing at Newdegate was less due to the later start (June) and late rains benefiting some of the varieties (refer to Wheat Variety Guide 2010).

New releases King Rock and Katana were the highest yielding, or among the highest yielding varieties, at both the Katanning and Newdegate Research Station sites. The season generally favoured the medium to shorter maturing varieties at both sites. The performance of Katana was not as solid in 2008.

Even with the relatively late first sowing date (25 May) at Katanning some frost damage was evident, but less severe than in 2008. As a consequence a number of varieties, particularly Wyalkatchem, yielded below their potential. Bullaring, Calingiri, EGA2248, EGA Jitarning, Espada, Mace and Magenta were amongst highest yielding varieties at this site (average yields across all sowing times). Endure, Fang and Yitpi were competitive at the earlier (late May) sowing time.

Sowing did not commence at the Newdegate site until June where yields of Wyalkatchem and Mace were dominant in both June sowing times. Other varieties that performed well when sown in early June were Magenta, Calingiri and EGA2248.

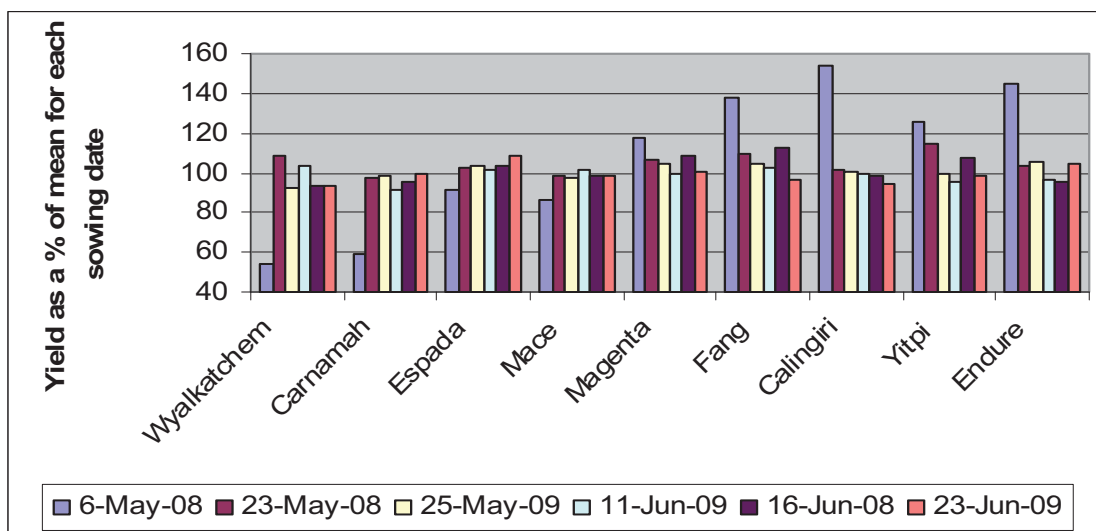


Figure 1 Relative yield performance of nine varieties over six sowing dates at Katanning in 2008 and 2009.

Although 2008 and 2009 were contrasting seasons it is interesting to compare how varieties performed at different sequential sowing times over the two seasons. Figure 1 illustrates the relative advantage the longer maturity varieties when sown in early May (2008), where frost has affected the yields of the shorter maturing varieties to a greater degree. Fang has performed well at the Katanning site, which is not reflected in NVT data, however the variety has a high risk of being downgraded due to excessive screenings (see Figure 2).

The soft wheat varieties Bullaring, EGA2248 and EGA Jitarning offer a range of maturities, with yields that are competitive with the leading APW varieties. However, these varieties are more prone to excessive screenings and tight protein requirements increase the risk of not meeting the grade.

The tight finish in 2009 caused some issues with small grain screenings in the Great Southern. Fang produced screenings well above 5 per cent when sown in June at Katanning (Figure 3).

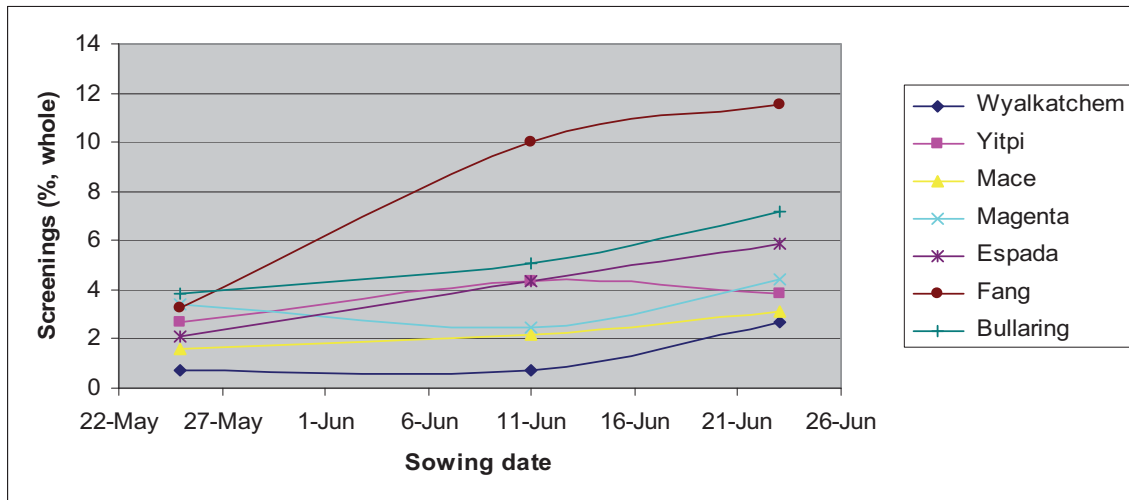


Figure 2 Effect of variety and sowing time on small grain screenings (%) at Katanning in 2009.

Central Agricultural region

The 2008 season was a reasonable to average year in terms of growing season rainfall (Wongan Hills 301 mm, Merredin 208 mm, Corrigin 310 mm). However, there was little rainfall over summer, leading to low stored soil moisture and the break of season was relatively late meaning that pre-sowing weed germination and control was poor and there were crop establishment problems in the partially dry soil. In 2009 less growing season rainfall was received (Pithara 264 mm, Merredin 205 mm, Quairading 244 mm) and dry conditions throughout September and October created stress, reducing yields and elevating protein level, particularly for the late sown crops.

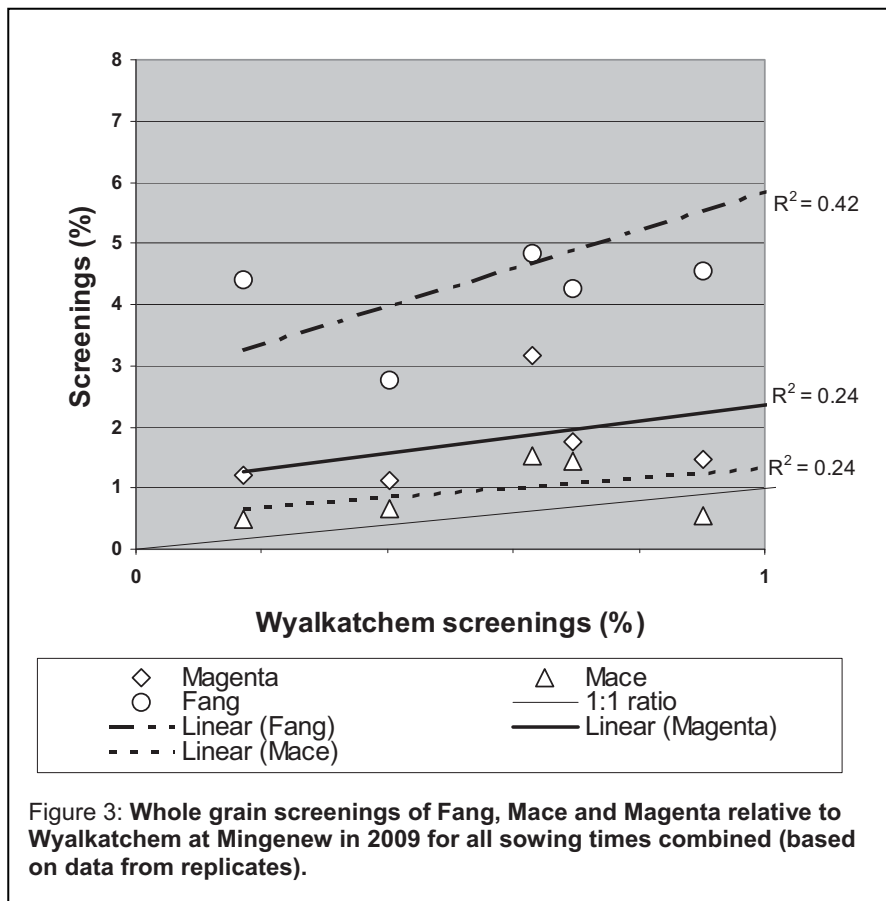
The first time of sowing (TOS1), at Merredin in 2009 was sown on 30th April after irrigating the trial site to generate information on early sowing. A light irrigation was applied in May to save the crop due to a very dry spell. This created artificially high yields (average 2.44 t/ha). The most obvious fact is that follow-up rain is critical, and sowing very early in a highly variable environment carries high risk.

Within TOS1 the highest yielding varieties are Magenta, Katana, Fang, Espada, Mace, Yitpi and Wyalkatchem. The narrow data range (2.0–2.9 t/ha) with an l.s.d. of 0.45 t/ha indicates that varieties were largely growing to their water limited yield potential and unable to express differences in genetic potential or adaptation. There was little evidence of maturity length favouring any varieties. Yitpi was among the higher yielders whilst Endure (also a long season) was the lowest. This was consistent with 2008, indicating, unsurprisingly, that Endure is not adapted to this environment.

Across sites and seasons, the most consistent varieties, those that are among the highest yielding at the site (not always TOS1) and yield at or above the mean yield for each TOS include Mace, Magenta, Espada and Gladius* (*not at Quairading 2009). Other varieties that have performed well in individual instances include Calingiri (Quairading 2009), King Rock, Bumper and Binnu (Pithara 2009) EGA2248 (Corrigin 2008).

Northern Agricultural region

Crops in 2009 were reliant on winter rainfall with no summer rain prior to seeding. The first sowing times at Coorow, Mingenev and Mullewa were sown dry on 14 May in 2009 with germination commencing on 20 May after ~25 mm. A separate comparison was undertaken at Mullewa to benchmark the effect of dry sowing (on 14 May) compared to sowing into a wet seedbed 11 days later. While dry sown treatments emerged one week earlier, plant establishment was similar for both treatments (130 plants/m²). There was no difference in yield of Wyalkatchem (2.55 t/ha) when sown dry or wet.



The yield penalty (averaged across all varieties) was 22, 31 and 14 kg/ha/day at Mingenev, Coorow and Mullewa when sowing was delayed from 20 May to 2 June. The penalty increased to 28, 45 and 55 kg/ha/day for each respective site with delayed sowing from early June to mid June.

Whole grain screenings of Fang were higher than those of Mace, Magenta and Wyalkatchem at Mingenev (Figure 3).

Yields and screenings of Fortune were similar to Calingiri in 2009 and 2008 at each sowing time in Mingenev. However, protein levels in Fortune were higher than Calingiri in 2008 and 2009 at this site.

Fortune levels exceeded 11.5 per cent when sown in late May and mid June in 2009 and when sown in mid June in 2008. Protein levels of both varieties were not significantly different at Coorow in either 2008 or 2009.

CONCLUSION

Mace and Magenta have exhibited consistent performance over a range of sowing times at all sites in 2009. The performance of King Rock in the first year of testing in DAFWA time of sowing trials was competitive with Bonnie Rock in the areas where this variety is widely adopted. Results for Katana indicate an opportunity for growers in the Grain Pool target areas to attract a potential premium with downside returns likely to be competitive with leading APW varieties if not able to meet to 12.5 per cent protein requirement.

Performance of short maturity varieties in late sown situations over several years indicates that not all of these varieties have a yield advantage over well adapted varieties from other maturity groups. Variety choice for these situations should not be based on maturity as the most important factor.

Because of the inconsistency in falling numbers data over three sites in 2008 and 2009 it is difficult to support or refute claims about varieties having superior tolerance. For example data generated at Mingenev in 2008 indicate that Mace and Wyalkatchem were comparable at two different sowing times. The only variety that consistently exhibits better tolerance in this data set is Eagle Rock.

Complete 2009 yield and grain quality results, along with disease resistance, agronomic and quality characteristic ratings, herbicide tolerance, phenology data and long term yield data are available from the Wheat variety guide 2010 Western Australia.

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The influence of genetics and environment on the level of seed alkaloid in narrow-leafed lupins

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KEY MESSAGES

Field experiments have confirmed that adequate supply of potassium and manganese to lupins is required to help keep seed alkaloid levels in narrow-leafed lupins acceptably low. A glasshouse experiment has shown that the effect of potassium deficiency on alkaloid level is greater where phosphate supply is greater. In a field experiment carried out at Merredin in 2008 with irrigation treatments and rain shelters, drought reduced seed alkaloid levels. This effect was opposite to that found in Danish research and contrary to the general understanding within the research community. Greater understanding of these agronomic and environmental factors will help the industry manage and predict alkaloid levels in seed in the future. Successful management of alkaloid levels will allow access to developing markets in human consumption of lupins.

AIMS

Quinolizidine alkaloids (QZ) are an important class of secondary metabolites of plants belonging to the genus *Lupinus*. They confer resistance towards insects and are biosynthesised in the green tissues of the plant and then transported via the phloem and stored in all organs including the seeds. The main QZ in *Lupinus angustifolius* are lupanine, 13-hydroxylupanine and angustifoline.

Quinolizidine alkaloids are the main anti-nutritional factors that limit lupin's use for animal feed and human consumption (Petterson, 1998). The average seed alkaloid concentration of commercial varieties is strictly regulated and in narrow-leafed lupin grain for food or feed it must be < 200 mg/kg (Culvenor and Petterson, 1986). However, large and unpredictable fluctuations in seed alkaloid concentrations were found in sweet narrow-leafed lupin in different locations in the same year or the same location over different years (Harris, 1994).

Although varieties of narrow-leafed lupin with a significantly reduced alkaloid level have been released in WA, it needs to be recognised that agronomic and environmental factors influence the alkaloid content in lupin grain. The understanding within the research community in Western Australia is that the high alkaloid levels which sometimes occur in lupins are associated with drought stress in the WA wheatbelt (J Gladstones pers. comm.).

Cowling and Tarr (2004) measured seed quality of 6 narrow-leafed lupin (*Lupinus angustifolius*) cultivars in 126 Crop Variety Testing field trials in Western Australia over 11 years at 55 locations. An analysis was conducted to determine the effect of locations, years, genotypes, and genotype × environment interactions on total seed alkaloids and other quality traits.

The levels of seed alkaloids were highly variable across years and locations with a range from 27–666 mg/kg in the 126 trials during the 11 years of the study. There did appear to be an association between large seeds, produced at some experimental sites, and a high concentration of alkaloid in the seed.

Grain marketers and end users of the grain would benefit from knowledge of the main sources of variation in alkaloid content in lupin seed in order to ensure consistent supply of product that meets the FSANZ standard.

This paper aims to summarise the main genetic and environmental factors that are likely to be playing a role in the level of alkaloids found in West Australian narrow leafed lupins and suggests some agronomic practices that will lower the risk of violative levels of QZ in lupin seed.

GENETIC FACTORS

Lupin breeders have made use of the mutant gene, *iucundus*, (*iuc*) to ensure levels of QZ are at an acceptable level. The alkaloid synthesis pathway is disrupted in any plant containing this gene resulting in a 10 fold reduction to below 0.02 per cent on average. However, there is a significant environmental and climatic influence over alkaloid levels and this response is still expressed in lines or varieties with the gene for low alkaloids (*iuc*). As such, breeders measure the alkaloid levels of advanced lines over a number of years to confirm that, on average, the alkaloid levels are below 0.02 per cent. Making sure that lines released as varieties meet this standard is a significant part of the breeding program and about 10 per cent of the budget is spent in this area. It is also a frustrating activity given the variation across sites and years and our lack of specific knowledge on what most influences the alkaloid levels.

PLANT NUTRIENT SUPPLY

Gremigni (1998, 2002) showed that soil amendment with lime in an experiment at South Dargin in 1996 increased soil surface and subsurface pH when it had been applied for three years. Liming caused a small increase in seed alkaloid concentration in the narrow-leaved lupin variety Merrit (Figure 1). This effect was only significant when considering the contrast between unlimed and limed plots, but did not depend on level and year of lime application or their interaction. Unlimed plots had seed total alkaloid concentrations higher than the maximum acceptable limit of 200 mg/kg DM. The trial indicates that low soil pH, combined with K and Mn deficiency (either induced or exacerbated by the lime application) may contribute to high seed alkaloid concentrations. Plant biomass was reduced in plots that had been limed for the longest time and these plots probably suffered most severe K and Mn deficiency. However, seed yield was depressed by lime only when foliar Mn spray was not applied. Seed yield increased with Mn but was not affected by K application. The trials showed that lime amelioration of an acidic sand loamy soil in WA, together with soil K fertilisation and foliar Mn fertilisation, decreased seed alkaloid concentrations in narrow leafed lupin. Plant growth and seed yield were depressed by soil Mn and K deficiency induced by lime. Seed yield and mineral content increased with the application of K to the soil and foliar Mn. The rate of manganese fertiliser used in the experiment is equivalent to 1kg /ha of elemental Mn which is the recommended foliar rate to prevent Mn deficiency in lupins. However, the timing was just prior to main stem flower emergence which is earlier than the recommended time of spraying. The recommended time is when the pods on the main stem are 2–3 cm long and the secondary stems have nearly finished flowering (Brennan 1993). A greater effect from applied Mn may have been measured if the timing was correct. More trials need to be carried out to verify the magnitude of the response in seed alkaloid level to applied Mn.

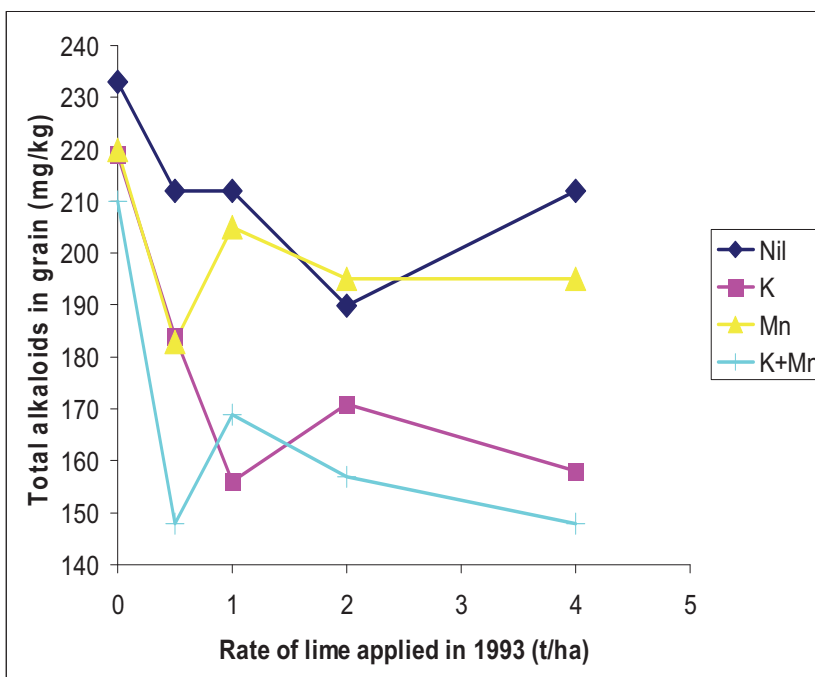


Figure 1 Concentrations (mg/kg) of total alkaloids in seed of Merrit lupins grown on soil amended with 5 levels of lime applied in 1993 and treated with soil K fertiliser, foliar Mn spray or both K and Mn applied in 1996 (from Gremigni (1998, 2002)).

In associated work in the glasshouse, K deficiency increased and P deficiency reduced seed alkaloid concentrations in sweet varieties of narrow leafed lupins, and there was a significant interaction of K and P. When both K and P were abundant, seed alkaloid concentrations were lowest (Figure 2) but, with abundant P alkaloid concentrations increased dramatically in response to K deficiency.

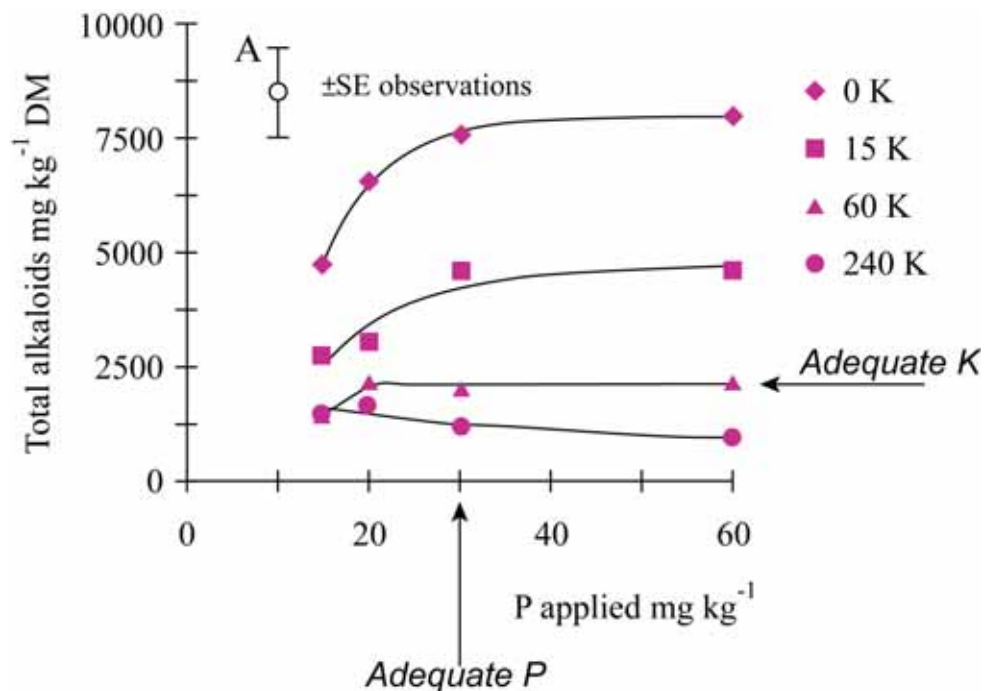


Figure 2 Total alkaloid concentrations in seed of NLL variety Danja grown in pots in a glasshouse at four levels of K and four levels of P applied (adapted from Gremigni 2003).

Thirty mg/kg P and 60 mg/kg of K was suggested as adequate for lupin growth based on the work of Tang (1998).

Gremingi et al. (2001) observed large increases in lupin grain alkaloids levels at different locations that were not low enough in K to cause significant loss of plant biomass or seed yield, or K deficiency symptoms. They suggest that asymptomatic K deficiency may be partly responsible for the unpredictable fluctuations of alkaloid concentrations in field grown lupins from different locations.

The response to applied K was confirmed by French (2002). In experiments near Eneabba in 2001, the response in both yield and alkaloid level to applied K was dependent on the level of soil K. One site which had a low soil K level, showed large, significant effects of applied K on yield.

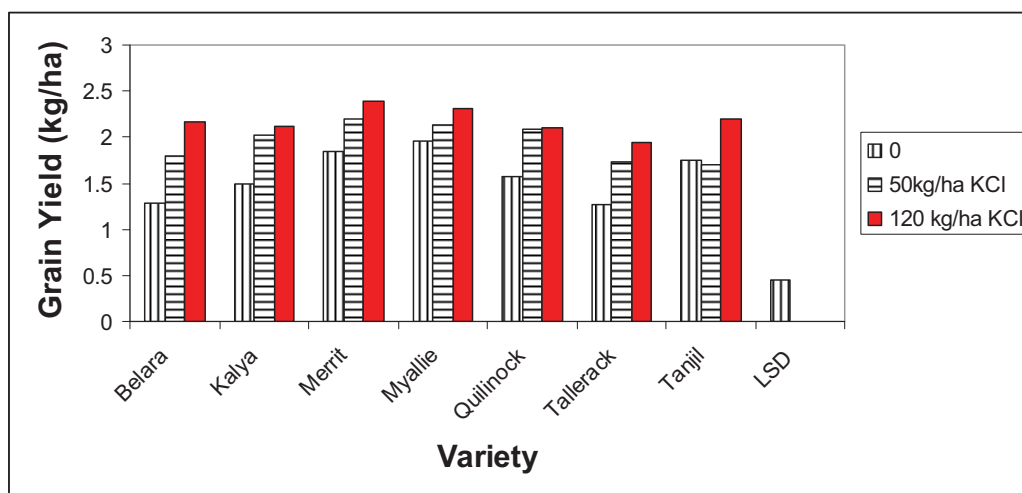


Figure 3 Effect of three rates of applied Potassium (kg KCl /ha) on grain yield of lupin on low K soil at a site near Eneabba in 2001 (R French unpublished data).

Seven lupin varieties were sown with three rates of potassium fertiliser (0, 50 120 kg/ha muriate of potash) on a site with deep grey sand. The extractable K was 14.7 mg/kg in the top 10 cm and 10 mg/kg in the 15–25 cm zone. The extractable P was also low at the 0–10 cm depth which was 14.3 mg/kg and 8 mg/kg at 15–25 cm. However, the whole site was topdressed with 150 kg/ha Extra Phos® and an additional 50 kg/ha drilled with the seed. The potash treatments were topdressed at seeding.

The response in alkaloid level was the same as observed in the glasshouse and field trials carried out by Gremigni et al. 2001.

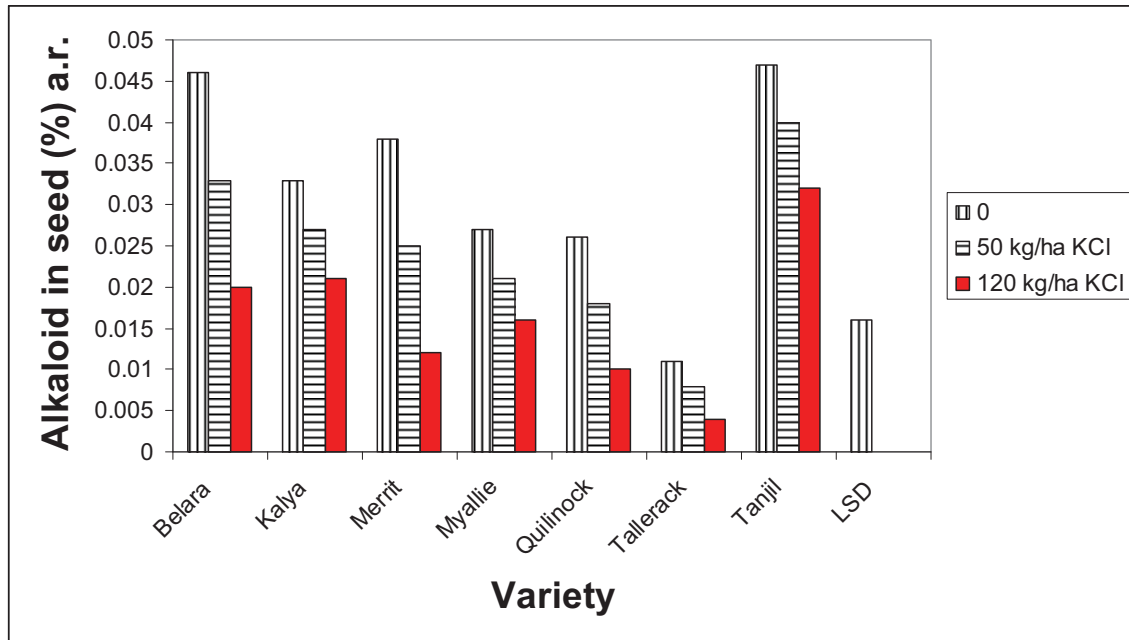


Figure 4 Effect of three rates of applied potassium on total alkaloid content of lupin grain on a low K soil at a site near Eneabba in 2001 (R French unpublished data).

This trial can be compared to another trial nearby which was on a soil with 35.3 mg/kg in the 0–10 cm layer and 16.7 mg/kg in the 15–25 cm layer. There was no yield response to applied K, alkaloids were very low and there was no reduction in alkaloids with applied K.

TEMPERATURE EFFECTS

Jansen et al. (2009) found that seed alkaloid levels were strongly influenced by the temperature during initiation of flowering up to pod ripening. Similarly, Gremigni (2003) reported that the levels of alkaloids in the low alkaloid varieties increased when the plants were grown in the glasshouse where the temperature during pod fill was high. However, the influence of root restriction in the pots cannot be discounted. Reader et al. (1997) found no effect of pod temperature on alkaloid levels where the experiment was conducted in the glasshouse.

EFFECTS OF DROUGHT

The effect of drought stress at three growth stages on seed alkaloid content in two sweet (W26 and Polonez) and one bitter variety (Zubr) of spring sown *Lupinus angustifolius* L. was investigated in an experiment on sandy soil in Denmark (Christiansen et al. 1997).

Plots were either fully irrigated or subjected to drought during the vegetative, flowering or pod filling stages. In the drought treatment, irrigation was withheld until available plant soil water had been reduced by 40–45 mm, and the plants showed severe drought symptoms including loss of leaves.

Full irrigation resulted in a medium alkaloid content (Table 1). Drought stress during the vegetative phase increased alkaloid content to 0.094, 0.192 and 2.55 per cent of seed dry matter for W26, Polonez and Zubr respectively. Stress at the flowering stage reduced alkaloid content to 0.070, 0.152 and 1.99 per cent, while drought stress during pod-filling increased alkaloid content for the determinate

variety W26 to 0.097 per cent, but decreased it to 0.161 and 1.98 per cent for the two indeterminate varieties Polonez and Zubr, respectively. Drought during either flowering or pod-filling resulted in an increased mean seed weight and a reduced number of seed per square metre. In this experiment, alkaloid content was negatively correlated to seed weight.

Table 1 Alkaloid concentration (percentage of dry matter), mean seed weight (mg) and number of seeds (seeds per m²) in fully irrigated plots and after drought stress at the vegetative, flowering and pod filling stage for three lupin varieties W26, Polonez and Zubr

	W26			Polonez			Zubr		
	Alkaloid content (%)	Seed weight (mg)	No. seeds per m ²	Alkaloid content (%)	Seed weight (mg)	No. seeds per m ²	Alkaloid content (%)	Seed weight (mg)	No. seeds per m ²
Fully irrigated	0.084	135	2580	0.18	175	1621	2.06	151	2694
Vegetative	0.094	133	2302	0.192	162	2073	2.55	148	2442
Flowering	0.07	215	1520	0.152	205	863	1.99	181	1927
Pod filling	0.097	146	2172	0.161	182	1257	1.98	179	1438
l.s.d. .05	0.022	13	287	0.034	15	493	0.41	19	439

In contrast, an experiment carried out at Merredin Research Station in 2008 (R French unpublished data) compared the effect of different levels of drought stress on Mandelup lupins (Table 2). Water was withheld using the rain shelters at Merredin Research Station on deep sand over gravel and watering was done using t-tape, replacing pan evaporation each week during the well-watered period. Four treatments were in the rain shelter and four treatments were outside the rain shelter.

Table 2 Average seed size, alkaloid concentration (per cent as received) grain yield (g/m²) and total standing biomass (g) for a range of drought stress treatments on Mandelup lupins (R French unpublished data)

Treatment	Average seed Size (g)	Alkaloid (%)	Grain yield (g/m ²)	Total standing biomass (g)
Inside rainshelter				
Stress flowering to maturity	0.1137	0.0057	60.4	179.1
Stress flowering to start grain fill	0.1779	0.013	200.1	482.8
Well watered flowering to maturity	0.157	0.034	356.1	759.8
Well watered flowering to start grain fill	0.1277	0.011	203.2	545.6
Outside rainshelter				
Stress flowering to maturity	0.1235	0.004	100.4	248.1
Stress flowering to start grain fill	0.1612	0.015	296.9	574.3
Well watered flowering to maturity	0.1591	0.029	389.2	809.1
Well watered flower to start grain fill	0.1278	0.006	166.5	424.2

Both inside and outside the rainshelter, the highest alkaloid concentrations recorded were found with the watering treatment that covered the period from flowering to maturity. When the results were expressed as alkaloid content, rather than concentration, this treatment also had the highest value both inside and outside the rainshelter (Table 3). These plots were observed to be greener for longer, hence they may have produced more alkaloid than the treatments which matured quicker. That the lupins that make the greatest growth have the highest alkaloid concentration in the seed fits with the observation that lupins that are grown in irrigated bulkup over summer at Manjimup also have very high levels of alkaloid concentration in the seed (Bevan Buirchell pers. comm.). This summer bulkup is characterised by a longer daylength than the normal winter production period which may also be driving higher alkaloid levels. This pattern also fits the trend found by Cowling and Tarr (1994) for large seed to be associated with higher alkaloid levels.

Table 3 Total alkaloid content (mg) in seeds for a range of drought stress treatments on Mandelup lupins (R French unpublished data)

Inside rainshelter	Total alkaloid content in seed (g/m ²)
Stress flowering to maturity	34
Stress flowering to start grain fill	260
Well watered flowering to maturity	1211
Well watered flower to start grain fill	224
Outside rainshelter	
Stress flowering to maturity	40
Stress flowering to start grain fill	445
Well watered flowering to maturity	1129
Well watered flower to start grain fill	100

In this experiment alkaloid level was positively correlated with seed weight, although the level in the stress from flowering to start grain filling treatment in the rain shelter deviates from this simple relationship. Even the lowest alkaloid levels in the Danish work (W26, stressed at flowering, 0.07 per cent) was more than twice the highest level in the Australian work (well-watered flowering to maturity in the rain shelter, 0.034 per cent). This may have been due to different cultivars being used in the two studies, and the differences between W26 and Polonez in the Danish study show there are large differences in alkaloid level in the seed for even nominally sweet lupin varieties. Alternatively, it could have been due to the different growth environment. Plants grown in Denmark are largely stress-free for the whole life cycle apart from short stress periods and fill their grain under very long day length. In Australia plants experience extended periods of stress in most treatments and grain is filled under much shorter day lengths. The greater proportional response of alkaloids to drought stress treatments in Australia is likely due to greater severity of stress, at least in terms of its effect on grain yield. In Australia, the highest and lowest yields differed almost six-fold, whereas in Denmark they differed by less than 10 per cent for W26, 58 per cent for Polonez and 53 per cent for Zubr. However, the absolute response of sweet cultivars in the two studies is not very different (the difference between the lowest and highest was 0.027 per cent for W26, 0.04 per cent for Polonez, and 0.03 per cent for Mandelup).

The possibility that late rain can cause an increased level of total alkaloid in the seed is contrary to the general experience that alkaloid levels in lupin delivered in drought years is high. It has been shown that most alkaloid production is in the pods rather than other organs in the plant (Lee et al. 2007) so having pods green and actively growing from late water supply would appear to be increasing the alkaloid concentration in the seed. Additionally, a common symptom of Mn deficiency in the field is 'regreening' of the crop so the mechanism of increased alkaloid production could be similar to that observed in the irrigation trial. Further research is required to elucidate the exact mechanism linking pod filling and nutrient supply with increased alkaloid levels in the seed of sweet varieties.

CONCLUSION

This paper has examined some factors that affect alkaloid levels in narrow-leaved lupin seed in Western Australia. Potassium and manganese deficiency can lead to higher alkaloid levels. In a field experiment carried out at Merredin in 2008 drought reduced seed alkaloid levels. This effect was opposite to that found in Danish research and contrary to the general understanding within the WA lupin research community. The physiological mechanisms for higher alkaloid production under the regimes of nutrient deficiency and higher water supply during grain filling in the seed are not known. It is clear that some of these factors will not be entirely under the grower's control. However, there needs to be greater understanding of the underlying mechanisms so that useful predictions of the level of alkaloid in lupin seed across the growing areas can be made.

KEY WORDS

quinolizidine alkaloids, phosphorus, potassium, manganese and drought

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REFERENCES

- Brennan, RF 1993, Treatment of manganese deficiency (split seed) in narrow leafed lupin Farmnote 71/93 Department Agriculture WA, Perth.
- Christiansen, JL, Jornsgrard, B, Buskov, S & Olsen, CE 1997, Effect of drought stress on content and composition of seed alkaloids in narrow-leafed lupin, *Lupinus angustifolius* L. European Journal of Agronomy 7: 307–314.
- Cowling, W & Tarr, A 2004, Effect of genotype and environment on seed quality in sweet narrow-leafed lupin (*Lupinus angustifolius* L Australian Journal of Agricultural Research, 55: 745–751.
- Culvenor, CCJ & Petterson, DS 1986, Lupin toxins—alkaloids and phomopsins. Western Australian Department of Agriculture, South Perth, Australia, Proceedings of the Fourth International Lupin Conference, Geraldton, Australia, 15–22 August 1986, pp. 188–198.
- French, RJ 2002, Crop updates Lupin genotypes respond differently to potash. In: Agribusiness Crop Updates 2002 Lupins updates ed A McLarty pp. 46.
- Gremigni, P, Gazey, C, Hamblin, J & Harris, D 1998, Adequate K and Mn decrease the risk of high alkaloids in lupin seed In: Agribusiness Crop Updates 1998 Lupin Updates ed G.Shea pp. 52.
- Gremigni, P, Wong, MTF, Edwards, NK, Harris, D & Hamblin, J 2001, Potassium nutrition effects on seed alkaloid concentrations, yield and mineral content of lupins (*Lupinus angustifolius*). Plant and Soil, 2001, 234, 1, pp. 131–142.
- Gremigni, P 2002, Control of seed alkaloid levels in narrow-leafed lupins (*Lupinus angustifolius* L.) through management of plant nutrition and agronomic practices PhD Thesis University of Western Australia.
- Gremigni, P, Hamblin, J, Harris, D & Cowling, WA 2003, The interaction of phosphorus and potassium with seed alkaloid concentrations, yield and mineral content in narrow-leafed lupin (*Lupinus angustifolius* L. Plant and Soil, 2003, 253, 2, pp. 413–427.
- Harris D.J. 1994, Quality production and breeding. In 'Proceedings of The 1st Australian Lupin Technical Symposium'. Perth, WA (Eds M Dracup, J Palta) pp. 98–105. (Department of Agriculture, Western Australia: Perth, W. Aust).
- Jansen, G, Jürgens, HU & Ordon, F 2009, Effects of temperature on the alkaloid content of seeds of *Lupinus angustifolius* cultivars. Journal of Agronomy and Crop Science, 2009, 195, 3, pp. 172–177.
- Lee, MJ, Pate, JS, Harris, DJ & Atkins, CA 2007, Synthesis, transport and accumulation of quinolizidine alkaloids in *Lupinus albus* L. and *L. angustifolius*, Journal of Experimental Botany, 2007, 58, 5, pp. 935–946.
- Reader, MA, Dracup, M & Atkins, CA 1997, Transient high temperatures during seed growth in narrow-leafed Lupin (*Lupinus angustifolius* L.). I. High temperatures reduce seedweight. Australian Journal Agricultural Research 48: 1169–1178.