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Next Meeting	**'Beware Jack Frost'**
Venue	**Richardson Theatre, Roseworthy Campus**
Date	**WEDNESDAY 20th AUGUST**
Time	**7.30 pm**

Speakers

Glenn McDonald: University of Adelaide
'Nitrogen'
Glenn will talk about N efficiency given this wet winter. What is N availability at this stage and how much will we need this season?

Michael Laws: University of Adelaide
'Frost'
A topical issue! The cold weather is much later this year, at a risky time of crop development. Michael will tell us what the Frost Research Program is doing to reduce frost losses and risk.

Pulse Variety Tolerance to Herbicides - 2013 Update

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Key Outcomes

In 2013 at Minlaton,

- Simazine caused the largest reductions to grain yield in all pulse crops.
- Of lentil varieties, Nipper was the most sensitive to the Group C herbicides and PBA Ace the most tolerant.
- PBA Herald XT and PBA Hurricane XT lentils displayed increased tolerance the herbicide Broadstrike®.
- Chickpea variety, PBA Striker appears more sensitive to simazine and Terbyne® compared to the other varieties evaluated.
- PBA Oura field peas were found to show increased tolerance to simazine and Terbyne® compared to other newly released varieties.

Treatments

A series of trials were conducted in 2013 to assess the herbicide tolerance of four varieties of field pea, three varieties of chickpea, six lentil varieties and two faba bean varieties at the Minlaton central YPASG site. A range of commonly used herbicides and tank mixes were applied at label recommended and higher than recommended rates to provide information on varietal tolerances and safety margins. This was achieved through observing differential responses between the two rates and an unsprayed control. Several weeks after herbicide applications, trials were assessed for visual damage and repeated approximately 3-5 weeks later. Trials were also assessed for biomass and phytotoxicity symptoms using a Greenseeker to measure the NDVI (Normalised Difference Vegetative Index). Grain yield was also recorded and results were analysed using spatial analysis techniques (REML). The measure of NDVI and grain yield were comparative to the unsprayed control

All trials were sown on the 18th June with seeding rates appropriate for each crop type. Trials were sown relatively late in order to achieve a high weed germination to provide best as possible weed control prior to the commencement of the trial. Trials were sown with narrow knife points at 9-inch spacing with press wheels, and rolled immediately. DAP @ 70kg/ha was drilled with the seed at an approximate depth of 4-5cm. Chickpea rhizobia nodulation was encouraged by sowing Nodule-Aid with seed. Each experiment included 6–8 herbicide treatments at high and low rates and a series of unsprayed controls.

Trial Results

Lentil

Newly released varieties, PBA Bolt and PBA Hurricane XT was introduced in 2013 herbicide tolerance trials, whilst PBA Ace, PBA Flash, PBA Herald XT and Nipper were tested again as in the previous year.

Table 1: *2013 Lentil yields under common in-crop herbicide applications at recommended (R) and double the recommended (2R) rates of application, expressed as a % of control. Highlighted values represent significant yield reductions (P<0.05).*

		PBA Ace	**PBA Bolt**	**PBA Flash**	**PBA Herald XT**	**PBA Hurricane XT**	**Nipper**
Control	**(t/ha)**	2.68	2.72	2.48	2.18	2.46	2.17
Broadstrike®	**R**	95	**86**	90	108	108	**86**
	2R	**89**	**78**	**82**	113	109	**84**
Brodal®	**R**	96	103	104	108	98	106
	2R	101	101	100	93	99	100
Diuron	**R**	107	107	104	110	105	104
	2R	106	102	107	110	106	100
Metribuzin	**R**	103	93	95	102	104	88
	2R	**71**	**69**	**62**	**57**	**73**	**39**
Simazine	**R**	**75**	**63**	**58**	**63**	**67**	**36**
	2R	**46**	**31**	**33**	**18**	**29**	**14**
Terbyne®	**R**	102	**71**	**74**	88	95	**60**
	2R	**53**	**28**	**36**	**22**	**37**	**18**

* For rates and timings of application, please refer to Table 5.

The Group C herbicides tested including, metribuzin, simazine and Terbyne (terbuthyazine) caused significant yield reductions to all varieties. The severity of the yield loss varied across varieties and herbicides. Simazine was the most damaging causing significant yield losses in all varieties at both rates tested. Nipper was clearly identified as the most sensitive to simazine, incurring a 64% yield reduction at the label recommended rate and 86% reduction at the higher rate. Other varieties tested showed similar levels of tolerance to simazine, apart from PBA Ace which showed slightly increased tolerance compared to the other varieties tested.

Herbicide damage was less severe for the other Group C chemistry's in metribuzin and Terbyne, but degrees of varietal tolerance were very similar. Metribuzin caused significant yield losses at the two times label rate for all cultivars, with Nipper incurring the highest yield loss of over 60%. Other varieties tested had similar levels of tolerance ranging between approximately 30-40% yield losses. Terbyne was more damaging than metribuzin, with PBA Bolt, PBA Flash and Nipper incurring yield reductions at the label rate. Higher crop damage can be expected from Terbyne in this trial as it was applied at post-sowing pre-emergent rather than incorporated by sowing as per label recommendations to best identify differences in tolerance between varieties. Nipper, known for its sensitivity to Group C's, again was the most sensitive incurring a 40% reduction at the label rate. PBA Ace was again the most tolerant and PBA Herald XT and PBA Hurricane XT showed intermediate levels of tolerance with no significant yield reductions at the label rate.

Broadstrike (flumetsulam) caused significant yield losses in PBA Bolt and Nipper at the label recommended rate. PBA Ace and PBA Flash were found to be slightly more tolerant, only suffering significant yield losses at the above label rate. While PBA Herald XT and PBA Hurricane showed their improved level of tolerance to Broadstrike by not incurring a yield reduction at either rate.

Of the other herbicides tested, Brodal (diflufenican) and diuron showed no significant yield losses in any variety, therefore no varietal differences in tolerance could be identified.

Chickpea

During 2013, three chickpea varieties were evaluated for herbicide tolerance. They included Genesis 090 (small kabuli), newly released PBA Monarch (medium kabuli) and PBA Striker (desi). Similarly to the lentil trial, simazine was the most damaging herbicide to chickpea varieties during 2013. All varieties suffered very similar yield reductions at the above label rate and only PBA Striker was found to have a significant loss of 13% at the label rate. This suggests PBA Striker may be more sensitive to simazine than the other varieties tested. It also was the only variety to have a significant yield loss when Terbyne was applied, 20% loss at the above label rate. This also supports data from the previous year, where PBA Striker was found to be more sensitive to other Group C chemistries in metribuzin and Terbyne. This trend over the past two seasons suggests PBA Striker may be less tolerant of Group C herbicides than other chickpea varieties, but further testing is required to confirm this.

Table 2: *2013 Chickpea yields under common in-crop herbicide applications at recommended (R) and double the recommended (2R) rates of application, expressed as a % of control. Highlighted values represent significant yield reductions (P<0.05).*

		Genesis 090	PBA Monarch	PBA Striker
Control	**(t/ha)**	2.11	2.09	2.42
Balance®	**R**	117	115	111
	2R	112	115	104
Broadstrike®	**R**	101	97	93
	2R	94	90	91
Metribuzin	**R**	114	114	113
	2R	115	110	91
Outlook®	**R**	100	107	110
	2R	107	108	100
Simazine	**R**	96	102	**87**
	2R	**70**	**72**	**71**
Terbyne®	**R**	120	117	110
	2R	94	99	**80**

* For rates and timings of application, please refer to Table 6.

Of the other herbicides tested during 2013, Balance (isoxaflutole), Broadstrike, metribuzin and Outlook (dimethenamid) showed no significant differences to untreated controls at either rate for each of the varieties tested. Long-term summary tables should be used to access the level of tolerance to these herbicides for current chickpea varieties.

Field Pea

During 2013 four field pea varieties were assessed for herbicide tolerance, this included PBA Gunyah, PBA Pearl, PBA Oura and yet to be released line, OZP1101. Again simazine caused the largest losses to grain yield compared to all the other herbicides tested. Simazine cause similar yield reductions at both of the applied rates in all varieties evaluated except for PBA Oura. PBA Oura grain yield was unaffected at label rate applications of simazine, other varieties yield loss ranged from 14-16%. For the two times rate of simazine again PBA Oura showed no significant loss compared to losses ranging from 28-35% in other varieties. This difference in varietal tolerance response was identical for the application of Terbyne, where only PBA Oura had no significant yield reduction at the two times rate. This supports long-term data, which shows PBA Oura has increased tolerance to Group C herbicides, simazine, Terbyne and metribuzin.

Table 3: *2013 Field Pea yields under common in-crop herbicide applications at recommended (R) and double the recommended (2R) rates of application, expressed as a % of control. Highlighted values represent significant yield reductions (P<0.05).*

		PBA Gunyah	PBA Pearl	PBA Oura	OZP1101
Control	**(t/ha)**	3.29	3.38	3.19	3.39
Broadstrike®	**R**	97	98	100	99
	2R	99	97	98	104
Brodal® + MCPA Amine	**R**	101	97	101	101
	2R	97	101	99	102
Diuron	**R**	103	104	99	103
	2R	102	101	98	105
Metribuzin	**R**	101	101	109	98
	2R	95	102	103	99
Outlook®	**R**	99	97	99	99
	2R	100	97	99	101
Raptor®	**R**	105	100	105	104
	2R	102	**88**	101	102
Simazine	**R**	**86**	**85**	101	**84**
	2R	**72**	**71**	94	**65**
Terbyne®	**R**	99	101	101	101
	2R	**87**	**91**	99	**86**

* For rates and timings of application, please refer to Table 7.

Of the other herbicides included in the testing process, only Raptor (imazamox) caused significant reductions in grain yield. For this herbicide, application at two times the recommended rate caused 12% reduction in grain yield for PBA Pearl. All other varieties tested were unaffected, suggesting PBA Pearl may be more sensitive. This was the first season this reaction from PBA Pearl has been observed in this evaluation program, therefore further testing is required to confirm this.

Broadstrike, Brodal + MCPA, diuron, metribuzin and Outlook caused no significant yield reductions at either of the rates tested for any varieties. As a result no differences in varietal tolerance can be identified from this trial. For any further information on these herbicides level of tolerance to current pea varieties refer to the long-term summary table.

Faba Bean

Two faba bean varieties were evaluated during 2013, they were Nura and soon to be released breeder line AF05069-2. Of all the herbicides tested, there were no significant yield reductions identified at any rate for either of the two varieties tested. From this no conclusions can be drawn on any differences in herbicide tolerance between Nura and AF05069-2. Also neither variety has shown any sensitivity to any of the herbicides tested during 2013. For herbicide safety ratings on these and other current varieties, refer to the long-term summary of this herbicide tolerance evaluation program.

Table 4: *2013 Field Pea yields under common in-crop herbicide applications at recommended (R) and double the recommended (2R) rates of application, expressed as a % of control. Highlighted values represent significant yield reductions (P<0.05).*

		Nura	AF05069-2
Control	**(t/ha)**	2.75	3.02
Diuron	**R**	107	104
	2R	105	98
Outlook®	**R**	103	99
	2R	100	98
Raptor®	**R**	105	94
	2R	91	91
Simazine	**R**	99	108
	2R	89	101
Spinnaker®	**R**	101	112
	2R	97	99
Terbyne®	**R**	95	99
	2R	104	91

* For rates and timings of application, please refer to Table 8.

Conclusion and into the paddock

This research has shown pulse varieties can differ substantially in their sensitivity to important selective herbicides when applied at registered label rates and timings. Therefore it becomes important to check the safety of various herbicide and variety combinations prior to sowing and spraying. Long term summaries should also be used to identify herbicide and crop varietal combinations for potential grain yield penalties, as herbicide tolerance is strongly influenced by seasonal conditions. Information pertaining to varieties, which have been tested in one year only, should be treated with caution pending further trials over multiple growing seasons.

Acknowledgements

SARDI New Variety Agronomy Groups based at Clare and Waite are greatly acknowledged for their support in management of the trials. This project is jointly funded by GRDC and the South Australian Government and is supported by cooperating farmers (Bruce Cook and Michael Richards, Minlaton).

Long-term summaries

The sensitivity of the variety is summarised using the following symbols based on the yield responses across all trials.

x-y% (w/z)	Significant yield reductions at recommended rate in w years out of z years tested.
x% (1/z)	Significant yield reduction at recommended rate in 1 trial only in z years of testing
N (w/z)	Narrow safety margin – yield loss at higher than recommended herbicide rate only in w years of z years tested.
✓ (z)	No yield loss during z years of testing.

Table 5: *Long-term summary of safety rating and potential % yield loss for lentil varieties to various herbicides and tank mixes.*

Herbicide		Broadstrike® Flumetsulam	Brodal Options® diflufenican	Diuron Diuron	Lexone® Metribuzin	Simazine* Simazine	Terbyne®* Terbuthylazine
Variety	**Years Tested**	1994-2013	1994-2013	1996-2013	1994-2013	2004-2013	2009-2013
PBA Ace	2012-2013	**N** (1/2)	✓(2)	✓(2)	**N** (2/2)	**25** (1/2)	**N** (2/2)
Aldinga	1994-2001	**N** (2/7)	**N** (2/7)	**N** (1/5)	**N** (3/7)	-	-
PBA Blitz	2010-2012	**10-13** (2/3)	✓(3)	**N** (1/3)	**10** (1/3)	**N** (3/3)	**N** (3/3)
PBA Bolt	2013	**14** (1/1)	✓(1)	✓(1)	**N** (1/1)	**36** (1/1)	**29** (1/1)
Boomer	2005-2009	**7-19** (2/5)	**7-11** (2/4)	✓(5)	**19** (1/5)	✓(5)	**N** (1/1)
Bounty	2009-2011	**12** (2/3)	**9** (1/3)	**N** (1/3)	**N** (2/3)	**9** (1/3)	**11** (1/3)
PBA Flash	2006-2013	**10-14** (3/8)	**N** (3/8)	**N** (1/8)	**N** (5/8)	**42** (1/8)	**26** (1/5)
PBA Herald XT	2012-2013	✓(2)	✓(2)	✓(2)	**N** (2/2)	**37** (1/2)	**N** (2/2)
PBA Hurricane XT	2013	✓(1)	✓(1)	✓(1)	**N** (1/1)	**33** (1/1)	**N** (1/1)
PBA Jumbo	2011-2012	**12** (1/2)	✓(2)	✓(2)	**N** (2/2)	**N** (2/2)	**N** (1/2)
Nipper	2004-2013	**8-20** (5/10)	**7** (1/10)	**N** (3/10)	**N** (6/10)	**13-64** (3/10)	**21-40** (2/5)
Northfield	1994-2004	**10-25** (3/9)	**16-24** (3/9)	**14** (1/7)	**17-19** (2/9)	✓(1)	-
Nugget	1999-2005	**6-20** (3/6)	**11** (1/6)	**N** (1/6)	**6** (1/6)	✓(2)	-
Rates (product/ha)		20g	150ml	1 L	280 g	1.2 L	1kg
Crop stage at spraying		6 weeks	6 weeks	PSPE	PSPE	PSPE	PSPE

* Denotes an off label use. This use is not endorsed by this data and no responsibility will be taken for its interpretation.

Table 6: *Long-term summary of safety rating and potential % yield loss for chickpea varieties to various herbicides and tank mixes.*

Herbicide		Balance®	Broadstrike®	Lexone®	Outlook®	Simazine	Terbyne®
		Isoxaflutole	Flumetsulam	Metribuzin	Di-methenamid-P	Simazine	Terbuthylazine
Variety	**Years Tested**	2004-2013	2004-2013	2004-2013	2012-2013	2004-2013	2009-2013
Almaz	2006-2007	✓ (2)	**N** (1/2)	**N** (1/2)	-	✓ (2)	-
Genesis 090	2004-2013	✓ (10)	**N** (2/10)	✓ (10)	**8** (1/3)	**11** (1/10)	**N** (1/10)
Genesis 079	2007-2009	✓ (3)	**16-20** (2/3)	✓ (3)	-	✓ (3)	✓ (1)
Genesis 114	2010-2011	✓ (2)	✓ (2)	✓ (2)	✓ (1)	**N** (1/2)	**N** (1/2)
Genesis 509	2005-2006	✓ (2)	✓ (2)	✓ (2)	-	✓ (2)	-
PBA Monarch	2012-2013	✓ (2)	**11** (1/2)	✓ (2)	✓ (2)	**N** (1/2)	✓ (2)
PBA Slasher	2008-2011	✓ (4)	**N** (1/4)	✓ (4)	✓ (1)	**N** (1/4)	**N** (1/3)
PBA Striker	2012-2013	✓ (2)	✓ (2)	**N** (1/2)	✓ (2)	**13** (1/2)	**N** (2/2)
Rates (product/ha)		100 g	20 g	280 g	1 L	1.2 L	1 kg
Crop stage at spraying		PSPE	6 weeks	PSPE	IBS	PSPE	PSPE

* Denotes an off label use. This use is not endorsed by this data and no responsibility will be taken for its interpretation.

Table 7: *Long-term summary of safety rating and potential % yield loss for field pea varieties to various herbicides and tank mixes.*

Herbicide		Broadstrike®	Brodal Options® + MCPA Amine	Diuron	Lexone®	Outlook®	Simazine*	Simazine + Diuron*	Raptor ®	Terbyne®
		Flumetsulam	diflufenican + MCPA Amine	Diuron	Metribuzin	Di-methenamid-P	Simazine	Simazine + Diuron	Imazamox	Terbuthylazine
Variety	**Years Tested**	1994-2013	1994-2013	2011-2013	1994-2013	2011-2013	2011-2013	1994-2010	1994-2013	2009-2013
Kaspa	2002-2012	**N** (1/11)	**11** (1/11)	**N** (1/2)	**N** (4/11)	✓ (2)	**N** (1/2)	**N** (1/8)	✓ (10)	**N** (1/4)
PBA Gunyah	2008-2013	**N** (1/6)	✓ (6)	✓ (3)	**N** (3/6)	✓ (3)	**14** (1/3)	**9-11** (2/3)	**11** (1/6)	**9** (1/5)
PBA Oura	2011-2013	✓ (3)	✓ (3)	✓ (3)	✓ (3)	**N** (1/3)	✓ (3)	-	✓ (3)	✓ (3)
PBA Twilight	2008-2011	**N** (1/4)	**N** (1/4)	✓ (1)	**13** (1/4)	✓ (1)	✓ (1)	**9** (1/3)	✓ (4)	**N** (2/3)
OZP1101	2012-2013	✓ (2)	✓ (2)	✓ (2)	✓ (2)	✓ (2)	**16** (1/2)	-	✓ (2)	**N** (1/2)
Parafield	1996 - 2005	**11-13** (2/10)	✓ (10)	-	**N** (5/10)	-	-	**29** (1/10)	**7** (1/10)	-
PBA Pearl	2012-2013	✓ (2)	✓ (2)	✓ (2)	✓ (2)	✓ (2)	**15** (1/2)	-	**N** (1/2)	**N** (1/2)
PBA Wharton	2012	✓ (1)	✓ (1)	✓ (1)	✓ (1)	✓ (1)	✓ (1)	-	✓ (1)	✓ (1)
Rates (product/ha)		25 g	125 ml + 125 ml	1 L	280 g	1 L	1.2 L	350 ml + 650 ml	45 g	1 kg
Crop stage at spraying		5 Node	5 Node	PSPE	3 Node	IBS	PSPE	PSPE	3 Node	PSPE

* Denotes an off label use. This use is not endorsed by this data and no responsibility will be taken for its interpretation.

Table 8: *Long-term summary of safety rating and potential % yield loss for faba bean varieties to various herbicides and tank mixes.*

Herbicide		Diuron®	Outlook®	Simazine	Simazine	Lexone ®	Spinnaker®	Raptor®*	Terbyne®
		Diuron	Di-methenamid-P	Simazine	Simazine	Metribuzin	Imazethapyr	Imazamox	Terbuthylazine
Variety	**Years Tested**	2000-2013	2011-2013	2000-2013	2001-2008	2003-2010	2000-2013	2003-2013	2009-2013
AF05069-2	2013	✓ (1)	✓ (1)	✓ (1)	-	-	✓ (1)	✓ (1)	✓ (1)
Farah	2002-2008	✓ (7)	-	**N** (1/7)	**6-18** (3/7)	✓ (6)	**28-39** (2/3)	**N** (3/6)	-
Fiesta	2000-2007	**N** (1/8)	-	**18** (1/8)	**21** (1/7)	✓ (5)	**11-32** (2/8)	**N** (4/5)	-
Fiord	2000-2002	**N** (1/3)	-	**N** (2/3)	**N** (1/2)	-	**18-30** (2/3)	-	-
PBA Rana	2009-2011	✓ (3)	✓ (1)	✓ (3)	-	**N** (1/2)	**14** (1/3)	**18** (1/3)	**N** (1/3)
Nura	2003-2013	✓ (10)	✓ (2)	**N** (1/10)	**N** (1/6)	✓ (8)	**10-53** (5/10)	**20** (1/10)	**N** (1/4)
Rates (product/ha)		1 L	1 L	1.5 L	1.5 L	280 g	85 g	45 g	1 kg
Crop stage at spraying		PSPE	IBS	PSPE	6 weeks	PSPE	PSPE	3-4leaf	PSPE

* Denotes an off label use. This use is not endorsed by this data and no responsibility will be taken for its interpretation.

Cereal varietal herbicide tolerance – 2013 results

Michael Zerner and Rob Wheeler, SARDI – New Variety Agronomy.

Key outcomes

Background

Australian cereal varieties are extensively tested to determine level of tolerance to commonly used herbicides in South Australia as part of a GRDC funded national program. All newly released varieties are tested to identify any potential herbicide sensitivity to provide additional information to cereal growers for the agronomic management of new varieties. Varieties are first tested in preliminary trials at higher than recommended rates of the herbicides to identify any sensitivity to specific herbicides. Once a significant variety and herbicide interaction has been identified, the variety is tested with the specific herbicide in more advanced trials using recommended and higher than recommended herbicide rates to determine the severity of the yield reductions caused by the herbicide.

Trial Results

Preliminary screening trials were conducted at Mallala, SA and advanced herbicide tolerance trials were conducted at Kybunga, SA during 2012. Trials were sown relatively late in order to achieve a high weed germination to provide best possible weed control, prior to trial commencement. All herbicide treatments were applied with good levels of soil moisture available to the crop early in the growing season. All cereal variety and herbicide entries selected in advanced trials were based on results in preliminary trials from previous years. Preliminary screening in cereal crops included the use of the following herbicides; Boxer Gold®, Sakura®, diuron + MCPA, Affinity Force®, Hussar®, bromoxynil + MCPA, Achieve®, Ally® + MCPA, Axial®, Conclude®, Glean®, Eclipse® + MCPA, dicamba + MCPA, Tigrex®, Broadstrike® and 2,4-D amine.

Wheat

A number of recently released varieties were screened in preliminary evaluation trials at Mallala during 2013. These varieties included Mace, Shield, Grenade CL Plus, Trojan, Lancer, Dart and Harper, as well as a range of breeder lines yet-to-be released. Of the herbicides used in the screening process, Achieve® (tralkoxydim) was found to be the most damaging, with four of the above mentioned varieties incurring significant yield reductions (Table 1). As preliminary screening involves the use of double the recommended rates of herbicide, Grenade CL Plus, Harper, Trojan and Shield have all registered narrow safety margins for the application of Achieve® and now will be evaluated in the advanced stage of testing. Ally® (metsulfuron) + MCPA also caused severe biomass reductions following application, but most varieties recovered, avoiding any impact on grain yield apart from Dart and Shield. Shield was also found to be sensitive to Hussar® (iodosulfuron) the other sulfonylurea herbicide used in the evaluation process. Further studies will now be undertaken to identify the extent of this sensitivity to sulfonylurea herbicides. Numerous other narrow safety margins were identified during 2013, refer to Table 1 for all observed significant yield reductions.

Table 1. Grain yield of wheat varieties with herbicide treatments applied at double the recommended rate in the Preliminary Evaluation trial at Mallala. Yields are expressed as a % of control. Shaded figures indicate a significant yield reduction at the P<0.05 level.

	Untreated control	Achieve®	Ally® + MCPA	Amicide 625	Axial®	Boxer Gold®	Dicamba + MCPA	Diuron + MCPA	Hussar®	Sakura®	Tigrex®
	t/ha	760 g/ha	14 g/ha + 1 L/ha	2.8 L/ha	500 mL/ha	5 L/ha	400 g/ha + 2 L/ha	500 mL/ha + 350 mL/ha	200 mL/ha	236 g/ha	2 L/ha
Dart	3.38	93	**89**	93	90	99	93	**84**	91	98	96
Grenade CL Plus	3.46	**84**	91	**87**	**87**	92	100	93	96	94	95
Harper	3.02	**84**	102	98	94	101	96	92	91	103	93
Lancer	2.76	99	100	106	100	102	102	95	97	95	98
Trojan	3.58	**89**	100	106	90	103	102	95	95	100	95
Mace	3.62	91	94	96	**83**	93	99	**89**	93	97	100
Shield	3.37	**87**	**85**	100	90	99	100	96	**81**	94	98

In the advanced evaluation trials conducted at Kybunga, a number of varieties were tested for their tolerance to dicamba after incurring yield losses in preliminary studies last year. Phantom was found to be sensitive to dicamba, suffering a 9% yield loss at the label recommended rate of 200 g/ha. Justica CL Plus and Kord CL plus continued to show mild sensitivity to dicamba with significant yield losses at double label rates of 400 g/ha (Figure 1). Emu Rock was tested with Sakura® (pyroxasulfone) during 2013 after indicating some sensitivity to the herbicide in the previous year's preliminary evaluations. This sensitivity was confirmed as Emu Rock was found to incur a 5% yield at the label rate of 118 g/ha (figure 1). This interaction will again be tested in the upcoming season and for all other responses of other current wheat varieties refer to the long-term summaries found on the NVT website.

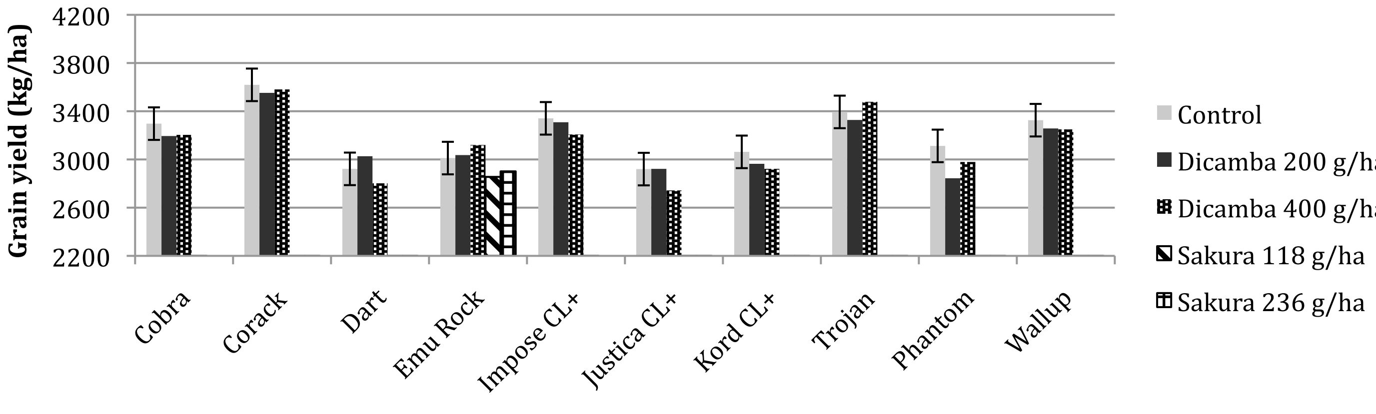

Figure 1. Comparison of wheat variety grain yields to the application of dicamba and Sakura® (Emu Rock only) at Kybunga, 2013. LSD (*p*<0.05) is shown on control treatment for each variety.

Barley

Barley grain yields ranged in-between 3-4 t/ha at Mallala in preliminary herbicide screening trials during 2013. Few of the tested varieties were found to suffer reduced yields resulting from herbicide application (Table 2). Fairview and GrangeR were found to have significant yield reduction from the application of diuron + MCPA at twice the recommended rate. Newly released La Trobe was found to be more sensitive to Tigrex® (diflufenican + MCPA), with a 13% yield decrease when applied at double rate. Further testing of these interactions will now occur during 2014 to identify the severity of these initial sensitivities.

Table 2. Grain yield of barley varieties with herbicide treatments applied at double the recommended rate in the Preliminary Evaluation trial at Mallala. Yields are expressed as a % of control. Shaded figures indicate a significant yield reduction at the P<0.05 level.

	Untreated control	Achieve®	Affinity Force® + MCPA	Ally® + MCPA	Amicide 625	Axial®	Boxer Gold®	Broadstrike®	Dicamba + MCPA	Diuron + MCPA	Tigrex®
	t/ha	760 g/ha	200 mL/ha + 1 L/ha	14 g/ha + 1 L/ha	2.8 L/ha	500 mL/ha	5 L/ha	50 g/ha	400 g/ha + 2 L/ha	500 mL/ha + 350 mL/ha	2 L/ha
Charger	2.99	108	101	114	101	100	100	90	105	102	101
Commander	3.64	98	105	102	103	96	99	95	98	93	96
Fairview	3.39	105	101	100	100	98	100	92	104	**86**	95
GrangeR	3.12	95	96	100	101	100	97	88	106	**85**	97
La Trobe	3.77	94	97	90	101	96	98	97	97	94	**87**
SY Rattler	3.30	99	99	94	103	89	98	91	112	91	94
Compass	4.15	107	104	105	112	96	99	102	106	91	97

In the advanced evaluation of barley varieties no significant yield reductions were found in any of the variety and herbicide combinations tested, having previously reported narrow safety margins in the preliminary testing stage. Only three varieties were tested, they included Fathom, Flinders and Westminster to a range of herbicides such as, Banvel M® (dicamba + MCPA), Broadstrike® (flumetsulam), dicamba, diuron + MCPA and Tigrex®. Despite no varietal sensitivity being identified during 2013, it is important to refer to long-term herbicide tolerance summary (located on NVT website) as the degree of herbicide sensitivity can be strongly influenced by seasonal conditions.

Oat

Three oat varieties were evaluated in preliminary trials at Mallala during 2013 and they were Bannister, Potoroo and Tammar. Of the 12 registered herbicides used in the screening process only dicamba + MCPA (400 g/ha + 2 L/ha) was found to cause a significant yield reduction in the variety, Potoroo (Table 3). In advanced evaluation experiments, dicamba was also the most damaging herbicide treatment, where the yield of Wombat was reduced by 19% at double the recommended rate (400 g/ha) (figure 2). Wombat has previously been identified to suffer severe yield reductions from the use of dicamba and this result confirms its sensitivity to this particular herbicide. All other variety and herbicide combinations in the advanced stage of testing were found to be safe (Table 3).

Table 3. Grain yield of oat varieties with herbicide treatments applied at double the recommended rate in the Preliminary Evaluation trial at Mallala. Yields are expressed as a % of control. Shaded figures indicate a significant yield reduction at the P<0.05 level.

	Untreated control	Affinity Force® + MCPA	Amicide 625	Broadstrike®	Conclude®	Dicamba + MCPA	Diuron + MCPA	Eclipse® + MCPA LVE	Glean®	Tigrex®
	t/ha	200 mL/ha + 1 L/ha	2.8 L/ha	50 g/ha	1.4 L/ha	400 g/ha + 2 L/ha	500 mL/ha + 350 mL/ha	100 mL/ha + 1 L/ha	40 g/ha	2 L/ha
Bannister	3.6	106	106	99	104	102	100	96	104	99
Potoroo	3.0	105	104	91	95	**81**	92	103	106	97
Tammar	2.0	103	107	93	103	102	108	103	109	100

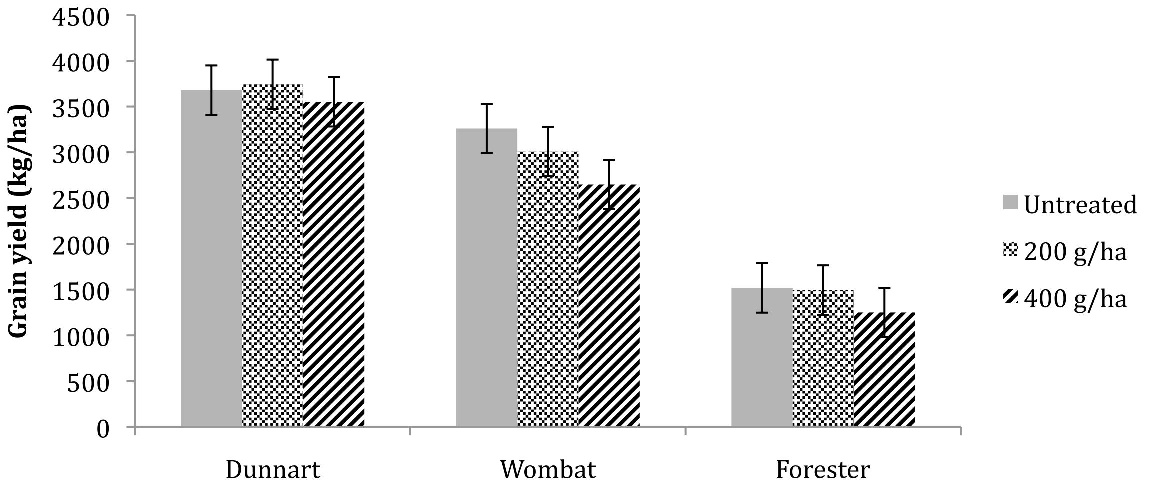

Figure 2. Comparison of oat varieties grain yields to the application of dicamba (200 g/ha and 400 g/ha) at Kybunga, 2013. LSD (*p*<0.05) is shown on herbicide treatments.

Conclusion and into the paddock

This long running research has identified cereal varieties can differ substantially in their sensitivity to commonly used herbicides when applied at registered label rates and timings. Therefore it becomes important to check the safety of various herbicide and variety combinations prior to sowing and spraying. Long-term summaries should also be used to identify herbicide and crop varietal combinations for potential grain yield penalties, as herbicide tolerance is strongly influenced by seasonal conditions. Information pertaining to varieties, which have been tested in one year only, should be treated with caution pending further trials over multiple growing seasons as environmental conditions can strongly influence herbicide interactions. Long-term summaries of herbicide tolerance testing for all crops can be found online from the NVT website (www.nvtonline.com.au).

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Achieving Success with Break Crops in the Mallee Farming System

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Take home messages

- Combined analysis of trials hosted by BCG and MSF show that first year effects of legumes are generally more reliable than oilseeds for improving subsequent wheat yield.
- Increased nitrogen supply could be measured up to two years following the break and played a key role in the break effects at Karoonda and Hopetoun where weed burden was low.
- Disease breaks tended to only last for one wheat growing season.
- Sites with a high grass weed burden require a two year break to reduce the weed seed bank to a level that enables consistent improvements in cereal production.
- Measuring the gross margin of production over a three-four year period showed that the inclusion of legume and canola breaks in the sequence was at least as profitable as continuous wheat.
- Two year breaks can increase the variability in gross margins in the years breaks are implemented but significant profit gains compared to continuous wheat were made at both sites for a small selection of treatments.

Methodology

In the last five years, break crops have been evaluated at Karoonda in the Southern SA Mallee (2009 and 2010), Mildura in the Northern Victorian Mallee (2011 and 2012), Chinkapook in the Northern Victorian Mallee (2011 and 2012), Hopetoun in the Southern Victorian Mallee (2009, 2010 and 2011) resulting in nine years of break crop site-year data with the effect of the break crop on subsequent wheat production measured for up to three years. In addition, the effect of the break crop on the level of nutrition, diseases and weeds were measured at the trials at varying levels of intensity dependent on the key limiting factors at each site. The break crops grown at each site varied but included species of legume (vetch, field pea, lupin, volunteer pasture), brassica (canola, juncea) and grass (cereal rye, barley, oaten hay) (Table 1).

Table 1. Treatments at each field site. Not every combination tested at Mildura and Chinkapook is shown.

Site	Site Average Annual Rainfall (mm)	Factors Limiting Continuous Wheat Yield	Soil Types	Break Crop Year	Break Crop Type	Break Crop
Karoonda	337	Low N and organic matter, Moderate soilborne disease inoculum	Deep Sand, sand over clay and clay loam	2009 2010	Legume Pasture Cereal Legume Brassica Pasture Cereal	Field Pea Volunteer Cereal Rye Lupin Canola Volunteer Cereal Rye
Hopetoun	342	Low N and organic matter, Moderate soilborne disease inoculum	Sand over clay and clay loam	2009	Brassica Legume Fallow Brassica Legume Fallow Brassica Legume Fallow	Canola, Juncea Peas, Vetch Fallow Canola, Juncea Peas, Vetch Fallow Canola Peas, Vetch Fallow
Mildura/ Chinkapook	275/332	High weed density, Moderate soilborne disease inoculum	Deep sand	2011 (one year breaks) 2011-2012 (two year breaks)	Cereal Brassica Brassica/Legume Legume Fallow	Barley, Oaten Hay Canola Canola/pea mix Peas Fallow Canola-chickpea Canola-pea Canola-vetch Chickpea-canola Fallow-canola Fallow-fallow Fallow-peas Medic-pasture Peas-canola Peas-vetch

Results and discussion

Effect of One Year Breaks at Karoonda and Hopetoun

A combined analysis of the effect of growing a legume or brassica break on subsequent wheat yield demonstrated that legumes provided a bigger yield effect than brassica (Figure 1). For a 2t/ha wheat crop the effect is approximately 0.9 t/ha additional yield following a legume break and 0.3 t/ha following a brassica break.

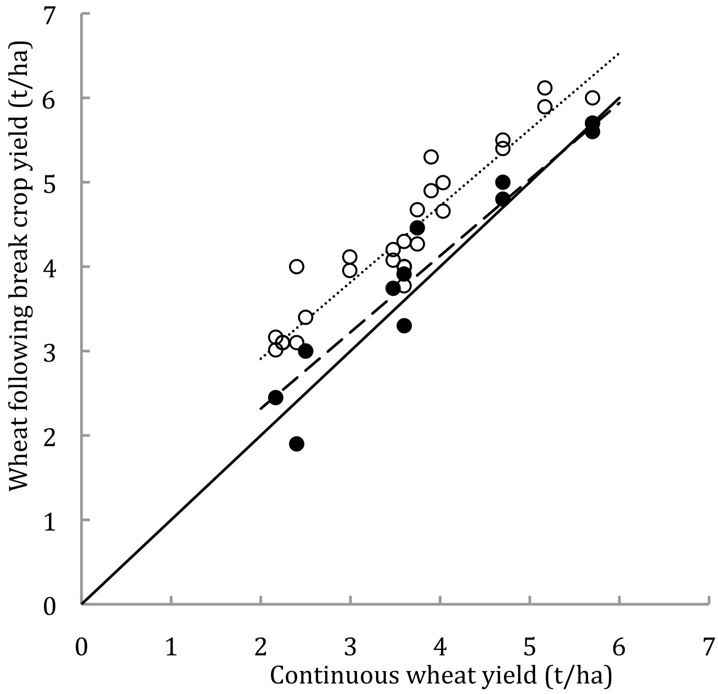

Figure 1. The relationship between yield of wheat following break crops and yield of continuous wheat at Karoonda and Hopetoun. Wheat yield following a *Brassica* break crop (●) was CW= 0.51 + 0.91 CW yield (dashed line), and following a legume break crop (○) was LW= 1.10 + 0.91 CW yield (dotted line) ($P<0.001$). Source: Kirkegaard et al. 2014.

One year breaks trialled at Mildura showed benefits of 0.3 t/ha of extra wheat production following a legume or fallow and 0.1 t/ha following a brassica, but weed populations constrained cereal yields following a single-year break (Moodie et al. 2014).

<u>Effect of Two Year Breaks at Mildura and Chinkapook</u>

Where weed populations were a major problem in continuous cereal, the break crop effect on cereal yield was large. These benefits were in the order of 0.75- 1.25 t/ha (continuous wheat yield 1.4 t/ha) in the first wheat crop grown after the two breaks at Mildura with two years of pasture returning the lowest benefit of the options tested (Figure 2). At Chinkapook the benefits were in the order of an extra 1.2 – 2.5 t/ha (where the average continuous wheat yield was 1 t/ha) and two years of chemical fallow returned the highest level of yield benefit while combinations of canola-peas, fallow-canola, two Clearfield (CL) wheats, and vetch hay-canola returned the lowest level of yield benefit (Figure 3).

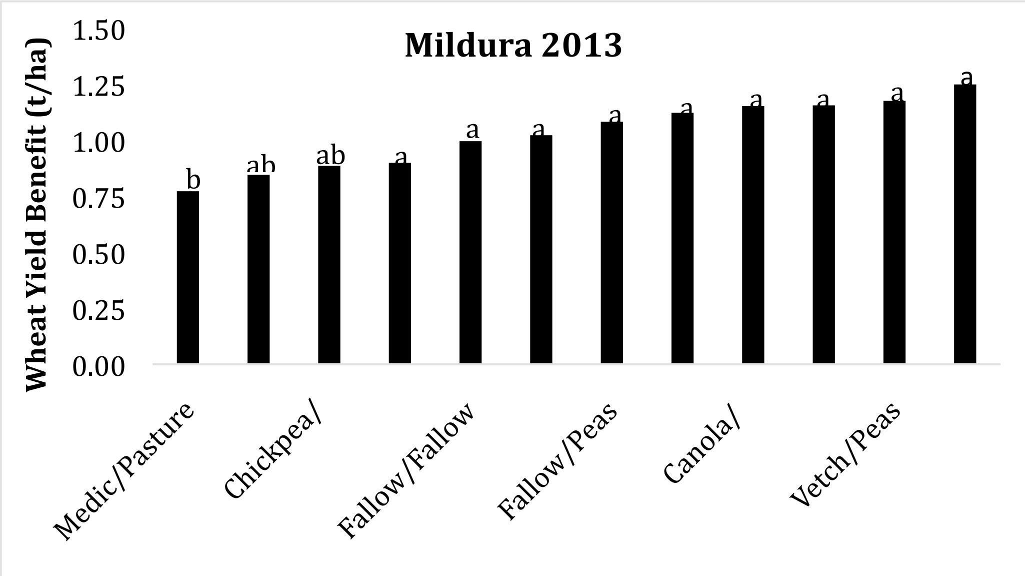

Figure 2. The extra wheat yield (compared with continuous wheat) generated when two break crops were grown in the preceding two years at Mildura. Treatments that are significantly different are annotated by a different letter (P<0.05, LSD 0.30 t/ha).

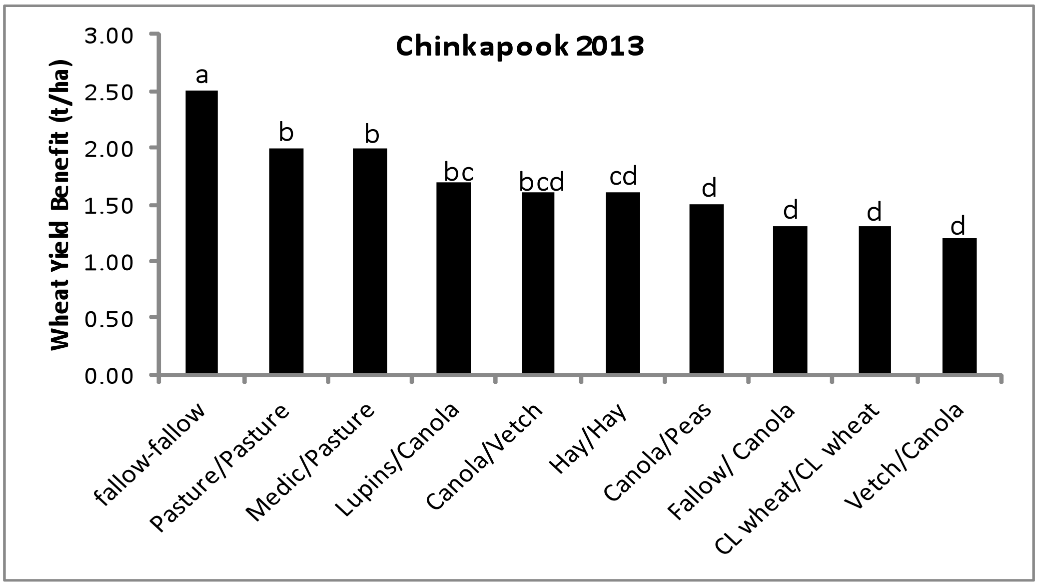

Figure 2. The extra wheat yield (compared with continuous wheat) generated when two break crops were grown in the preceding two years at Chinkapook. Treatments that are significantly different are annotated by a different letter (P<0.05, LSD 0.40 t/ha).

<u>Factors Causing the Break Effect</u>

Nitrogen

Break crops at all sites influenced the supply of nitrogen to subsequent crops. Wheat following vetch was consistently a highest yielding treatment at Hopetoun and atmospheric nitrogen fixation was measured at 77 (clay)-132 (sand) kg N/ha. Peas also fixed lower but significant amounts of atmospheric nitrogen with 48 (clay)-124 (sand) kg N/ha (Browne et al. 2012). At Karoonda measurements of nitrogen supply potential showed that canola caused an increase in nitrogen supply potential (through changes in the microbial activity) for the subsequent crop (14-29 kg N/ha/season) over all three soil types while legumes increased nitrogen supply (11-20 kg N/ha/season) on the clay loam and sand over clay soils. In addition there were carryover benefits into the second year after a pasture break (16-23 kg N/ha/season) (Gupta et al. 2012). At Chinkapook there were variable changes in mineral nitrogen following breaks compared with continuous wheat which had substantial soil nitrogen at 100 kg N/ha. Of note, a two year fallow led to a significantly higher level of soil nitrogen (136 kg N/ha) in the subsequent wheat crop. At Mildura the use of legume breaks resulted in significant increases in 0-60 cm soil mineral nitrogen with an additional 45-55 kg N/ha compared with continuous wheat (which had just 10 kg N/ha).

Disease

The main soilborne disease detected at all sites was rhizoctonia. The inclusion of non-cereal break crops resulted in lowered soilborne disease inoculum levels in subsequent cereal crops at all four sites. However, the effect of crop type on rhizoctonia disease incidence in the following wheat crop was variable and influenced by crop season. At Karoonda during 2010 when the rhizoctonia disease incidence was generally low, the effect of the 2009 break crop was not significant. A canola break in 2010 had the biggest effect of reduced disease incidence in the following 2011 wheat crop but the this break effect only extended into 2012 on the clay loam soil type and not the sand (Gupta et al. 2012).

Weeds

The primary grass weed pressure at both Chinkapook and Mildura was brome grass. By the end of 2013, the continuous wheat brome grass density at Chinkapook was 450 plants/m^2. Two year breaks were better than one year breaks for reducing brome grass numbers and those that included legumes or Clearfield technology reduced brome grass numbers to very low levels (6-12 plants/m^2) (Price 2014). The continuous wheat brome grass density at Mildura at the end of 2013 was 45 plants/m^2 (but 108 plants/m^2 for the wheat-barley sequence) and this was reduced to 6-14 plants/m^2 with two year sequences that included legumes and brassica and 19-33 plants/m^2 with sequences including a one year break (Moodie et al. 2014).

<u>Economics of Breaks in the Sequence</u>

One year breaks

The recent rapid increase in break crops in the Victorian Mallee, in particular vetch for brown manure suggests that growers perceive that they are of economic value, and the outcomes of field trials in the Mallee region support this perception to some degree. At both the Hopetoun and Karoonda trial sites, where weeds were not a major constraint, three-four year sequences that included break crops were found to be at least as profitable as continuous wheat (Browne et al. 2012; Llewellyn et al 2013). There was a higher level in variability in return in the year that the break crop was grown due to the variability in both price and yield that is inherent in the production of break crops in the Southern cropping region. The profitability of including the legume in the sequence was derived from the impact of the legume on subsequent wheat yield while the profitability of including the brassica was a result of strong prices for canola in the years that it has been grown (Kirkegaard et al. 2014).

Two year breaks

Three year gross margins at Chinkapook clearly demonstrate that while a two year fallow can generate substantial yield gain, the loss of two years of crop income has a high price. Sequences that included Clearfield technology had the best three year gross margin due to the major effect of reducing brome grass numbers. However, the potential risk and cost of the development of Group B resistance that may result from an over-reliance on this technology is not factored into this gross margin.

Three year gross margins at Mildura where brome grass was influential, suggest that most of the two year break options were at least equivalent to wheat and the breaks that generated the highest yielding wheat crop in 2013 (peas-vetch, canola-peas, canola-chickpea) generated up to an additional $316/ha/3 yrs.

Conclusion

Using a combined analysis of trials from across the Mallee environment we have shown that for single year break legumes are generally more reliable than brassicas for improving subsequent wheat yield. The legume break improved N supply. Two year breaks are required to manage weed seed banks effectively. Disease inoculum levels were lowered at all sites but the disease break effect tended to only last for one wheat growing season. T the effects on nitrogen supply were measurable in both the first and second year following the break. Measuring the gross margin of production over a three to four year period showed that the inclusion of most break options in the sequence was at least as profitable as continuous wheat. There were several examples where the inclusion of breaks in the sequence resulted in substantial potential profit gains.

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