Paddock variability — the next big challenge

Wave effect: A wave effect on cereal paddock near Finley 2008.

KEY POINTS

- Recent research has identified that variation within soil types is proving a significant barrier to effective crop nutrient management.
- Strip trials to determine trace element deficiencies produced 'wave effects' often seen in local crops.
- A variation in natural vegetation before clearing could explain some of the variability seen within paddocks.

WRITTEN BY
Dave Eksteen NSW DPI, Finley

Recent GRDC-funded research suggests that not only may soil types vary within a single paddock, but characteristics within a single soil type vary significantly, providing a challenge for optimal fertiliser management.

It is well known that paddocks on a single property are not uniform and often can display a number of soil types within even one paddock. Optimal fertiliser management during the past has been to treat different soil types separately, based on the assumption that each soil type is fairly homogeneous. But recent GRDC-sponsored research and grower demonstration trials have shown that this may not be the case.

The colourful maps generated by yield monitors show marked variation spatially in a paddock even across similar soil types. This has made the analysis and interpretation of yield data challenging.

In addition to the interpretation challenges, within paddock-variability can be a major constraint to crop production, at times overriding the treatment effects applied.

Paddock variability

During 2003, a GRDC-sponsored project used satellite imagery to produce biomass images (Silverfox) for each of 12 paddocks for the past 3–5 years. These images identified that, on average, 23 per cent of the paddocks showed low biomass production, 45% average biomass production and 32% above average biomass production. Soil tests were then taken to compare nutrition between the low-producing areas and the above average areas.

The soil tests revealed nutrition to be one of the main factors limiting yield in these low biomass areas (see Figure 1). The other factors contributing to low yields were waterlogging and non-wetting sands, which affected plant population, sowing time and yield.

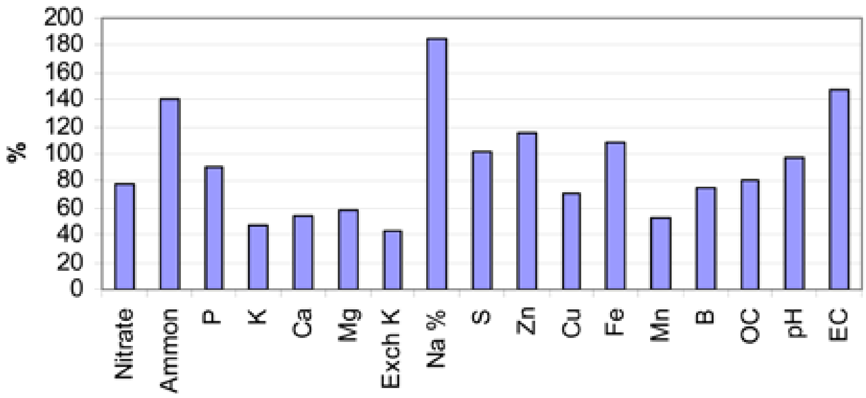

FIGURE 1 Low-producing area as a percentage of high-producing area

Figure 1 shows that potassium (K), Calcium (Ca), Magnesium (Mg) and Manganese (Mn) were the main nutrients that were much lower in the low-producing areas compared with the high-producing areas. The sodium (Na) levels were higher in the low-producing areas as were the salt levels higher when compared with the high-producing areas.

Strip trials were then carried out to see if trace element deficiencies could be reducing yields in some paddocks. The results produced an interesting trend, where there were notable 'wave 'effects in the paddock (see Figure 2).

It would appear there are strips or better and poorer areas, which affect yield and override the treatment effects.

Each treatment was one boomspray width (10 metres), with the control being 20m from the edge of the paddock and each treatment being applied every 10m.

This wave effect has since been noted in a number of other trials. When examining data from a pasture trial in NSW, and the data was plotted spatially, it showed a poor section in the trial from plots 5 to 7 across all three replications (see Figure 3).

Taking a closer look

In order to look at this variability more, a paddock was selected and soil samples taken every 10m from one corner to the other. The results showed high levels of variability in the phosphorus (P) and potash levels (see Figure 4). There also was a high variability in the above-ground dry matter (DM) production at each of these sample sites.

This variability probably accounts for the reason many trials do not show statistical significances between treatments.

The variability is caused by firstly the natural vegetation of long ago. Initially the landscape was not uniform with clusters of shrubs and trees, which would have had an effect on the nutrient deposition and accumulation in the soil. During clearing, vegetation was pushed into piles and burnt. Then the farming practices of laser levelling, broadcasting of fertiliser and nitrogen would have resulted in uneven nutrient application. Harvesting, windrowing and burning of windrows has added to this nutrient variability.

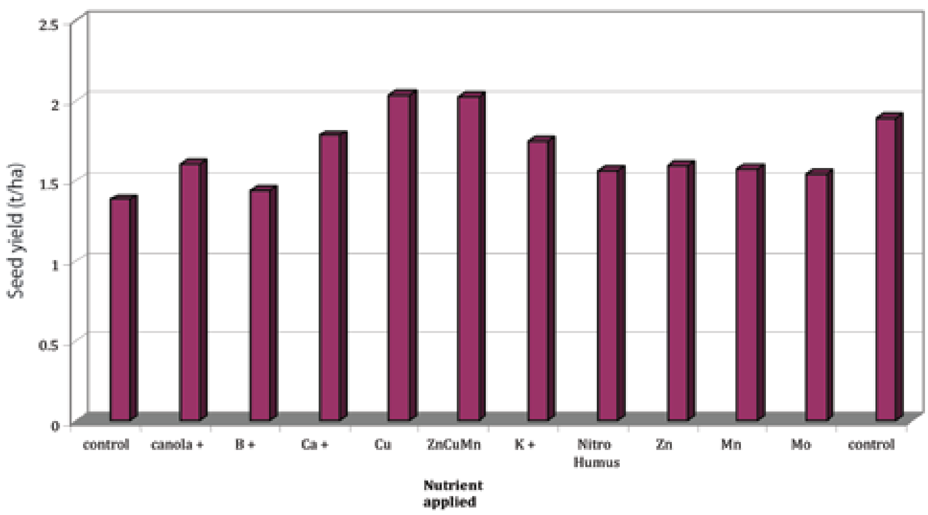

FIGURE 2 Tom Walker, nutrient demonstration trial (clay) — 2003

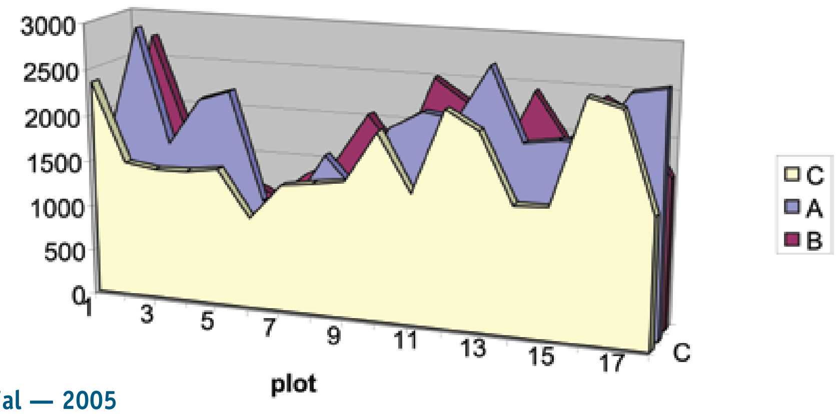

FIGURE 3 Pasture trial — 2005

FIGURE 4 Soil test results from samples taken every 10m in a linear line in a paddock

Site	Gravel (%)	Nitrate (ppm)	Ammonium (ppm)	P (ppm)	K (ppm)	S (ppm)	OC (%)	pH (water)	Exc Ca	Exch Mg	Yield (t/ha)
1	5–10	3	4	22	46	5.1	1.6	6.7	2.34	0.48	0.56
2	5–10	2	3	13	38	2.5	1.1	5.8	1.76	0.28	1.23
3	5–10	3	3	10	41	9.8	1.5	6.6	2.97	0.68	1.09
4	5–10	3	3	14	23	9.7	1.3	5.3	2.50	0.34	1.42
5	5–10	2	3	11	101	5.3	1.2	6.3	2.45	0.52	1.29
6	30–35	3	4	11	62	5.5	2.5	6.3	2.82	0.67	1.68
7	5–10	2	4	13	30	3.8	1.6	6.2	2.63	0.48	1.43
8	5–10	5	6	17	64	7.7	2.4	6.5	4.32	1.01	1.27
9	5–10	5	6	20	91	6.3	1.7	6.0	3.66	1.02	1.21
10	5–10	4	5	18	30	7.3	1.6	5.6	2.61	0.47	1.58

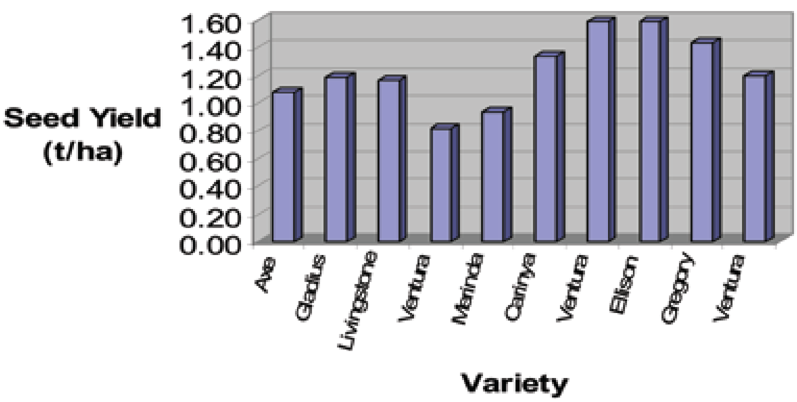

FIGURE 5 Cereal variety trial (plus fungicide) — Martin Robertson 2008

The wave effect

A recent trial at Logie Brae, Finley, confirmed this problem of 'wave' effects in paddocks (see Figure 5). Ventura wheat was sown as a control and yield followed the trend of the 'wave' confirming that paddock variability has overridden the variety effect.

One of the greatest challenges in improving crop production is firstly in identifying this variation in paddocks and then developing strategies to overcome the low yields from these paddocks. In this paddock, there was no visual difference in-crop, yet there was a significant yield difference. In many paddocks around the Finley region there are visually significant differences with these translating to huge losses to the grower.

We need to address this paddock variability in order to improve paddock yields and profitability.

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Best bets for fodder — production, nutrition and cost

Canola perfoms: Brassicas, such as canola, may be the best option for growers looking for potential fodder crops where water is a limiting factor.

WRITTEN BY
Dave Eksteen NSW DPI, Finley

High water costs and lack of availability are forcing growers in the Murray Region to evaluate feed options and find the best and most cost-efficient feed source to improve profitability. A recent trial carried out in the Finley, New South Wales district evaluated the performance of grazing cereals and some canola and grazing brassicas to determine how the quantity and quality of feed produced, the amount of water required and the cost per kilogram of feed stacked up under local conditions.

KEY POINTS

- High water costs and low availability could see producers turn away from irrigated pastures and to alternative fodder crops during winter.
- High yields and feed values could see brassicas such as grazing rape and turnips play a role in providing feed for mixed farming operations.
- Brassicas also outperformed cereals for water-use efficiency and costs of production, although at current water prices ($350/ML), silage production from both cereals and brassicas is uneconomical.

In the Murray Irrigation Area (MIA) the bulk of fodder for mixed farmers has been traditionally supplied by grazing irrigated perennial and annual pastures. In this system the key profit drivers are:

- Forage yield
- Utilisation of feed produced, and
- Feed conversion efficiency of fodder to livestock products (for example, milk and meat).

With the shortage and high cost of water many farmers are now moving away from summer pastures to silage and hay to assist with balancing the fodder availability thoughout the season.

Dairy Australia funded a three-year project at the University of Sydney, Camden, NSW, evaluating 30 forage species for dry matter (DM) yield, water-use efficiency and nutrient content. As feed costs represent 25–30 per cent of producers cash costs, it is crucial to get forage management right.

The results showed that a summer maize silage gave the best DM production per hectare (29t DM/ha), and best water-use efficiency (4.5t DM/ML), but the lowest profitability due to the higher cost of protein supplements.

Perennial ryegrass gave only 1.2t DM/ML yet it was found to be the best pasture option for profitability. This would not be necessarily the same for the Murray Region because of the high rainfall in Camden, different growing conditions and the lower irrigation cost.

Because of the high cost of water and lack of availability growers in the Murray Region need to evaluate feed options available and find the best feed sources that are the most cost efficient to improve profitability.

Local investigations

A trial was set up to evaluate grazing cereals and some canola and grazing brassicas to see how much feed could be produced under local conditions, the amount of water required and the cost per kilograme of feed.

The paddock selected was under maize during summer and cut for silage on March 15, 2008, yielding just more than 20t DM/ha.

The paddock was pre-irrigated on the April 4, 2008 and sown with knifepoints and press wheels with 90 kilograms per hectare Granlock 15 (50kg/ha urea broadcast before sowing). There were three replicates with grazed and ungrazed treatments, sown on two sowing dates, the April 10 and May 9, 2008. The plots were 1.56 metres wide and 10m long (6 rows at 26 centimetre spacing).

Nine grazing wheat varieties were used, two barley varieties, four triticale varieties, eight canola varieties, one grazing turnip (White Star) and one grazing rape (Greenland).

Yield results

There was no significant final yield difference between the two times of sowing for the cereals, although the earlier sowing did produce earlier grazing opportunities.

There was a significant reduction in DM production in the grazed canola sown one month later, showing the importance of early sowing for canola.

The following results are for first time of sowing.

The plots were cut three times (May 25, June 17 and July 15) with the exception of the brassicas which were only cut twice due to slow recovery after the second cut. The plots were then harvested for silage on the September 26 for the brassicas and October 10 for the cereals.

The results are shown in Table 1. The first cut yielded between 40kgDM/ha to 400kgDM/ha. Although it must be noted that the erect varieties gave better yields because all the plots were cut at the same height (6cm) using a lawnmower. The more prostrate varieties gave lower yields but more was left behind enabling them to recover more quickly.

In this trial the canola brassicas were disappointing due to suspected carryover herbicide (Broadstrike) problems affecting growth.

The grazing turnip gave the best early production as well as the best final production (11.7tDM/ha).

The grazing rape (Greenland) gave the next best overall production but not the best early production.

The wheat gave the lowest total production. Overall the barley gave the best cereal production (8.4tDM/ha), followed by triticale (7.5tDM/ha) and then wheat (6.6tDM/ha).

When the plots were left and not grazed, cut only for the final dry matter production, the wheat, triticale and barley yielded less than the accumulated yields obtained by grazing (see Table 2). This indicates that these grazing varieties need to be grazed to stimulate tillering and DM production. Grazing the early sown canola reduced yields by 15% compared with the ungrazed plots. For the later sown canola the grazing reduced yields by 44%, reinforcing the need to establish canola early.

Sowing one month later did not have a big effect on the grazed and ungrazed cereal plots, but did have a significant effect on the later sown grazed canola.

Quality results

The grazing cereals and brassicas were analysed for hay quality at the each cut. Results are shown in Table 3.

The wheat provided high-quality feed for the first two cuts while the digestibility (59%) and crude protein (9.7%) dropped for the final cut. The barley had better quality for the final cut — digestibility 65% and crude protein 11.4%. The triticale was similar to the wheat in quality.

TABLE 1 Average dry matter yields of wheat, triticale, barley and canola at three cuts and the final cut.*

	Average dry matter production (t/ha)					
Sown 10/4/08	**1st cut**	**2nd cut**	**3rd cut**	**sub**	**Final cut**	**Total**
Grazed	23-May	17-Jun	15-Jul	Total	10-Oct	
Wheat	0.193	1.107	0.840	2.139	4.553	**6.693**
Triticale	0.306	1.315	0.932	2.552	4.966	**7.518**
Canola*	0.175	0.866		1.041	6.426	**7.467**
Barley	0.346	1.514	1.219	3.080	5.366	**8.446**
Greenland (GR)*	0.207	0.963		1.171	7.747	**8.918**
Whitestar (GT)*	0.424	1.196		1.620	10.102	**11.722**

* Note the final cut was October 10 for the cereals and September 26 for brassicas.
GR — grazing rape GT — Grazing turnip

TABLE 2 Comparison of total dry matter production (t/ha) of grazed and ungrazed treatments

	Total Dry Matter (tDM/ha)	
Sown April 10	Grazed*	Ungrazed
Wheat	6.693	6.253
Triticale	7.518	6.449
Canola	7.467	8.685
Barley	8.446	7.003
Greenland (GR)	8.918	12.102
Whitestar (GT)	11.722	10.519

* Grazed is total of 1st, 2nd, 3rd and final cut.
GR — grazing rape GT — Grazing turnip

	Total Dry Matter (tDM/ha)	
Sown May 9	Grazed*	Ungrazed
Wheat	6.399	6.232
Triticale	7.097	6.812
Canola	3.996	7.238
Barley	7.415	6.852
Greenland (GR)	7.062	10.954
Whitestar (GT)	8.089	10.891

* Grazed is total of 1st, 2nd, 3rd and final cut.
GR — grazing rape GT — Grazing turnip

TABLE 3 Quality analysis of feeds at three times of harvest*

Results	Wheat			Barley			Triticale		
	1st cut	2nd cut	3rd cut	1st cut	2nd cut	3rd cut	1st cut	2nd cut	3rd cut
Digestibility DMD (%)	65	69	56	52	59	65	56	68	55
Crude Protein (%)	25.3	24.5	9.7	18.8	20.6	11.4	21.6	23.1	9.3
Metabolisable Energy (MJ/kg DM)	8.5	9.3	8.0	6.3	7.1	9.5	7.2	9.1	7.8
Results	**TT Canola**			**Grazing rape**			**Grazing turnip**		
	1st Cut	2nd Cut	3rd Cut	1st Cut	2nd Cut	3rd Cut	1st Cut	2nd Cut	3rd Cut
Digestibility DMD (%)	50–60*	64	59	53	59	75	–	60	70
Crude Protein (%)	10–20*	25.6	16.6	18.8	22.6	14.7	–	20.4	20.0
Metabolisable Energy (MJ/kg DM)	6–9.0*	8.0	7.7	6.2	7.0	10.5	–	6.9	9.0

* The first cut was May 23, the second cut was June 17 and the third cut was October 10.

Photo: Kondinin Group

The canola gave incorrect readings for the first cut as there was a lot of sand and maize stubble in the sample. The second and final cuts showed good digestibility (64 and 59% respectively) and high protein levels (25 and 16% respectively). But the metabolisable energy was low (7.7 MJ/kg DM). This would have been due to the high frost damage resulting in few seeds developing.

The grazing rape and grazing turnip both gave excellent digestibility (70–75%) and protein (14–20%). The metabolisable energy was also the best (9–10.5 MJ/kg DM). Together with the high yields, the brassicas have a role to play in the formulating of quality feeds for mixed farmers.

Water-use efficiency (WUE)

Rainfall from sowing to harvest totalled 108mm, while the calculated evapo-transpiration for the crop from sowing to harvest was 484mm. The estimated irrigation from flood was:

- Pre-irrigation: 1.3ML/ha on March 30, 2008
- First irrigation: 0.9ML/ha on June 2, 2008
- Second irrigation: 1.1ML/ha August 29, 2008
- Third irrigation: 1.2ML/ha September 30, 2008.

The total irrigation used for the brassicas was 3.3ML/ha and the cereals 3.9ML/ha. This suggests that brassicas could perform better than cereals when water is limiting. For the sowing on the April 10, 2008 the WUE is shown in Table 4.

Economics

With the current cost of quality cereal hay at about $170–200/t, when irrigation water costs $350/ML then it was uneconomical to produce either cereal or canola silage (see Table 5). The cost per tonne dry matter was $360/tDM for canola and $490/tDM for wheat.

TABLE 4 Water-use efficiency (WUE) for early sowing (tDM/ML)

	WUE (t DM/ML)	
Sown April 10, 2008	Grazed*	Ungrazed
Wheat	1.71	1.60
Triticale	1.92	1.65
Canola	2.26	2.63
Barley	2.16	1.79
Greenland (GR)	2.70	3.66
Whitestar (GT)	3.55	3.18

* Grazed is total of first, second, third and final cut.
GR — grazing rape GT — grazing turnip

TABLE 5 Gross margin budgets for ungrazed treatments — GUNYA PARK 2008

	Wheat	Barley	TT Canola
Actual yield (DM t/ha) from uncut plots	6.2	6.9	8.0
Yield (DM t/ha) 20% LOSS	5.0	5.5	6.4
Expenses	**Wheat ($/ha)**	**Barley ($/ha)**	**TT Canola ($/ha)**
Spraying (herbicide)	6.00	6.00	6.00
Seeding (machinery)	10.50	10.50	10.50
Seed (100kg@0.97c/kg)	97.00	97.00	48.00
Granlock 15 (90kg/ha)	112.00	112.00	112.00
Herbicide (500ml glyphosate + 2L Tref)	20.50	20.50	20.50
Insecticide (300ml Fastac)	3.60	3.60	3.60
Urea pre (50kg/ha)	35.00	35.00	35.00
Nitrogen top dresses machinery (x3)	31.50	31.50	31.50
Urea (200kg/ha)	140.00	140.00	140.00
Sulphate of ammonia (200kg/ha)	80.00	80.00	80.00
Torpedo (100ml/ha)	11.50	11.50	
Achieve (500g/ha)	42.50	42.50	
Atrazine (4L/ha)			28.00
Aphid spray — Pirimicarb			11.60
Arial spray			15.00
Fungicide spray (x2)	12.00	12.00	
Folicure (145ml/ha x2)	14.50	14.50	
Irrigation (@$350/ML	1,365.00	1,365.00	1,155.00
Cutting/conditioning	35.00	35.00	35.00
Rake and bale (silage) $89/t DM	443.58	491.28	566.75
Total cost	**2,460.18**	**2,507.88**	**2,298.45**
Feed cost /t DM (@$350/ML)	493.61	454.33	360.94
Feed cost /t DM (@$80/ML)	281.72	263.57	221.02

If the water cost dropped to $80/ML (actual cost of pumping from bore) then canola produced the cheapest feed ($221/tDM).

Acknowledgements

Thanks to Garry Bond for sowing, spraying and assisting with the harvest, Lachlan and Adam Marshall for allowing the trial to be on their property and for irrigating the trial. Thanks also to GRDC for the funding supplied through the Irrigated Cropping Forum.

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OVERVIEW

Summing up the results

Previous research has shown that oats and other cereal grazing types normally used to help overcome winter feed shortages have higher daily winter growth rates than most pastures.

Oats were not used in this trial due to the need to use Trifluralin for grass weed control. But for overall forage production, oats will generally produce more than wheat, barley, cereal rye or triticale. Grain recovery, however, is not so clear cut, with winter wheats and triticale often having similar or even better grain yields than oats.

Quality tests on the forage value of oats, wheat, barley, cereal rye and triticale, when grown under similar conditions, are reported to show no significant differences in protein, energy and digestibility. In this trial the barley was slightly better quality than the wheat and triticale. But the brassicas showed the best feed quality of all fodder crops trialled.

This trial looked at grazing and then cutting the crop for silage to determine how much feed could be produced. This enabled the paddock to be double cropped and a summer maize and sorghum crop to be sown during November.

For the cereals, barley was the best early feed and overall cereal to sow, followed by triticale, then wheat. Canola did not produce early feed but did give better final dry matter yields. It was severely frosted, resulting in a low metabolisable energy in the resulting hay. The grazing rape and grazing turnip were high in dry matter production and quality and are worth further investigation as a possible feed source.

The economic analysis showed brassicas produce the cheapest feed. When irrigation water is $350/ML then feed is expensive. When the water price drops to $80 or less/ML then quality feed is produced for less than $300/t DM.

On-farm variety demonstrations provide local results

Varieties: Trials comparing varietal differences in wheat were affected more by in-paddock variation than variety alone.

WRITTEN BY
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Cereal variety and fungicide trials at local grower, Martin Robertson's property, *Logie Brae* during 2008 aimed to demonstrate which wheat variety is best suited to local conditions, but in-paddock variations had a greater effect on yields than variety.

KEY POINTS

- Local cereal trials aimed to determine the highest yielding wheat variety, under local conditions.
- Fungicide application on observed stripe rust had negligible yield effects when compared with a no-fungicide treatment.
- In-paddock variation proved more significant that any variety differences.
- In-paddock variation needs to be removed before meaningful variety comparisons can be made.

A strip with eight varieties was sown to a single seeder with, 300 metres long, with no replications. Ventura was sown into the rest of the paddock and used as control strips between the varieties. Varieties used included:

Axe, Gladius, Carinya, Livingstone, Merinda, Ellison, Gregory and Ventura.

The trial paddock was sown using a Janke airseeder with 9" row spacing on May 8, 2008 with 70 kilograms per hectare of diammonium phosphate (DAP) and 60kg/ha seed.

Stripe rust was observed on September 3, 2008 and half the trial was sprayed on September 16, 2008 with 145ml/ha Tebuconazole (Folicure) while the other half was left unsprayed.

The trial was harvested with a 1.8m plot harvester (25m rows) on November 26, 2008.

Ellison yielded the highest followed by Gregory and then Ventura (see Table 1).

From the yield results it would appear there was no benefit from applying the fungicide.

However, there was a plot effect that overrode the variety effect. If the results are viewed linearly then it can be noted there was a paddock effect (see Figure 1) — a 'good' area and 'poor' area. Varieties are listed in Figure 1 in the order in which they appeared in the paddock.

There is definitely a wave effect along the paddock. The Ventura was sown three times and in each plot the yield varies significantly. The Ventura next to the Ellison was on a 'good' part of the paddock, while the Ventura next to the Merinda was on a 'poor' part of the paddock. It would therefore be safe to say there is no variety effect, only a paddock effect.

TABLE 1 Yield results (t/ha)

Variety	Plus fungicide	No fungicide
Axe	1.07	1.17
Gladius	1.19	1.31
Livingstone	1.16	1.38
Ventura	0.81	1.11
Merinda	0.93	1.39
Carinya	1.33	1.43
Ventura	1.59	1.58
Ellison	1.59	1.69
Gregory	1.44	1.59
Ventura	1.20	1.37
Average yield	**1.23**	**1.40**

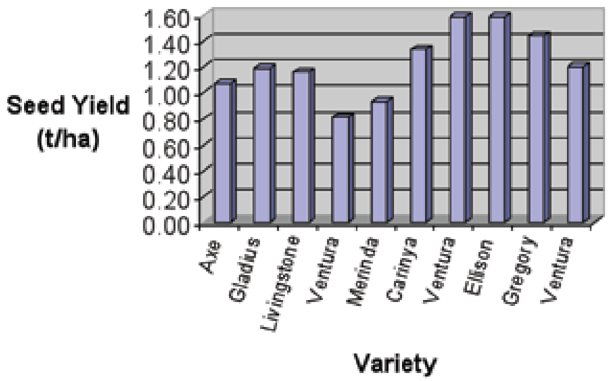

FIGURE 1 Cereal variety trial (plus fungicide)

The area sprayed with fungicide was also on a weaker part of the paddock, so it yielded less than the unsprayed section (see Figure 2).

Both plots show exactly the same trend in yield across the paddock, but with the sprayed plots yielding less.

This wave effect is common in growers paddocks and has been observed in trials in Western Australia (see Figure 3).

This paddock variation is greater than and overrides any treatment effects. And so, any variety comparison is meaningless until the paddock variability is eliminated.

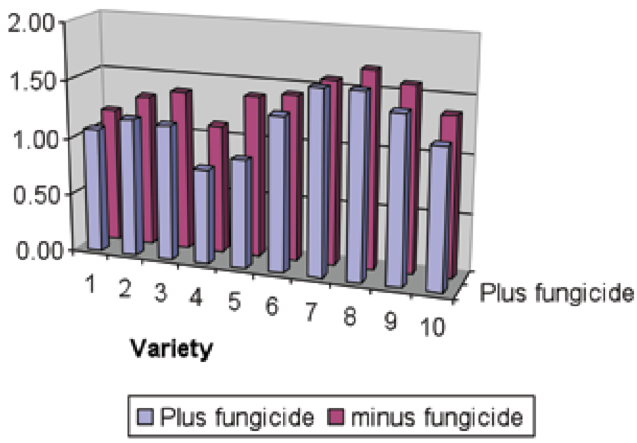

FIGURE 2 Linear yield of different varieties

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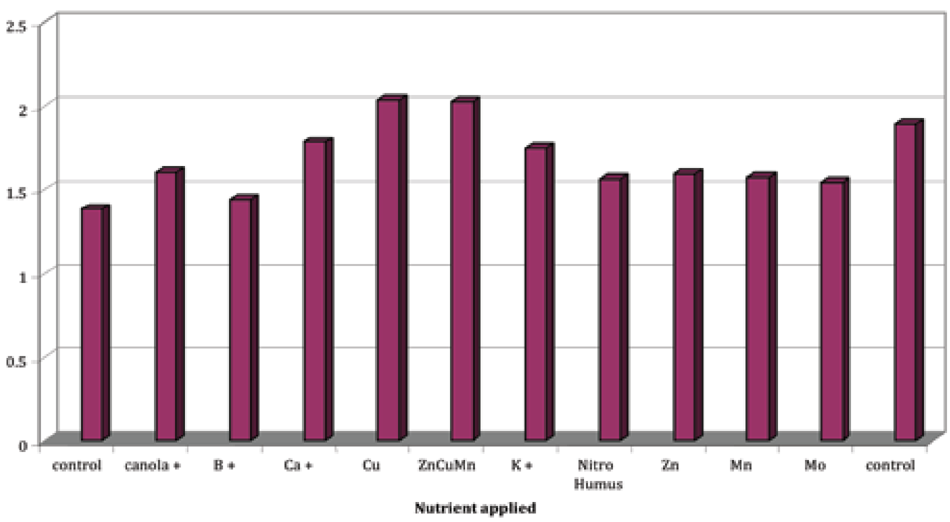

FIGURE 3 Nutrient demonstration trial on clay soil

Source: Tom Walker, 2003

North east Victorian phosphorous response trials

WRITTEN BY
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KEY POINTS

- **No responses to phosphorus (P) were observed on paddocks with a Colwell P greater than 61.**
- **A strong, positive response to applied phosphorus was observed in a paddock with a low Colwell P of 23.**

Aim

To observe phosphorous (P) responses in paddocks with a range of Colwell P values in north east Victoria.

Method

The data was obtained from replicated small plots installed at sites across the north east during 2008. Each of the four trial sites was selected on the basis of either being of low, medium or high Colwell P status. Each site was sown to plots that received 0, 5, 10, 20 or 40 units of phosphorus (as triple super), which was placed with the seed at sowing. All sites were sown on the same day using the same equipment. Yield was measured with a small plot header.

Results

See Table 1.

Observations and comments

Adding phosphorus to high phosphorus soils — At the Yarrawonga 'high' phosphorus site (84 Colwell), there was no significant response between the nil phosphorus and other phosphorus treatments. Given the background levels of phosphorus and the relatively low yield, there was more than adequate phosphorus available for plant uptake and growth. At this site, the Phosphorus Buffering Index (PBI) was very low at only 38, indicating a very high percentage of applied phosphorus would be available to plants and not bound to the soil in an unavailable form.

Adding phosphorus to medium-high phosphorus soils — At the Youanmite 'medium-high' phosphorus site (70 Colwell), there was no significant response to applied phosphorus. In this paddock, there were sufficient phosphorus reserves to achieve yields of

TABLE 1 Results of 2008 phosphorus trials at various sites throughout the north east

Boorhaman Colwell P = 61 PBI = 74		Youanmite Colwell P = 70 PBI = 53		Katamatite Colwell P = 23 PBI = 77		Yarrawonga Colwell P = 84 PBI = 38	
Units of P (kg/ha)	Yield (t/ha)	Units of P (kg/ha)	Yield (t/ha)	Units of P (kg/ha)	Yield (t/ha)	Units of P (kg/ha)	Yield (t/ha)
5P	2.57	10P	3.21	40P	2.06	20P	2.03
20P	2.57	20P	3.20	20P	1.88	0P	2.02
10P	2.49	5P	3.19	10P	1.47	40P	1.96
40P	2.46	40P	3.18	5P	1.27	10P	1.89
0P	2.45	0P	3.17	0P	0.93	5P	1.87
F prob	0.81 NS	F prob	0.998 NS	F prob	0.001	F prob	0.275 NS
LSD	0.33 NS	LSD	0.27 NS	LSD	0.2017	LSD	0.184 NS
CV%	7.8	CV%	5.5	CV%	8.6	CV%	6.1
Sowing date	15/5/08	Sowing date	15/5/08	Sowing date	15/5/08	Sowing date	15/5/08
Harvest date	4/12/08	Harvest date	22/12/08	Harvest date	22/12/08	Harvest date	22/12/08
NS — Not significantly different							

more than 3 tonnes per hectare without the addition of phosphorus fertiliser. The low PBI value (53) suggests most of the applied phosphorus was available to plants and not tied up in the soil.

Adding phosphorus to medium phosphorus soils — At the Boorhaman 'medium' phosphorus site (61 Colwell), there was also no significant response between the nil phosphorus and other plus phosphorus treatments. This indicates there was sufficient available phosphorus to meet the needs of the crop during 2008. Boorhaman also had a low PBI (74).

Adding phosphorus to low phosphorus soils — The Katamatite site was a relatively 'low' phosphorus site by north east Victorian standards (23 Colwell). At this site, the addition of phosphorus fertiliser at rates between 5 and 40kg/ha phosphorus gave significant, positive responses compared with the nil treatment. While there was a positive response to increasing the rate from 5 to 10 units of phosphorus, this was not significant. However, applying 20 units of phosphorus significantly increased yield above the 5 or 10 unit rate. Increasing the rate to 40 units gave a yield response but again, this was not significant compared to the 20kg/ha phosphorus application. This trial was almost textbook perfect in that there was a curvilinear response to increasing levels of phosphorus fertiliser. Crop growth and height was proportional to phosphorus rate. Of note was the obvious visual difference that 5kg of phosphorus per hectare made, even on seven inch row spacing.

Again dry seasons probably increase the likelihood of a phosphorus response. We live in hope that we might be able to test these phosphorus rates at higher than 3t/ha yields.

Summary

At the low yields of 2009 and the 'medium' to 'high' phosphorus sites, there was no yield advantage in applying phosphorus compared with the nil phosphorus treatment. This suggests soil phosphorus reserves in these paddocks were adequate to ensure crops yielded their maximum.

Where Colwell P levels are less than 35, crops will benefit from applications of phosphorus even after a succession of dry years. Above 35 Colwell yield responses are less predictable and are in the order of 10 per cent extra. Early sowing during April-May is an advantage to requiring less phosphorus.

Sponsors

Thanks to all the farmer co-operators.

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Boorhaman stubble trials 2008

WRITTEN BY

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Rob Harris DPI Victoria, Hamilton
for Boorhaman LANDCARE group

KEY POINTS

- **No significant yield losses or benefits were observed under retained stubble compared with burnt stubble.**

Aim

To observe crop yields and under varying stubble treatments.

Method

The Boorhaman LANDCARE group stubble management project funded by the National Landcare Project (NLP) finished during 2008, after three years of trials.

Paddocks were divided into large unreplicated strips of 100m+ long by 20m+ wide. Stubble treatments included, burning, mulching onto the surface, incorporating with a disc plough, mowing and raking or standing stubble. All stubbles were grazed. Summer weeds were controlled at Chiltern Valley, Boorhaman and Lilliput.

Results

See Tables 1-5: Results of stubble trials in the Boorhaman district, 2008.

TABLE 1 Cobbler canola sown May 22, 2008 into 2.5t/ha triticale stubble on 30cm spacing, harvested November 22, 2008

Boorhaman	Plants/m²	Hay (t/ha)	Grain (t/ha)
Standing	30	4.3	0.82
Mulched (mow)	27	4.1	0.61
Incorporated	20	4.0	0.61

TABLE 2 Whistler wheat sown May 5, 2008 into 0.2t/ha lupin stubble on 25cm spacing, harvested December 4, 2008

Norong	Plants/m²	Hay (t/ha)	Grain (t/ha)
Mulched (Coolamon harrows)	116	8.0	3.43
Burnt	129	8.6	3.26
Standing	120	8.0	3.24
Mulched/ incorporated	113	8.0	3.16

TABLE 3 Diamondbird wheat sown May 24, 2008 into 4t/ha triticale stubble on 17cm spacing, harvested December 4, 2008

Peechelba East	Plants/m²	Hay (t/ha)	Grain (t/ha)
Burnt	115	6.3	2.90
Standing	129	5.3	2.90
Mulched (weldmesh)	121	4.6	2.86

TABLE 4 Flipper chickpeas sown June 16, 2008 into 2t/ha oaten hay residue on 30cm spacing, harvested December 28, 2008

Lilliput	Plants/m²	Hay (t/ha)	Grain (t/ha)
Standing	24	1.5	0.55
Burnt	27	1.4	0.55

TABLE 5 Kosciuszko triticale sown June 4, 2008 into 2t/ha wheat stubble on 30cm spacing, harvested December 3, 2008

Chiltern Valley	Plants/m²	Hay (t/ha)	Grain (t/ha)
Burnt	143	7.2	2.63
Mow/rake	156	7.1	2.51
Mulched (mow)	152	6.8	2.44
Standing	160	7.0	2.32

Observations and comments

Generally, establishment was poorer where stubble was incorporated and direct drill equipment had difficulties with deep seed placement. More weeds were also present on incorporated plots.

The low stubble loads didn't affect establishment, with poorer germination occurring on burnt treatments at later sowings. The positive moisture retention effect from stubble on germination was probably the reason for this.

At four of the five sites there was no significant dry matter (DM) response to any treatment. Despite slightly lower plant numbers at the Peechelba East site there was visibly better growth on the burnt treatment. This site had the most stubble and the retained treatments may have suffered growth retardation due to alleopathy or nitrogen tie up.

There were few major yield differences at all sites, indicating rainfall was the most limiting factor. Where small differences occurred they could not be explained by soil water measurements or stubble treatment. At the Peechelba East site, where the greatest dry matter difference existed, this did not transfer into grain yield differences.

Sponsors

Thanks to the farmer co-operators, Boorhaman LANDCARE group and the National LANDCARE Program.

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Variety trial — Picola district

WRITTEN BY
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Location: Kotupna

Growing season rainfall:
GSR (Apr-Oct) 113mm

Soil:
Soil type: Grey loam over medium clay
pH (CaCl): 4.6 (0–10cm)
Colwell P: 44mg/kg

Sowing information:
Sowing date: 29 May 2008
Fertiliser: 40kg/ha
Nurtismart/MAP blend at 1:1

Row spacing: 25cm

Paddock history: 2007 — Canola

Plot size: 9.1 x 80m

Pepicates: 'Nearest neighbour' trial design

KEY POINTS

- **Earlier maturing lines fared better in this trial than the longer season types given the severe spring drought.**

Aim

To evaluate the performance of several recently released wheat varieties against established varieties in a low rainfall region near Picola, in Victoria's north east.

Method

A range of varieties was sown in plots measuring 80 metres x 9.1m (0.073 hectares) using the farmer's air seeder. The plots were sown on May 29, 2008 with 40 kilograms per hectare of a Nutrismart/MAP blend at a ratio of 1:1. Plots were harvested on January 2, 2009 using the farmer's header and a yield monitor.

Results

See Table 1.

Observations and comments

The crop was direct drilled into the previous years' canola stubble. Soil moisture was adequate at sowing, which resulted in good germination and emergence. Weed and disease pressures, including stripe rust, were not significant at this site. Some of the longer season types may have been slightly disadvantaged by a late May sowing.

This site experienced its third successive year of severe drought during spring. Site location, soil type differences and severe moisture deficit may have contributed to the high variability in this trial.

Catalina was the highest yielding variety at this site, followed by GBA Ruby, Ventura, Axe and Guardian. Catalina yielding significantly better than Gladius, Correll, Gregory and Diamondbird, but was not significantly different to the other top five varieties. The better performed varieties were all early-mid maturing types, which yielded more when compared to the mid-late maturing lines which included Gladius, Correll, Gregory and Diamondbird. The earlier types again proved to be better adapted to severe moisture deficit in spring, because they flower and set grain in relatively damper and cooler temperatures than their longer season counterparts. The poor performance of Diamondbird could not be explained.

TABLE 1 Yield results from the Picola variety trial

Variety	Maturity	Max quality classification	2009 stripe rust rating	Yield (t/ha)
Catalina	E-M	AH	MR-MS	0.98
GBA Ruby	E-M	ASW	R-MR#	0.65
Ventura (avg 4)	E-M	APW	MS	0.60
Axe	E	APW	MR	0.58
Guardian	E-M	APW	MS	0.58
Gladius	M	AH	MR-MS#	0.48
Correll	M	AH	MR-MS	0.45
Gregory	M-L	APW	R-MR	0.32
Diamondbird	M	AH	MS	0.16
			CV%	**17.9**
			LSD	**0.42**
			p prob	**0.10**

R = Resistant; MR = Moderately resistant; MS = Moderately susceptible; S = Susceptible; VS = Very susceptible
# Varieties with an as yet unknown reaction to new strains.
n/a — not available

Sponsors

Farmer Co-Operator: Murray Gilby, Kotupna.

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Variety trial Miepoll

WRITTEN BY
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Location: Miepoll

Growing season rainfall:
GSR: (Apr-Oct) 177mm

Soil:
Type: Grey loam over heavy clay
pH (CaCl): 4.7 (0–10cm)
Colwell P: 17mg/kg

Sowing information:
Sowing date: 23 May 2008
Fertiliser: 100kg/ha DAP

Row spacing: 20cm

Paddock history:
2007 — 'native' pasture
2006 — 'native' pasture

Plot size: 7.6 x 100m

Replicates: 'Nearest neighbour' trial design

KEY POINTS

- **Earlier maturing lines fared better in this trial than the longer season types.**
- **The 2007 Miepoll variety trial produced similar results to this trial, confirming that shorter season types work best during a tough season.**

Aim

To evaluate the performance of several recently released wheat varieties against established varieties in a higher rainfall region of north east Victoria.

Method

A range of varieties was sown in plots measuring 100 metres x 7.6m (0.076 hectares) using the farmer's air seeder. The plots were sown on May 23, 2008 and all varieties were sown at 85 kilograms per hectare with 100 kg/ha DAP. Plots were harvested on January 22, 2009 using the farmer's header and yield measured using a weigh bin.

Results

See Table 1.

Observations and comments

The crop was sown into a recently reclaimed 'native' pasture paddock, following cultivation to break up clods and grass tussocks. Soil moisture was ideal at sowing, which ensured good germination and emergence. Weed and disease pressures, including stripe rust, were not significant at this site. Sowing time was later than ideal for the longer maturing types, which may have put these varieties at a yield disadvantage.

Guardian was the highest yielding variety, followed by GBA Hunter and GBA Ruby, with EGA Gregory and Gladius rounding out the top five. None of the top five varieties had results that were statistically significantly different from each other; however the top five were all significantly higher yielding than Bolac, EGA Wedgetail and Chara. This highlights the advantage that earlier maturing varieties have over longer maturing types during seasons characterised by severe moisture stress. Interestingly Gregory, a longer maturing line, performed well in this trial despite the tough finish. The yield results are almost the same as last year's Miepoll variety trial in which Guardian, Ruby and Gregory were the top three performing varieties.

The top five varieties performed well given the season and must have benefited from subsoil moisture. Outcomes in a year with higher disease pressure and no fungicide control may vary depending on the resistance status of a given variety.

TABLE 1 Yield and quality results from the Miepoll variety trial

Variety	Maturity	Max classification	2009 stripe rust rating	Yield (t/ha)
Guardian	E-M	APW	MS	2.63
Hunter	E-M	FEED	R	2.57
GBA Ruby	E-M	ASW	R-MR#	2.57
EGA Gregory	M-L	APW	R-MR	2.37
Gladius	M	AH	MR-MS#	2.32
Sentinel	M-L	ASW	R-MR	2.22
Bolac	M-L	AH	R-MR	1.70
EGA Wedgetail	L^	APW	MR-MS	1.70
Chara (avg 5)	M-L	AH	MS-S	1.38
			CV%	**5.4**
			LSD	**0.39**
			p prob	**0.002**

R = Resistant; MR = Moderately resistant; MS = Moderately susceptible; S = Susceptible; VS = Very susceptible
# Varieties marked may no longer be resistant due to the occurrence of new races making these varieties susceptible.
^ Winter wheat requiring some vernalisation.

Sponsors

Farmer Co-Operator: Albert and Mervyn Gough, Gerald Kennedy, Miepoll.

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Optimum cutting time and forage mix for quality silage or hay

WRITTEN BY
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Location: Henty field day site
Growing season rainfall: **Annual:** 464mm **GSR:** 278mm
Soil type: Red loam
Sowing information: **Sowing date:** May 13, 2008 **Fertiliser:** 100kg/ha GLS
Paddock history: **2007** — wheat **2006** — wheat **2005** — canola
Plot size: 20 x 3m
Replicates: 3

KEY POINTS

- **Cut forage crops at optimum time to achieve the feed quality needed for end use.**
- **Sowing mix ratio is important, grasses lose quality faster than legumes, but have higher early dry matter (DM) production.**
- **High density legumes (HDL) produced the highest feed quality but lower dry matter production.**
- **Sow high density legumes and vetch early for optimal dry matter production or consider an alternative if early sowing is not possible.**

Aim

The aim of this trial was to compare sowing rates to find the optimum harvest growth stage for quality and quantity of hay or silage production.

Method

Five silage mix options were sown at the Henty field day site on May 13, 2008 with 100 kilograms per hectare of grain legume super (GLS). There were three randomised replicates of the following silage mixes.

1. High pea — low oats, 80kg/ha Morgan, 10kg/ha Yiddah (HPLO).
2. Low pea — high oats, 60kg/ha Morgan 40kg/ha Yiddah (LPHO).
3. High vetch — low oats, 30kg/ha Capello 40kg/ha oats (HVLO).
4. Low vetch / high oats, 40kg/ha Capello 10kg/ha oats (LVHO).
5. High density legume mix (HDL), 16kg/ha of persian, arrowleaf, balansa and berseem clovers.

The plots were sampled three times during spring with crops at the growth stages shown in Table 1. Samples were dried and quality tested through Wagga feed testing service.

Results

The quality and quantity of treatments for dry matter production, energy and protein over the season are shown in Figures 1, 2 and 3. The dry finish to the season with little spring rainfall impacted on results, particularly the final cut. The oats was moisture stressed and the later-maturing HDL mix did not have a high growth period during spring because of the short season. There were also some problems with mislabelling of the HPLO samples at the lab, hence the later energy and protein values for this treatment are not shown.

TABLE 1 Cutting time and crop growth stage

Cut 1 September 15, 2008	Cut 2 October 1, 2008	Cut 3 October 14, 2008
• Oats boot stage • HDL vegetative • Peas and vetch just starting to flower	• Oats flowering • Peas flowering some flat pods/vetch mid flowering • HDL early flowering	• Oats early grain fill • Peas some pods filling/vetch flowering • HDL flowering

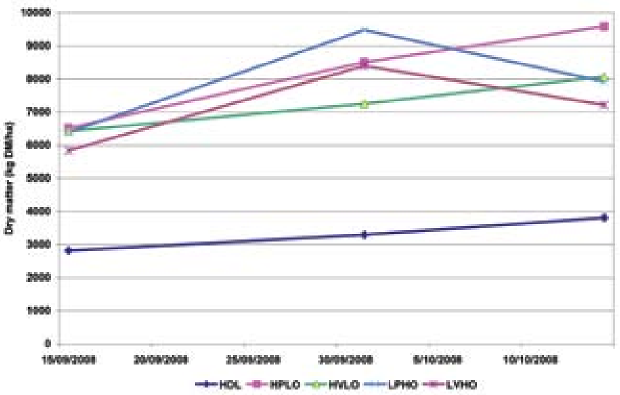

FIGURE 1 Dry matter production (kgDM/ha) over cutting time

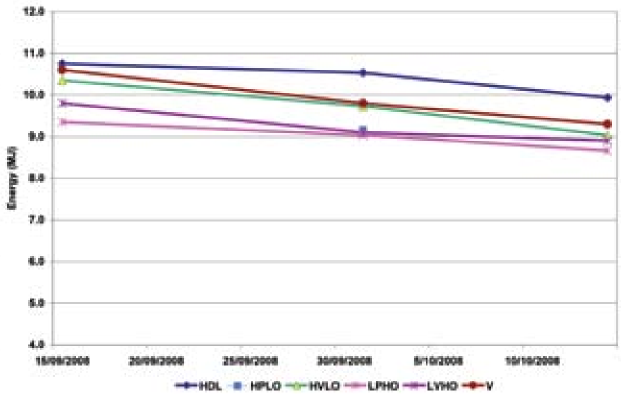

FIGURE 2 Energy of mixes by cutting time

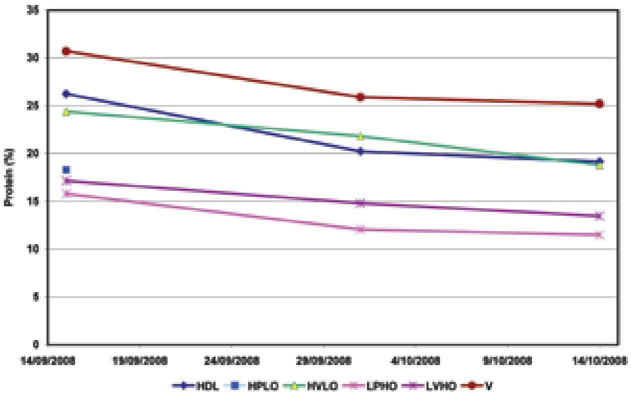

FIGURE 3 Protein % of mixes by cutting time

The dry matter shows no difference in production between high pea and high oat rates. The high vetch plots and particularly HDL had lower dry matter production. In a better spring it would be expected the HDL mix would increase dry matter production by the time of the third cut.

The plots with high legume content had higher energy levels particularly the HDL mix. These plots also maintained a higher energy level through the season.

The protein levels of the high legume treatments were better than low legume treatments. The vetch in particular had very high protein and Figure 3 shows the comparison with a single vetch only plot, which had 30 per cent protein through the season.

Observations and comments

As expected, higher legume component in a mix maintained feed quality longer than high oat mixes. Growing stock require, at most, 16% protein in the diet so some of these treatments have protein in excess of stock requirements. The optimum vetch:oat ratio may be between the rates used in this trial — 1:1 may be a better option.

Adding a legume to the cereal results in a better quality feed to meet livestock protein requirements, however does not necessarily provide more flexibility in cutting time and quality as all mixes except the HDL declined rapidly later in the season. However while HDL mixes provide greater quality and flexibility with grazing after harvest, they need to be sown early for adequate dry matter production.

Using pea or vetch/oat mixes, the ratios can be optimised to suit feed quality requirements. Getting the right balance is important as too much cereal may reduce quality. Regardless of the mix used these results show that cutting time is as important as the mix to produce high-quality fodder.

Sponsors

NSW DPI, Henty Landcare Agfund project.

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Management and agronomy trials

WRITTEN BY
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Current pulse research is investigating time of sowing to match the growing season development of different varieties across the range of southern NSW environments, plant populations to optimise grain yield, row spacings to optimise plant spatial arrangements for different plant architectures and harvest efficiency (desiccation, early harvest) to optimise yield and quality.

KEY POINTS

- Trials for pulse crops suggest 19–30 centimetre row spacing is ideal, with little yield differences. Wider spacing of 50cm significantly reduced grain yield. Trials were carried out under drier-than-average spring conditions, with little subsoil moisture.
- Highest grain yields were obtained with plant populations of about 25 plants/m^2, 30 plants/m^2 and 40 plants/m^2 for faba beans, chickpeas and field peas respectively.
- During dry years such as 2007 and 2008, early sown treatments yielded higher than later sown treatments for chickpea and faba bean. The early sown treatments were planted from the start of May, which is at the very start of the recommended sowing window.

The southern NSW pulse agronomy research programme is centred at Wagga Wagga, NSW (high rainfall) with a second site targeting the lower rainfall regions based at Yenda, NSW. Additional sites are also collaboratively managed at Cowra, Harden, Oaklands and Temora. The objective of the programme is to develop agronomic strategies for the management of new pulse varieties released in Australia for the current and developing farming systems of southern and central NSW.

All trials are direct drilled in minimal till conditions with all stubble retained when possible. During recent years minimal stubble has been present at experimental sites due to drought conditions.

Results discussed in the paper are from trials conducted during 2007 and 2008. Further testing is planned for 2009 and 2010.

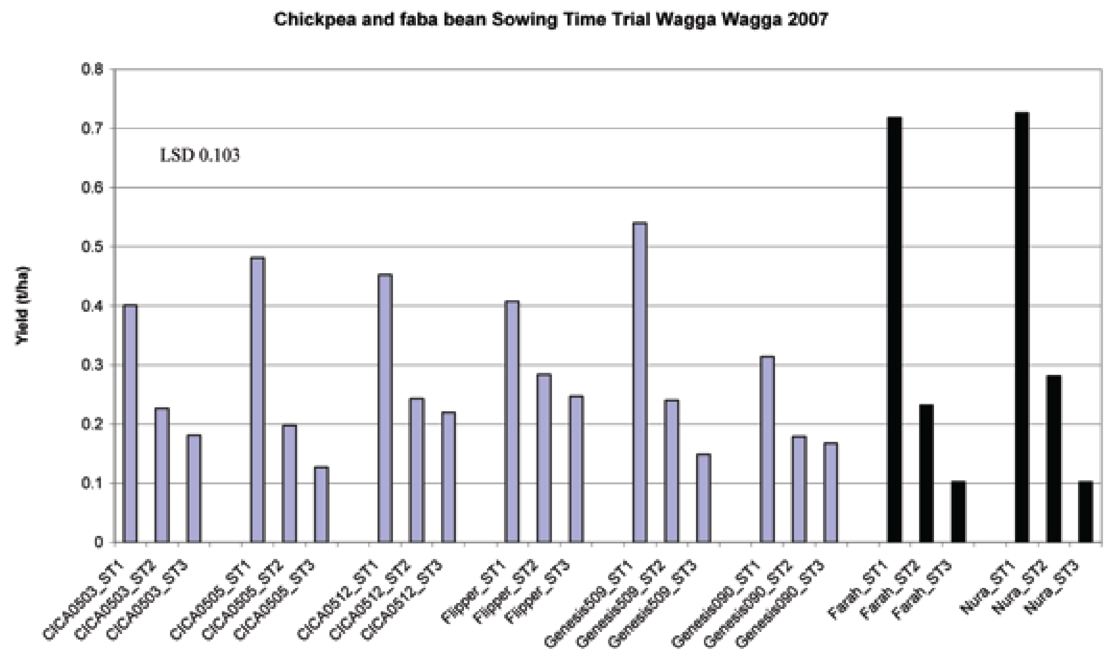
Drought conditions have prevailed during the past two seasons and very low levels of subsoil moisture were present during 2007. Substantially better levels of subsoil moisture were present during 2008, but moisture was highly variable across sites.

Chickpea and faba bean results — 2007

Results showed that 2007 was the season to sow early (see Figures 1 and 2). Preliminary data also indicate 2008 was also an ideal year to sow early.

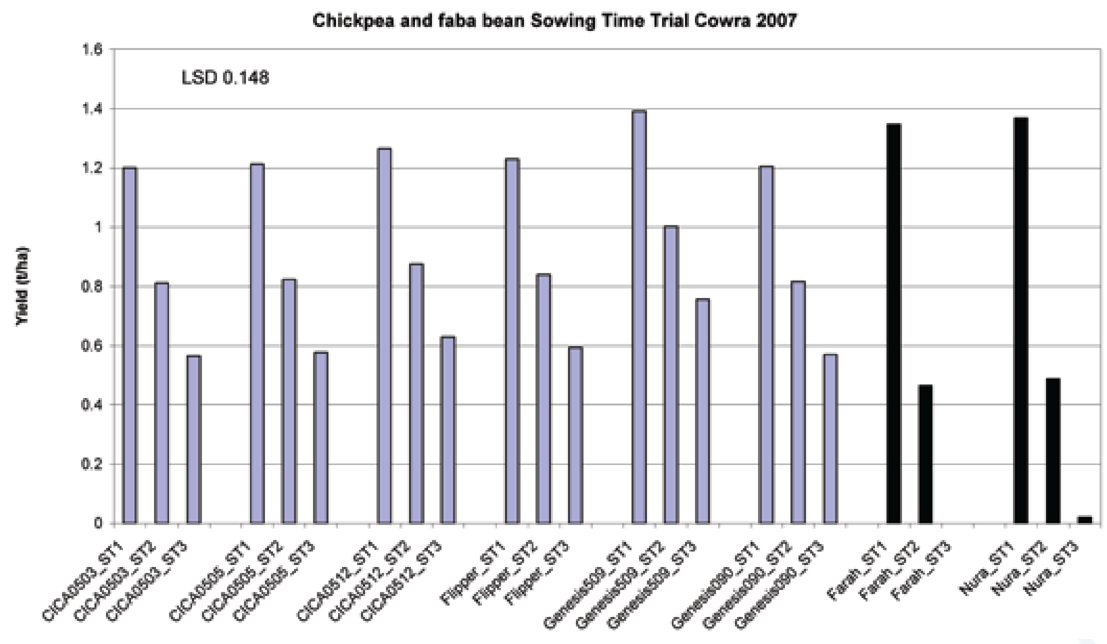
The actual sowing times during 2007 were May 16 (sowing time 1 — ST1), June 12 (sowing time 2 — ST2) and July 2 (sowing time 3 — ST3). These dates correspond with NSW DPI's *Winter Crop Variety Sowing Guide* recommendations, with sowing dates representing the start, mid-way and end of the sowing window respectively.

During 2008, trials had one extra earlier sowing date than 2007 starting April 30, but final data was unavailable at the time of publication. However, preliminary results from 2008 indicate a similar trend to 2007, with early sown treatments having higher yields.



Variety and sowing time

FIGURE 1 The effects of sowing time on grain yields of chickpea and Faba bean at Wagga Wagga 2007
Actual Sowing date: ST1 was May 16, 2007 ST2 was June 12, 2007 and ST3 was July 2, 2007.



Variety and sowing time

FIGURE 2 The effects of sowing time on grain yields of chickpea and faba bean at Cowra 2007
Actual Sowing date: ST1 was May 15, 2007, ST2 was June 25, 2007 and ST3 was July 19, 2007.

During 2007 experiments, sowings after mid-May were severely penalised. This was due to shorter flowering periods combined with increasing moisture and temperature stress during flowering and pod fill. Faba beans lost, on average, 30 and 13 kilograms of seed/hectare/day from delays after mid-May at Cowra and Wagga Wagga respectively while chickpeas lost 13 and 6kg of seed/ha/day respectively.

The 2007 time of sowing trial was badly affected by the poor spring conditions, with low yields recorded all treatments.

The effect of sowing time within variety changed, with generally significant differences between all sowing times, but the difference was not as clear between ST2 and ST3. All chickpea varieties showed no significant difference between ST2 and ST3 while both the faba bean varieties showed a significant negative response to later sowing (ST3).

During a more favourable 'typical' season, these early sowings have more potential to lose yield from increased disease pressure and greater frost damage during spring. However, both frost and disease were of little or no consequence during 2007.

Sowing rates

All crops responded to increasing plant populations (see Figures 3, 4 and 5).

Field peas generally required 40 plants/m^2 but the early-maturing lines OZP0703, 96–019*6–3 and SW Celine

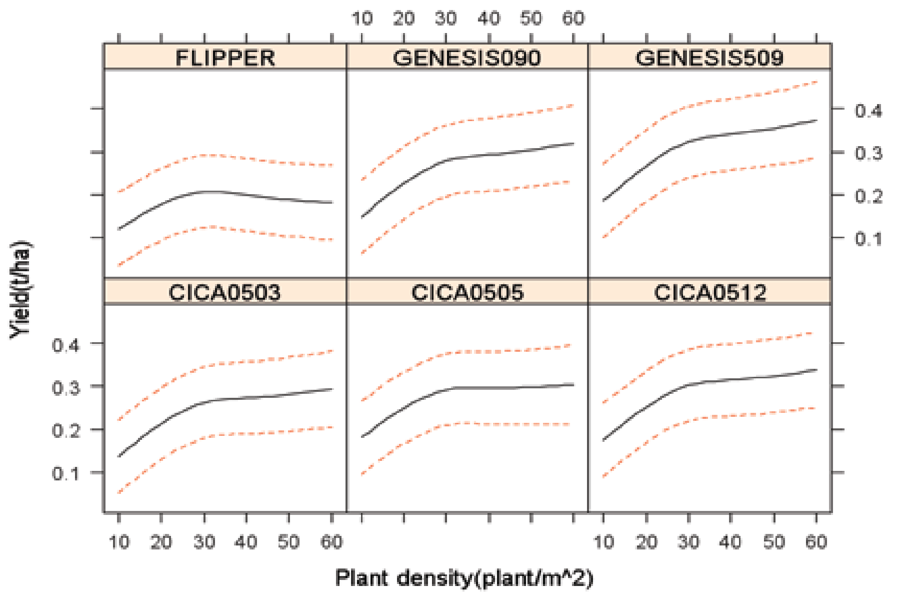


FIGURE 3 The effects of plant density on grain yield of chickpea at Yenda 2007 Sown June 5, 2007.

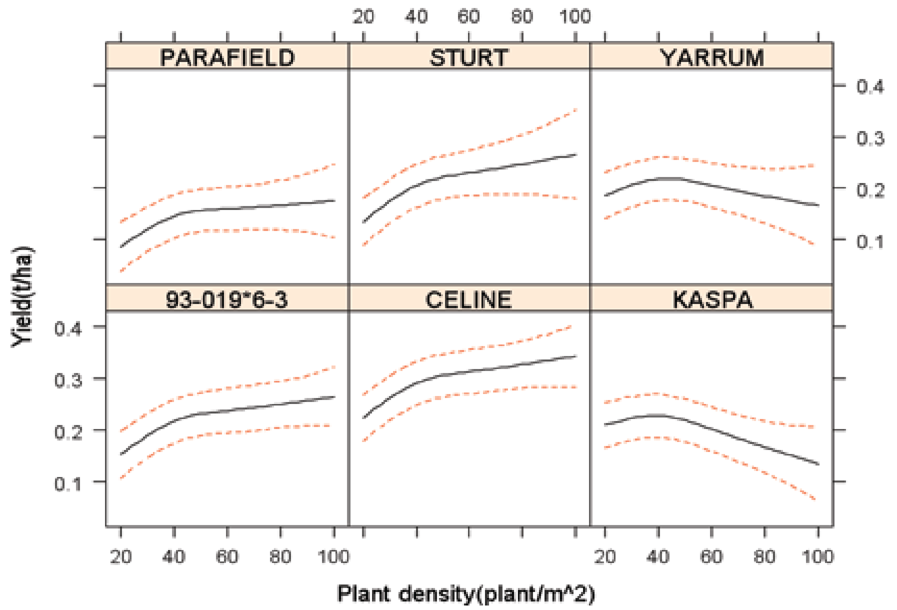


FIGURE 4 The effects of plant density on grain yield of field pea at Yenda 2007 Sown June 5, 2007.

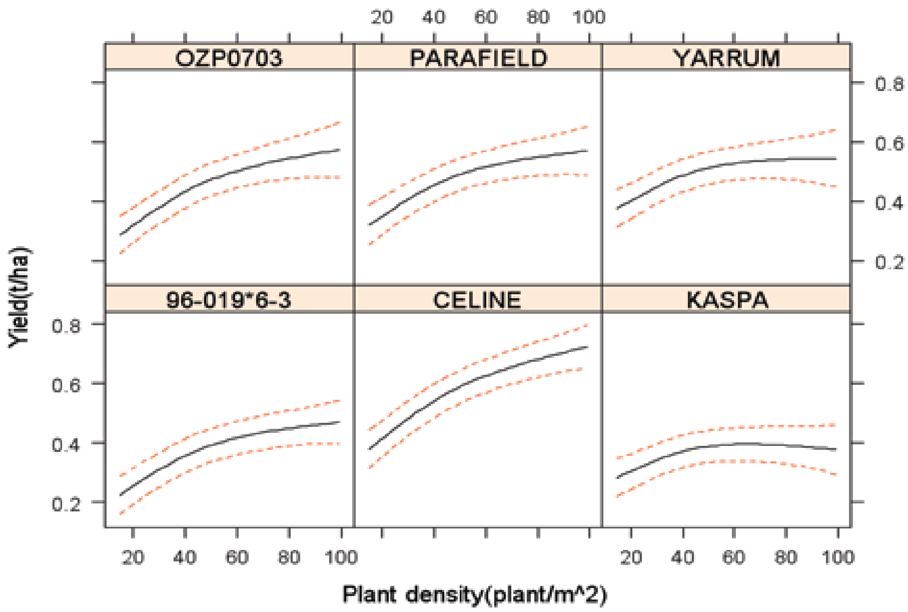


FIGURE 5 The effects of plant density on grain yields of field pea at Wagga Wagga 2007 Sown June 18, 2007.

continued to respond at higher sowing rates. However, yield in later maturing varieties (particularly Kaspa and Yarrum) frequently declined at higher rates, probably as a result of their later flowering, associated with excessive plant competition and limited spring moisture.

All faba bean varieties responded similarly to increasing sowing rate, reaching an optimum density at about 25 plants/m^2. Below this the crop was unable to adequately compensate, but higher densities only resulted in marginal yield responses.

For chickpeas at Yenda, optimum densities were about 30 plants/m^2 for all varieties.

Row spacing

There were no significant yield differences between row spacings of 19cm, 30cm and twin rows (35/15cm arrangement) for all varieties of field peas and chickpeas during 2007. However, yields were significantly lower for both crops at the wider (50cm) row spacing.

Implications of these findings are: the twin row arrangement does not appear to give any yield or management advantages; and secondly it is safe for producers to widen row spacing to 30cm. But, going any wider than this in such a season can reduce yield, particularly when soil moisture reserves are too low to allow the plant to effectively branch, fill and compensate. In most situations in southern NSW where acidic red/brown duplex soils predominate, row spacing in pulses can be safely widened from the narrow traditional spacing of 18–20cm to 30cm, thereby providing easier sowing into cereal stubbles, particularly for those set up for GPS guidance and inter-row sowing. A 30cm row spacing may also help facilitate air-flow in the canopy and help reduce disease risk compared to narrow 18cm row spacing.

Management and disease implications

Traditionally, time of sowing has been used as a cultural control option for the management of foliar diseases in pulse crops. Early sowing of pulse crops was not recommended because:

- Early sown crops traditionally produce more vegetative growth resulting in a dense crop canopy during late winter/spring. This dense microclimate is ideal for the rapid development of foliar diseases, such as botrytis grey mould in lentil and chickpea, and chocolate spot in faba bean. Sclerotinia stem rot is also favoured by a dense crop canopy. The use of foliar fungicides to control foliar diseases is also more difficult with a dense canopy due to reduced spray penetration.
- Early sowing also results in seedlings being exposed to fungal pathogens for longer durations early in the growing season when plants are vulnerable. Research from Victoria has shown that early sown field pea crops are exposed to higher levels of air-borne spores from old field pea stubbles, during wet and cold periods, which are ideal for infection. This results in early sown crops having higher levels of foliar disease during spring, which can significantly reduce yield. Early sowing of chickpea crops can also result in crop seedlings being exposed to fungal spores of *Ascochyta rabiei* during ideal infection conditions for longer periods, which can result in crop damage and reduced yields in susceptible varieties.

During recent years, the impact of foliar diseases on pulse production has been reduced with drier conditions resulting in a less favourable environment for pathogen infection and disease spread. Growers have not been penalised for sowing early, but rather rewarded, given the limited late spring rainfall, with earlier sown crops able to set pod before moisture and heat stress stop crop growth.

With the recent experiences, the question is *"Do you sow in the current locally adapted sowing windows or bend the rules and being aware of the risks involved sow earlier?"*.

Growers could choose to sow early for several reasons:

- to take advantage of early rains, or
- to avoid the hotter/drier conditions during spring and make better use of available stored soil moisture.

In these situations, growers need to review the overall disease risk for the crop and where possible take every opportunity to reduce the risk of disease establishment and spread. This includes implementing disease management strategies at sowing and being prepared to implement disease control post sowing if environmental conditions become favourable for disease development.

Reducing disease potential

Strategies that can be implemented to reduce a crop's disease potential at sowing include:

- **Previous pulse cropping history.** In particular, ensure a break of at least three years between pulse crops.
- **The proximity to old pulse crop stubbles.** This stubble can harbour foliar diseases, which later release spores.
- **Seed used for sowing.** Sow using seed from a disease-free crop and treat it with a fungicide seed dressing.
- **Plant population and row spacing.** High plant populations, with narrow row spacings can result in a dense crop canopy cover during spring, increasing the risk of disease. Follow the recommended plant populations for your district. Wider row spacings increase air-flow through the crop canopy and delay canopy closure, reducing disease risk.
- **Variety selection.** Does the variety being sown have an adequate level of disease resistance? Do not sow susceptible pulse crop varieties early.

Disease management strategies that can be implemented post-sowing are usually restricted to the strategic use of foliar fungicides. However, the availability of suitable fungicide products, timing of application and budget considerations for the costs of product and application have to be planned.

Weed control in early sown crops

Early sown pulses can still allow in-crop herbicide flexibility. However, there are limited opportunities for pre-sowing knockdown weed control and if sown into wide (for example, 30–75cm) rows there is no early crop competition. Weed control can still be achieved with the correct planning and management such as:

- Choosing low weed-burden paddocks or managing weeds in previous seasons to ensure there are low weed seed levels before planting.
- Avoid paddocks with known weeds that may be difficult to control in-crop.
- Knowledge of previous weed history and appropriate herbicide selection, timing and application is important.
- Absence of soil disturbance from between rows by knife points or disc seeders can often reduce subsequent weed germinations.

During recent years there have been instances of crop damage when herbicides are applied to dry soils and risk of herbicide damage is increased markedly when heavy rains occur, particularly if soil is left ridged. Metribuzin and diuron damage can occur in peas, as well as simazine and Balance® damage in chickpeas.

Damage from post-sowing, pre-emergence applications of herbicides can also occur from rain on dry soil. Ideally, apply 'post-sow pre-emergent' herbicides in moist soil conditions, regardless of the sowing time. The 'incorporated by sowing' technique may be more appropriate — or a split application to minimise risk.

Frost implications

Late sown and/or late flowering plant types generally flower after frosts have finished and conditions are warmer. In efforts to avoid frosts, late sown crops can incur yield reductions due to severe moisture deficiency or high temperatures during spring, as has occurred in recent dry years.

Strategies to minimise frost damage in pulses often are a combination of:

- **Frost-tolerant species.** Grow a more frost-tolerant species, such as faba beans (medium), lupins (low-medium), chickpeas (low), peas and vetch (very low).
- **Avoid early sowing.** Avoid sowing early into frost prone paddocks.
- **Spread risk.** Combine varieties and sowing dates based on spreading flowering time and duration.
- **Trace elements.** Ensure pulses are adequately nodulated by supplying adequate levels of trace elements and macro-nutrients. Nutrient deficiencies in copper, potassium and possibly molybdenum have shown more susceptibility to frost damage.
- **Retain stubble.** Mulched cereal stubble cools the soil temperature and root zone compared to bare soil. Leave cereal stubble standing to allow sunlight to penetrate.
- **Wide row spacing.** Sowing on wide rows (30cm) and row direction can also assist in allowing more sunlight and airflow through the crop.

Note: At the time of preparing this paper, full data analysis was not available.

This project is a collaborative joint venture between NSW DPI — Victoria and the South Australian Research and Development Institute (SARDI). GRDC supports the project and current funding runs until June 2010.

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Cover cropping — multiple benefits but beware of the limitations

Multiple benefits: Impact of cover crop on summer weeds and soil protection. Left: Cut-removed. Right: Crimp-rolled cereal rye.

WRITTEN BY

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Australian farmers have been moving toward minimum and no-till farming for the past two decades. During recent years the drier-than-average seasons have reinforced the benefits of stubble retention and minimal soil disturbance in retaining moisture for sowing and grain filling. However, the benefits of minimum or no-till under current conditions have reached a plateau and overseas experience is showing that the maintenance of soil groundcover holds great prospects in retaining soil moisture.

KEY POINTS

- NSW DPI researchers are investigating the multiple benefits of cover cropping including weed control in no-till and organic systems.
- Results suggest cover crops could increase yield of the following crop through improved weed control and soil moisture accumulation.
- Growers need to weigh up the relative benefits against the potential drawbacks before instigating a cover cropping programme.
- Cover cropping has enormous potential in organic systems to control weeds and ameliorate the soil.

As farmers search for new techniques to deal with a changing climate, several grower groups are evaluating the benefits of cover cropping for improved moisture infiltration, soil health and weed control.

A cover crop is defined as a crop primarily grown to produce biomass to provide soil cover and to prevent soil erosion, regardless of whether it is later incorporated.

Cover crops have been shown to possess multiple benefits to farming systems as a result of protecting soil from erosion, increasing water infiltration, improving soil structure and fertility, contributing to carbon sequestration and improving soil health. Cover crops can also immobilise available nitrogen after harvest and reduce the amount of nitrogen leached.

Cover crops have been extensively studied for weed management in North America, but such information is scarce in Australia.

Weed control

Cover cropping has long been recognised for its potential to suppress weeds through competition, physical suppression, chemical suppression via allelopathy, and improved soil biological activity.

Mulching of cover crop residue can also smother weeds. Cover crops reduce soil temperature and light transmission to the soil surface, resulting in slowed or reduced weed. Allelochemicals released by the cover crop may impose a continuous 'chemical stress' on weeds. For example, DIBOA (2,4-dihydroxy-1,4-benzoxazin-3(4H)-one) an allelochemical isolated from the cover crop rye (*Secale cereale L.*) suppresses a range of weed species.

Enhanced soil biological activity may increase weed seed predation and seed loss, thereby accelerating the seedbank decline.

Research from northern hemisphere has predominantly focussed on the weed suppressive effects of a short-term cover crop during winter before summer cropping, such as corn (*Zea mays L.*), cotton (*Gossypium hirsutum L.*) or soybean (*Glycine max L.*). This cropping system involving cover crops during winter followed by summer crops also is applicable to the northern grain region of Australia. However, the feasibility of introducing cover cropping into the southern farming systems deserves further investigation for soil moisture conservation and subsequent benefits to following crops.

Grower group experience

A number of grower groups across Australia are currently evaluating cover cropping for their own conditions including: The Western Australian No-Till Farming Association (WANTFA); South Australian No-Till Farmers Association (SANTFA); and Conservation Agriculture and No-Till Farming Association (CANFA).

As part of a GRDC-funded project on Integrated Weed Management (IWM), researchers from NSW DPI at the Wagga Wagga Agricultural Institute are investigating the multiple benefits of cover cropping including weed control in no-till and organic systems.

The use of a green or brown manure crop has previously been included in IWM strategies for problem weedy paddocks, but this still involves some cost in incorporation or using a non-selective herbicide to kill the crop.

Farmers in Central West NSW are evaluating crimp rolling of the standing cover crop. Crimp rollers are generally 600 millimetres to one metre in diameter with water or oil for additional ballast and are towed behind a tractor to flatten the standing crop. The roller has a series of 10–12 blades or blunt knives running around the drum about 15–16 centimetres apart and 6–8cm tall. The action of rolling the knives across the crop combined with the weight of the roller flattens the crop and crimps it every 5–6cm, breaking the stem and killing the cover crop.

Crimp rolling produces a mulched layer of several centimetres thick on the soil surface, suppressing weed germination, improving water infiltration into the soil and reducing evaporation.

Wagga Wagga experiments

A number of different crops are being evaluated in experiments at Wagga Wagga and Wellington, NSW including cereal rye, wheat, oats, barley, vetch, forage canola and mustard. At flowering, three management strategies were applied to the cover crops: cut-removed (as a control); cut-retained and crimp-rolled.

At Wellington during 2007 cereal rye and oats were the most successful at reducing winter weed biomass during the season, whereas vetch and forage canola were the weediest treatments (see Figure 1). Much of this is due to the competition from the crop biomass.

After the summer rain at Wellington the cereal treatments again were the best at suppressing summer weeds.

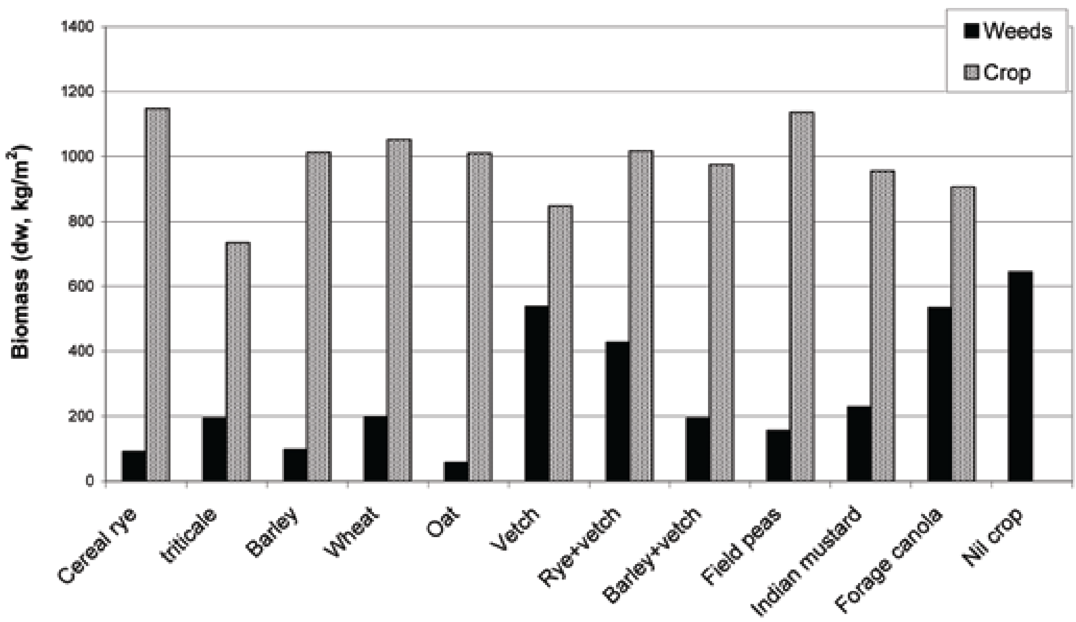

FIGURE 1 Biomass of weeds and cover crops in cut-retained treatment (September, 2007)

Cereal stubble does not break down as quickly as brassica or pulse stubble, with most cereals retaining more than three tonnes per hectare of stubble during May 2008 before sowing (see Figure 2).

Potential allelopathic compounds leached from the stubble could also contribute to this suppression of summer weeds.

Soil moisture accumulation

Cover cropping dramatically increased surface soil moisture. Compared with the control (cut-removed), the treatments of cut-retained and crimp-rolled resulted in 99 per cent and 48% increase in soil gravimetric moisture content in 0–10cm layer when assessed during May 2008 before sowing. These significant differences were maintained at the 10–30cm layer, with cut-retained and crimp-rolled treatments, resulting in 60% and 37% increase in soil moisture.

All three management strategies had similar moisture contents at 30–50 cm.

Accumulation of soil moisture under cover cropping has been translated into improved crop establishment and yield (see Figure 3).

Wheat was sown as a 'blanket' crop across the whole area during May 2008. Cover crops resulted in significant increase in the grain yield of the following wheat crop. The cover crops of cereal rye, barley, oats, vetch, canola had resulted in 94%, 70%, 85%, 48% and 45% yield increase when compared with the nil-cover crop control, which had an average wheat grain yield of 1.67 t/ha.

Among the three cover crop management options, the cut-retained and crimp-rolled treatments produced 26% and 17% more grains than the cut-removed treatment, respectively.

Beware of the drawbacks

The research on cover cropping has shown promising results. However, growers need to weight the multiple benefits of cover cropping against certain drawbacks.

There are many factors determining the success of cover cropping, such as cover crop species, time of sowing, management and climatic conditions.

In addition to the cost associated with cover crops (seed, sowing and desiccation or mechanical kill), sacrifice of a growing season and associated income could discourage adoption by growers unless compensated by increased yield of the following crop, reduced herbicide costs as well as other environmental benefits.

It is not clear if a dual-purpose cover crop can be grown in the southern cropping region. The vigorous growth of cover crops could potentially be cut for hay or silage and allows sufficient re-growth to provide the normal cover crop functions, including weed suppression. There might also be possibilities of utilising summer storms to grow summer cover crops for weed suppression, soil protection and moisture conservation.

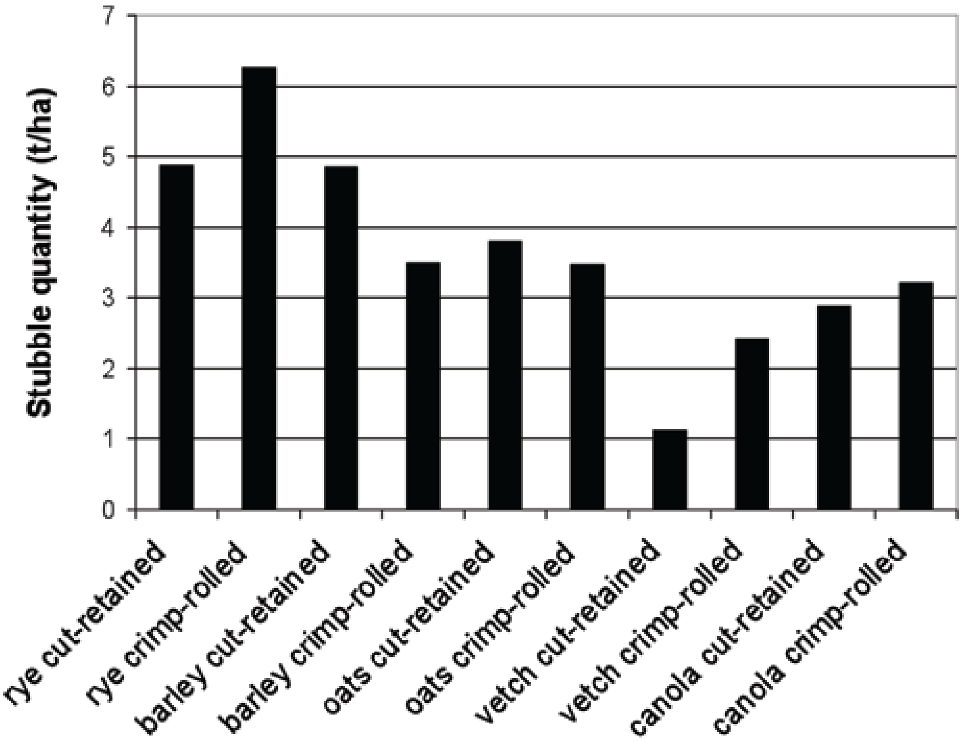

FIGURE 2 Stubble residues remaining at sowing during May 2008

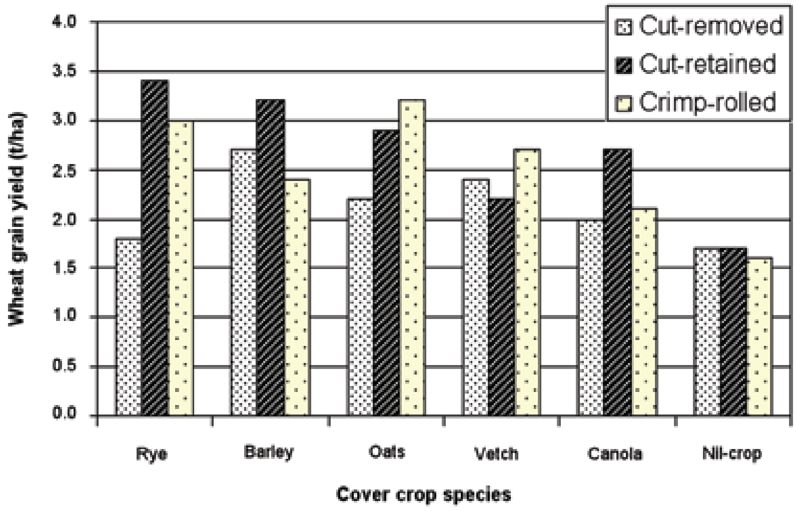

FIGURE 3 Cover cropping on the grain yield of the following wheat crop

The organic alternative

Cover cropping has enormous potential in organic systems to control weeds and ameliorate the soil. Retaining a thick mulch layer for weed control reduces the need to cultivate for weed control, reducing diesel use and tractor running costs.

The ongoing drought conditions during the past few years open up the opportunity to adopt cover cropping. Sacrificing a growing season for cover cropping to accumulate soil moisture would increase the success of the next winter crops. However, more research is needed in order to fit this cover cropping practice into Australian farming systems.

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