Barley Agronomy

David Moody, *BCG*

Take home messages

- *Good seed quality is essential for the successful adoption of No-Till farming systems*
- *Highest yields generally occur with row spacing narrower than 300 mm and the benefits of adopting wider row spacing needs to be evaluated against the costs (in terms of lower yields).*
- *Narrow row spacing should not be used with currently recommended rates of pre-emergent herbicides for No-Till farming systems.*
- *Slightly higher seeding rates may be required in No-Till farming systems due to reduced plant establishment percentages with these systems.*
- *Variety specific responses may be observed in aspects of No-Till farming systems at some stages of crop development but these differences are not apparent for final grain yield.*

Background

A large, tri-state, initiative, funded through both the GRDC and SAGIT, has been established to provide variety specific management advice for newly released barley varieties. Research partners include NSW DPI, BCG, and SARDI, with Southern Farming Systems and the Mallee Research Foundation subcontracted by BCG in Victoria to provide specific expertise and geographic coverage.

The focus of the initiative in Victoria is on the suitability of varieties for No-Till farming systems, and the differences between varieties in terms of weed competitiveness, herbicide tolerance and nitrogen response.

Methods

Field trials at Manangatang, Birchip and Longerenong, with factorial combinations of varieties, row spacing and herbicide or nitrogen treatments, were used to investigate variety specific management issues, using No-Till management systems. Specifically the No-Till systems required: the absence of prior cultivation, retention of previous stubble, knife points and press wheels. Row spacing configurations used in the comparisons included 150 mm, 225 mm and 300 mm. Herbicide treatments included varying rates of trifluralin, S-metalochor, tri-allate and metrabuzin. Nitrogen treatments were applied either at sowing, split between sowing and mid tillering, or applied all at mid tillering. Details of these trials are provided in Table 1.

Table 1: Locations, co-operators and treatment combinations for trials conducted by BCG during 2007.

		Treatments			
Location	**Cooperator**	**Herbicides**	**Nitrogen**	**Varieties**	**Row Spacing Configurations**
Manangatang	B. Barry	4	-	10	3
Jil Jil	I. McClelland	4	-	10	3
Birchip	B. Hogan	-	4	6	3
Horsham	Longerenong	-	4	6	3

The row spacing configurations used in all trials was 150 mm, 225 mm, and 300 mm. Seeding rates for all trials were adjusted according to grain weight, assuming 85% establishment, to produce target plant populations of 130 plants per m2 at Manangatang, Jil Jil and Birchip, and 150 plants per m2 at Horsham.

Variety responses to weeds management and row spacing

The aims of the trials at Manangatang and Jil Jil were to investigate:

- the efficacy of the pre-emergent herbicide treatments on brome grass at Manangatang and ryegrass at Jil Jil,
- the weed competitiveness of different varieties at different row spacing configurations,
- the relative yields of the different varieties with the different herbicide applications and row spacing configurations

Varieties included in these trials were Maritime, Fleet, Hindmarsh, Yarra, SloopVic, Schooner, WI3416-1572, Gairdner, Flagship and Buloke.

At Manangatang, the herbicide treatments were

1. 600 mls PowerMax
2. 600 mls PowerMax + TriflurX 1.5 L/ha – IBS
3. 600 mls PowerMax + TriflurX 1.5 L/ha + 130 gms Lexone - IBS
4. 600 mls PowerMax + TriflurX 2.0 L/ha + 150 gms Lexone – IBS

At Jil Jil, the herbicide treatments were

1. 600 mls PowerMax
2. 600 mls PowerMax + TriflurX 1.5 L/ha + Dual Gold 500 mls/ha IBS
3. 600 mls PowerMax + TriflurX 1.5 L/ha + Avadex 1.6 L/ha IBS
4. 600 mls PowerMax + TriflurX 1.5 L/ha + Dual Gold 500 mls/ha + Avadex 1.6 L/ha IBS

The Manangatang site was sown on 8/9 May and the Jil Jil site sown on 28 May 2007 without prior tillage using knife points with press wheels. No post sowing grass weed control was conducted. Sites were managed for the control of broad leaf weeds and nitrogen applied as required.

Variety responses to nitrogen management and row spacing

The aims of the trials at Birchip and Longerenong were to investigate:

- Interactions between the timing of nitrogen application and row spacing configurations,

- The relative response of the different varieties to different timing of nitrogen application with different row spacing configurations.

Varieties included in these trials were Hindmarsh, SloopVic, WI3416-1572, Gairdner, Flagship and Buloke.

The Birchip main site was sown on 4 June and the Longerenong site sown on 8 June 2007 without prior tillage using knife points with press wheels. The trials were managed for the control of grass and broadleaf weeds.

At Birchip, the nitrogen treatments were

1. Nil
2. 40kg N/ha broadcasted immediately pre-sowing and incorporated by the sowing operation.
3. 20kg N/ha broadcasted immediately pre-sowing and incorporated by the sowing operation with a further 20kg N/ha applied as Ezy N on August 30 2007.
4. 40kg N/ha applied as Ezy N in August.

At Longerenong, the nitrogen treatments were

1. Nil
2. 50kg N/ha broadcasted immediately pre-sowing and incorporated by the sowing operation
3. 25kg N/ha broadcasted immediately pre-sowing and incorporated by the sowing operation with a further 25kg N/ha applied as Ezy N (60l/ha) on August 14 2007.
4. 50kg N/ha applied as Ezy N at mid-late tillering, split equally between two application dates (14 and 21 August 2007) to prevent excessive leaf burn (60 L/ha Ezy N per application).

Results

The impact of the drought in 2007 was to cause the effective loss of one site of each of the nitrogen and herbicide trials. The results of the four series of trials are presented collectively in order to see patterns emerging across all trials.

Plant establishment – variety effects

Seed of all varieties used in these trials was provided by commercial seed companies as certified seed, with the exception of Schooner and the breeding line WI3416-1572. Seed of the majority of the varieties was tested by the Agriquality laboratories for germination percentage and vigor (see Table 2).

Significant variety differences in establishment occurred (Table 3) that were not suggested by seed weight, seed germination percentage or seed vigor assessments. In particular, in the trials conducted by BCG, the establishment of Buloke was poor, despite good seed weight and excellent germination and vigor scores assessments as conducted by commercial seed quality laboratories.

In general, plant establishment of all varieties was reduced by both the use of the highest registered rates of pre-emergent, soil residual herbicides and through the use of wider row spacing (Table 4). Whilst 130 plants per m2 was the target plant population at Manangatang, Jil Jil and Birchip, this was rarely achieved for the majority of varieties.

Table 2: 1000 seed weights, germination percentage and seed vigor for the ten varieties included in these trials. Germination percentage and seed vigor* assessments conducted by AgriQuality.

Variety	Seed weight (mgs)	Germination %	Seed Vigor		
			Normal Seedlings %	Abnormal Seedlings %	Dead Seeds %
Buloke	46.3	98	96	3	1
Flagship	44.6	86	86	7	7
Fleet	60.9				
Gairdner	41.7	95	92	4	4
Hindmarsh	47.6	98	95	4	1
Maritime	54.8	95	90	5	5
Schooner	36.4	83	77	6	17
SloopVic	39.5	94	93	5	2
WI3416-1572	36.1	98	95	2	3
Yarra	52.8				

* *Seed vigor is measured by placing seed on germination paper initially at 20ºC for 24 hours and then at 42ºC for 16 hours and then germinated normally.*

Tolerances, as measured by the effect on plant establishment, to TriflurX and Dual Gold, differed between varieties (Table 5). Herbicide effects on plant establishment were minimized but not eliminated by the use of the wider row spacing configurations.

At a given target seed number per square meter, greater intra-row competition in the wider row spacing configurations reduced plant establishment.

Table 3: Plant establishment (plants per m^2) at the Manangatang, Birchip (Jil Jil) and Birchip (Main) sites. Plant establishment counts are the means across varieties and replicates.

Variety	Manangatang	Jil Jil	Birchip
Buloke	79	93	57
Flagship	113	93	83
Fleet	134	119	
Gairdner	131	111	95
Hindmarsh	124	115	111
Maritime	128	114	
Schooner	111	108	
SloopVic	118	120	101
WI3416-1572	113	113	110
Yarra	108	108	
Lsd (5%)	**15.8**	**12.8**	**9.2**

At Manangatang, there was a strong correlation between the variety ranking in terms of trifluralin effects on plant establishment and the ranking of varieties in terms of the effect of wide row

spacing on plant establishment (Table 5), suggesting the observed "tolerances" are more related to (unidentified) seed quality issues rather than genetic differences between the varieties.

Table 4: Plant establishment (plants per m^2) for different herbicide treatments and row spacing configurations. Plant establishment counts are the means across varieties and replicates.

Site	Pre-sowing or IBS herbicide treatment	Plant establishment (plants/m^2)		
		Row spacing (mm)		
		150	225	300
Manangatang	600 mls PowerMax	129	115	99
	600 mls PowerMax + TriflurX 1.5 L/ha – IBS	90	102	90
	600 mls PowerMax + TriflurX 1.5 L/ha + 130 gms Lexone – IBS	86	94	85
	600 mls PowerMax + TriflurX 2.0 L/ha + 150 gms Lexone – IBS	83	87	81
	Lsd (5%)	**8.6**		
Birchip (Jil Jil)	PowerMax + Surpass	124	104	100
	PowerMax + Surpass + TriflurX 1.5 L/ha + Dual Gold 500 mls/ha IBS	109	101	95
	PowerMax + Surpass + TriflurX 1.5 L/ha + Avadex 1.6 L/ha IBS	123	107	96
	PowerMax + Surpass + TriflurX 1.5 L/ha + Dual Gold 500 mls/ha + Avadex 1.6 L/ha IBS	111	106	99
	Lsd (5%)	**7.0**		

Efficacy of herbicide treatments on weed control

Whilst the Manangatang site was chosen to investigate brome grass management, the early break resulted in good control of brome grass with the pre-sowing knockdown treatment and consequently low levels of brome grass in the trial (average brome grass plant density of about 1.5 plants per m^2). Nevertheless differences in brome grass populations occurred between varieties and row spacing treatments. Buloke and Flagship had the highest brome grass presence, and Fleet the lowest. These differences may have been due to the large differences in plant establishment between these varieties. Brome grass presence also increased as row spacing increased, presumably due to the lower level of competition in the 300 mm row spacing canopies.

The severe drought at Jil Jil meant that no useful data could be gained on the effects of varieties, herbicide treatments or row spacing on ryegrass populations at that site.

Table 5: Relative plant establishment expressed as percentage of the control treatment (no pre-emergent herbicide, 150mm row spacing configuration) for ten varieties when (i) TriflurX (at Manangatang) and Dual Gold (at Jil Jil) were incorporated by sowing using 150mm row spacing or (ii) the varieties were sown at 300mm row spacing and no pre-emergent herbicide applied.

	Manangatang		Jil Jil	
Variety	**Trifluralin**	**300mm**	**Dual Gold**	**300mm**
Buloke	53%	56%	77%	92%
Flagship	46%	47%	90%	77%
Fleet	60%	122%	99%	89%
Gairdner	57%	71%	82%	72%
Hindmarsh	87%	95%	97%	80%
Maritime	60%	63%	90%	80%
Schooner	82%	96%	83%	84%
SloopVic	74%	82%	80%	64%
WI3416-1572	82%	93%	95%	79%
Yarra	69%	74%	90%	78%

Flowering dates

Flowering dates were recorded at Manangatang and Longerenong. Results are presented in Table 6.

Table 6: Flowering dates for varieties at Manangatang and Longerenong.

Variety	Manangatang	Longerenong
Buloke	13 Sept	1 Oct
Flagship	13 Sept	5 Oct
Fleet	11 Sept	
Gairdner	18 Sept	7 Oct
Hindmarsh	10 Sept	28 Sept
Maritime	10 Sept	
Schooner	13 Sept	
SloopVic	14 Sept	3 Oct
WI3416-1572	13 Sept	2 Oct
Yarra	17 Sept	

Plant biomass and shoot density

At both Manangatang and Longerenong increased row spacing significantly reduced shoot density (measured at stem elongation), whilst at the Birchip Jil Jil site the 150mm row spacing configuration produced significantly more anthesis biomass than the 225mm and 300mm row spacing configurations (Table 7). The higher anthesis biomass produced at the 300mm compared to the 225mm row spacing treatment at Jil Jil can not be explained.

Varieties also produced significantly different shoot densities and anthesis biomass (Table 8). In general, Hindmarsh produced relatively high shoot numbers and also had the highest anthesis biomass at the Jil Jil site. Gairdner in comparison tended to produce low shoot numbers and had the lowest biomass production at Jil Jil.

Table 7: Stem elongation shoot densities for different row spacing at Manangatang and Longerenong, and anthesis dry matter at the Birchip – Jil Jil site.

Row spacing	Shoot density (shoots/m^2)	Anthesis dry matter (kg/ha)	Shoot density (shoots/m^2)	Anthesis dry matter (kg/ha)
	Manangatang	Birchip (Jil Jil)	Longerenong	Longerenong
150mm	491	2548	570	5291
225mm	382	1977	478	4510
300mm	343	2226	467	4495
Lsd (5%)	**21.8**	**54.0**	**28.0**	**291**

Table 8: Shoot densities at stem elongation for different varieties at the Manangatang and Longerenong sites, and anthesis dry matter at the Birchip – Jil Jil site.

Variety	Shoot density (shoots/m^2)	Anthesis dry matter (kg/ha)	Shoot density (shoots/m^2)	Anthesis dry matter (kg/ha)
	Manangatang	Birchip (Jil Jil)	Longerenong	Longerenong
Buloke	322	2558	524	4392*
Flagship	341	2233	510	5217#
Fleet	431	2289		
Gairdner	394	1651	418	4792#
Hindmarsh	438	2617	587	4754*
Maritime	423	2469		
Schooner	414	2022		
SloopVic	352	2333	477	3922*
WI3416-1572	446	2239	512	5516#
Yarra	494	2096		
Lsd (5%)	**39.9**	**195.6**	**39.0**	**412**

** Sampled on October 1 2007*

 # Sampled on October 9 2007

Harvest Index – row spacing, pre-emergent herbicide and variety effects

Harvest Index was determined at two sites: Manangatang and Longerenong. At both Manangatang and Longerenong, with significant differences between varieties at both sites (Table 9). Flagship recorded the lowest harvest index at both sites, whilst Fleet recorded the highest harvest index at Manangatang. The harvest index of Hindmarsh was amongst the highest at Manangatang and was the highest at Longerenong.

Herbicide and row spacing treatments at Manangatang, and nitrogen and row spacing treatments at Longerenong, did not influence harvest index (Table 10).

Table 9: Harvest index (%) and harvest biomass (kg/ha) for varieties at the Manangatang and Longerenong sites.

Variety	Manangatang		Longerenong	
	Harvest Index %	Harvest Biomass (kg/ha)	Harvest Index %	Harvest Biomass (kg/ha)
Buloke	37.6	4364	40.6	7367
Flagship	34.1	4965	38.4	7372
Fleet	39.9	4576		
Gairdner	38.0	4518	44.8	6650
Hindmarsh	39.6	5129	44.7	7257
Maritime	38.3	4478		
Schooner	37.7	4223		
SloopVic	36.8	4198	41.6	6704
WI3416-1572	37.8	4294	46.7	6452
Yarra	34.7	4965		
Lsd (5%)	**3.8**		**2.9**	

Table 10: Harvest index (%) for four herbicide treatments and three row spacing configurations at Manangatang.

Herbicide treatment		Row Spacing	
	150mm	225mm	300mm
Control	37.0	37.4	38.3
TriflurX 1.5 L/ha – IBS	38.1	37.6	36.9
TriflurX 1.5 L/ha + 130 gms Lexone – IBS	38.1	37.6	36.9
TriflurX 2.0 L/ha + 150 gms Lexone – IBS	39.1	37.7	35.4

Grain Yield – row spacing, pre-emergent herbicide and variety effects

Grain yield was unaffected by any of the herbicide treatment effects, despite significant effects of the herbicide treatments on plant establishment and shoot density. Row spacing did affect grain yield, with either the 150 mm or the 225 mm row spacing treatments significantly higher yielding than the 300 mm row spacing configuration. On average, over the three sites (Tables 11, 12 and 13), the 225 mm row spacing configuration was 4.9% higher yielding than the 300 mm row spacing and 0.5% higher yielding than the 150 mm row spacing. In general, the effect of row spacing on grain yield was consistent across all varieties.

Table 11: Grain yields (t/ha) for the ten varieties and three row spacing configurations at Manangatang and the mean grain yields for ten varieties at Jil Jil where no significant differences were observed between the row spacing treatments.

Variety	Row Spacing			
	150 mm	225 mm	300 mm	Mean
Buloke	1.37	1.58	1.36	1.43
Flagship	1.37	1.55	1.54	1.49
Fleet	1.59	1.75	1.52	1.62
Gairdner	1.48	1.58	1.46	1.51
Hindmarsh	1.82	1.96	1.69	1.82
Maritime	1.56	1.47	1.49	1.51
Schooner	1.33	1.45	1.37	1.39
SloopVic	1.27	1.35	1.40	1.34
WI3416-1572	1.41	1.54	1.29	1.42
Yarra	1.40	1.63	1.52	1.52
Mean	**1.46**	**1.59**	**1.46**	

Lsd (5%) at Manangatang between means for row spacing = 0.04 t/ha

Lsd (5%) at Manangatang between means for varieties = 0.09 t/ha

Lsd (5%) at Manangatang between values within table = 0.160 t/ha

Given the exceptionally dry spring conditions, it is interesting to note that the higher shoot densities and higher anthesis biomass of the narrower (150 mm and 225 mm) row spacing configurations did not contribute to "haying off". That is, higher anthesis biomass resulted in higher grain yields. At the Longerenong site, neither the anthesis biomass for the 225 mm and 300 mm row spacing treatments (Table 9), nor the final grain yields (Table 13) for these treatments, were significantly different. In comparison, the 150 mm row spacing treatment at this site, produced anthesis biomass and final grain yields that were both significantly higher than the wider row spacing configurations. Rainfall at the Longerenong site for the three month period August, September, October totaled only 38 mm (decile 1) and growing season rainfall (April – October) totaled only 206 mm (decile 2).

Table 12: Grain yields (t/ha) for ten varieties and three row spacing configurations at Birchip.

Variety	Row Spacing			
	150 mm	225 mm	300 mm	Mean
Buloke	0.385	0.485	0.397	0.42
Flagship	0.421	0.330	0.331	0.36
Fleet	0.321	0.263	0.313	0.30
Gairdner	0.215	0.179	0.179	0.19
Hindmarsh	0.491	0.597	0.334	0.47
Maritime	0.421	0.473	0.399	0.43
Schooner	0.463	0.372	0.438	0.42
SloopVic	0.338	0.375	0.300	0.34
WI3416-1572	0.201	0.284	0.264	0.25
Yarra	0.248	0.279	0.315	0.28
Mean	**0.35**	**0.36**	**0.33**	

Lsd (5%) between means for varieties = 0.11 t/ha

Differences between row spacing configurations were not statistically significant at this site.

Table 13: Grain yields (t/ha) for six varieties and three row spacing configurations at Longerenong.

Variety	Row Spacing			
	150 mm	225 mm	300 mm	Mean
Buloke	3.24	2.82	2.92	2.99
Flagship	2.94	2.75	2.80	2.83
Gairdner	3.06	2.87	3.01	2.98
Hindmarsh	3.54	3.13	3.06	3.24
SloopVic	2.90	2.74	2.72	2.79
WI3416-1572	3.19	2.80	3.05	3.01
Mean	**3.15**	**2.85**	**2.93**	

Lsd (5%) at between means for varieties = 0.13 t/ha

Lsd (5%) at between means for row spacing = 0.91 t/ha

Grain protein - row spacing, pre-emergent herbicide and variety effects

Grain protein concentration increased significantly as row spacing increased at Manangatang but decreased significantly as row spacing increased at Longerenong (Table 14). Significant differences occurred between varieties for grain protein (Table 15) at both Manangatang and Longerenong; Schooner and SloopVic tend to have higher grain protein whilst Buloke tends to have lower grain protein.

No differences in grain protein resulted from either the herbicide treatments at Manangatang or the nitrogen treatments at Longerenong.

Table 14: Mean grain protein concentration at Manangatang and Longerenong for three different row spacing configurations.

Row spacing	Site	
	Manangatang	Longerenong
150mm	10.6	10.4
225mm	10.8	10.2
300mm	11.1	10.1
Lsd (5%)	**0.38**	**0.21**

Grain plumpness - row spacing, pre-emergent herbicide and variety effects

Grain plumpness decreased significantly as row spacing increased at Manangatang but row spacing had no effect on grain plumpness at Longerenong (Table 16). Significant differences occurred between varieties for grain plumpness (Table 17) at both Manangatang and Longerenong.

Table 15: Mean grain protein concentration at Manangatang and Longerenong for ten and six varieties respectively.

Row spacing	Site	
	Manangatang	Longerenong
Buloke	10.7	9.8
Flagship	10.8	11.0
Fleet	10.8	
Gairdner	10.4	10.3
Hindmarsh	9.7	10.3
Maritime	10.5	
Schooner	11.8	
SloopVic	11.7	10.5
WI3416-1572	10.6	9.4
Yarra	11.3	
Lsd (5%)	**0.70**	**0.30**

Table 16: Mean plump grain retention (> 2.5mm) at Manangatang and Longerenong for three different row spacing configurations.

Row spacing	Site	
	Manangatang	Longerenong
150 mm	86.6	85.8
225 mm	84.7	85.8
300 mm	83.3	86.2
Lsd (5%)	**2.1**	**Ns**

Table 17: Mean plump grain retention (> 2.5mm) at Manangatang and Longerenong for ten and six varieties respectively.

Row spacing	Site	
	Manangatang	Longerenong
Buloke	87.0	88.9
Flagship	75.2	82.9
Fleet	90.2	
Gairdner	78.5	79.6
Hindmarsh	77.4	82.8
Maritime	97.1	
Schooner	86.0	
SloopVic	88.3	89.9
WI3416-1572	87.7	91.5
Yarra	80.9	
Lsd (5%)	**3.8**	**3.1**

Commercial practice

Key points for growers to consider are the following:

1. Seed quality has a major effect on the ability of barley to respond to more challenging conditions in No-Till farming systems. Poor seed quality increases the chances of plant establishment losses due to relatively high rates of pre-emergent herbicide use and wider row spacing adopted in No-Till farming systems. Unfortunately, commercial tests for assessing seed quality (germination and vigor) appear to be poor predictors of plant establishment.

2. Growers should not attempt to use the currently recommended rates of pre-emergent herbicides for No-Till farming systems with row spacing of less than 225mm due to the risk of severe effects on plant establishment.

3. Reductions in plant establishment through the adoption of relatively high rates of pre-emergent herbicide use and wider row spacing configuration may require slightly higher seeding rates to compensate for these reductions.

4. Growers should do a critical economic assessment of the benefits and costs of wider row spacing configurations. Benefits include:

   - an ability to sow in higher levels of retained stubble
   - a reduction in fuel costs during sowing and/or increased sowing speed
   - potential ability to inter-row sow subsequent crops
   - potential ability to adopt between row spraying technologies
   - reduced soil disturbance
   - reduced cost of sowing equipment

   Wider row spacing also

   - provides an ability to apply higher rates of trifluralin (which may be needed with higher levels of retained stubble and poor soil incorporation) to improve grass weed control

   Potential costs include:

   - lower yields with wider row spacing
   - greater weed competition

5. Growers should note that there are no clear variety differences (for grain yield) in terms of response to herbicide, row spacing or nitrogen management practices used by No Till farming systems. Whilst there were variety specific effects of the herbicide treatments on plant establishment, shoot density and plant biomass, these did not translate into variety specific effects on grain yield. Growers may observe differences between varieties in response to some management practices, but these trials suggest that these visual differences, observed relatively early in crop growth, probably do not translate into differences in grain yield.

6. Large differences exist between varieties for grain yield. The early maturing variety Hindmarsh was the highest yielding variety at all sites. However, growers should consult the more extensive NVT trial data for making choices between varieties based on both agronomic and quality (marketing) issues.