Management effects on barley varieties – row spacing, herbicides and nitrogen

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Surveys of herbicide resistant annual ryegrass

To evaluate the response of different barley varieties to various management aspects of no-till farming systems. Variables examined include row spacing, pre-emergent herbicides and nitrogen timing.

Take home messages

- *Increasing row spacing reduced plant establishment and shoot densities but this was not reflected in reductions in grain yield at wider row spacing treatments in drought-stressed trial environments: there were no statistically significant differences in grain yield between any of the row spacing treatments*
- *Key management decisions for optimising production were variety choice (at all sites) and nitrogen management (Curyo)*
- *At Curyo, barley varieties responded differently to row spacing, nitrogen timing and combinations of row spacing and nitrogen*
- *Varying pre-emergent herbicide did not effect yield at Manangatang or Jil Jil*
- *Variety yield performance was consistent with long-term National Variety Trial data (Hindmarsh, Buloke performing well, Commander and SloopVic performing poorly in dry environments).*

Background

A large tri-state project jointly funded by GRDC and SAGIT is in its second year of investigations to provide variety specific management advice for newly-released barley varieties. Research in Victoria is specifically focussing on variety response to aspects of no-till management. This paper reports on three trials managed by BCG in 2008.

Method

Location:	Manangatang, Curyo and Jil Jil
Replicates:	3 (split plot factorial design)
Sowing date:	1 May at Manangatang, 12 May at Jil Jil, 14-15 May at Curyo
Seeding density:	130 plants/m² (sowing rates adjusted for each variety)
Crop type:	Barley
Seeding equipment:	Janke tynes, knife points, press wheels, 25mm seed spread
Growing season rainfall:	115mm at Manangatang, 140 mm at Curyo, 113mm at Jil Jil
Soil type:	Sandy clay loam at Manangatang, sandy clay loam at Curyo, clay loam at Jil Jil

Three sites were established in cereal stubbles standing from the previous season, sowing into marginal soil moisture with knife points and press wheels. Stubble cover was moderate at Manangatang and Curyo and low at Jil Jil. Treatments at Curyo were row spacing, nitrogen timing and variety. Manangatang and Jil Jil treatments were row spacing, pre-emergent herbicide and variety (Table 1). All sites received a knockdown herbicide prior to sowing. The Curyo site had 1.5L/ha TriflurX™ applied pre-sowing to all treatments. An unforseen delay meant 150mm row spacing treatment was sown the morning after the other two row spacing treatments. An additional 0.75L/ha TriflurX™ was applied prior to sowing the 150mm treatment to compensate for any losses likely to have occurred by not incorporating within 24 hours. (Visual plant vigour reduction was observed but plant establishment or dry matter production not affected). All sites were to be sown with 50kg/ha MAP but a calibration error resulted in 145kg/ha MAP being sown (32kg/ha P, 15kg/ha N). An additional trial was set up at Curyo with a combination of spacing, nitrogen and variety treatments to evaluate the effects of the higher MAP rate: results indicate no statistically significant effect. The Curyo nitrogen treatments were applied as UAN through a boom spray with AI nozzles. Neither Jil Jil nor Manangatang required post emergent nitrogen application. Broadleaf weeds were controlled at each site.

A factorial analysis of variance at 95 percent confidence level was used to test for significant effects of treatments and interactions of treatments for the evaluations made (plant establishment, shoot density, dry matter production, grain yield and quality parameters).

Table 1. Treatment matrix for the three sites.

Treatment	Manangatang	Jil Jil	Curyo
Row spacing	- 150mm - 225mm - 300mm	- 150mm - 225mm - 300mm	- 150mm - 225mm - 300mm
Pre-emergent herbicide	- Nil - TriflurX™ 1.5L/ha - TriflurX™ 1.5L/ha and Lexone® 140g/ha	- Nil - Triflur X™ 1.5L/ha - BoxerGold® 2.5L/ha	
Nitrogen timing			- Nil - 40kg/ha N pre-sow - 20kg/ha N pre-sow + 20kg/ha N GS30 (18 July) - 40kg/ha N GS30 (18 July)
Variety	Buloke, Commander, Flagship, Fleet, Hindmarsh, Sloop Vic.		

TriflurX™ is Trifluralin 480g/L; Lexone® is metribuzin 750g/L; Boxer Gold® is 800g/L Prosulfocarb (Group E) and 120g/L S-metolachlor.

Results

All three sites were subject to low growing season rainfall. Crop emergence at Manangatang was staggered and influenced by variation in soil texture and stubble cover. Crop emergence at Jil Jil and Curyo was excellent. As the dry growing season played out, soil type variations influenced plant growth and final yield at Manangatang and Jil Jil and to a lesser extent Curyo. Results presented do not account for spatial variability. The row spacing treatments are the most affected data. Further analysis using EM surveys to separate soil type effects from treatment effects are currently being conducted. An updated report will be distributed at a later date.

What was the effect of row spacing?

Plant establishment was acceptable at each site for all row spacings, but was significantly lower for the 300mm row spacing (Table 2a) at Curyo and Jil Jil. At both Curyo and Jil Jil there was a trend for 150mm spacing to have the highest plant density, although this effect was only statistically significant at Curyo. Shoot density was also reduced by increased row spacing, with the two extremes in row spacing treatments being significantly different at all three sites (only 94 percent confidence at Jil Jil) (Table 2a).

Despite the effects on plant and shoot populations, row spacing did not significantly affect yield at any site (Table 2b). At Manangatang, there was a consistent trend for 225mm spacing to be higher yielding for all varieties, whilst at Curyo there was a weaker trend for the 300mm row spacing to be higher yielding, particularly for the varieties Fleet and Flagship (Figure 1). The variety by row spacing interaction at Curyo was statistically significant. The trial design was such that interactions between variety and row spacing were easier to detect than differences between row spacing *per se*. At the Curyo site, a statistically significant three-way interaction for grain yield was also observed between row spacing, nitrogen and variety. This is discussed further in the section below. Site variability may have influenced row spacing results at Manangatang.

There was no consistent trend for Jil Jil, where row spacing effects may have been masked by site variability. As the variety by row spacing interactions were only statistically significant at Curyo, no strong recommendations can be made regarding the selection of particular varieties to suit particular row spacing configurations.

Table 2a. Effect of row spacing on plant density at GS14 and shoot density at GS30-31 for the three sites. The means are calculated from all treatments for each spacing.

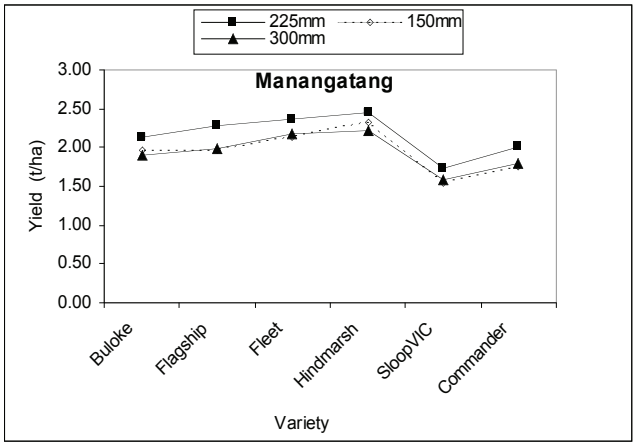
Row spacing	Plant density/m²			Shoot density/m²		
	Manang	Jil Jil	Curyo	Manang	Jil Jil	Curyo
150mm	129	140	138	668	577	528
225mm	128	131	132	546	530	480
300mm	116	123	126	454	440	466
P Value **Lsd (5%)**	**NS**	**0.05** **13**	**<0.001** **3**	**<0.01** **85**	**0.06** **110**	**<0.05** **34**

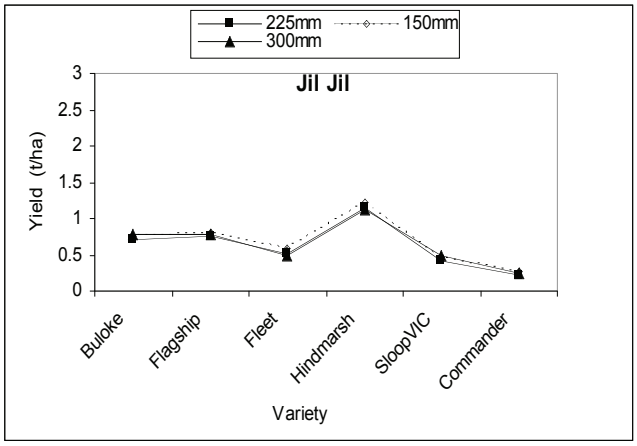
Table 2b. Effect of row spacing on grain yield and quality for the three sites. The means are calculated from all treatments for each spacing

Row spacing	Yield t/ha			Plump grain retention > 2.5mm %			Protein % dry basis		
	Manang	Jil Jil	Curyo	Manang	Jil Jil	Curyo	Manang	Jil Jil	Curyo
150mm	1.95	0.68	2.10	12.7	3.6	46.1	16.4	19.8	10.0
225mm	2.16	0.63	2.05	20.4	5.0	42.6	15.0	19.8	9.8
300mm	1.94	0.65	2.15	16.4	4.0	44.0	16.1	19.8	10.1
P Value **Lsd (5%)**	**NS**	**NS**	**NS**	**<0.005** **2.7**	**NS**	**NS**	**<0.05** **0.9**	**NS**	**NS**

** Row spacing × variety and row spacing × variety × nitrogen interactions were significant.*

The only significant effects of row spacing on grain quality were at Manangatang where there was higher retention and lower protein for the 225mm spacing compared to the 150 and 300mm spacings (Table 2b). Retention was poor at all sites. Protein was high at Jil Jil and Manangatang. No significant interaction for grain quality occurred with spacing and the other treatments (variety, herbicide or nitrogen).





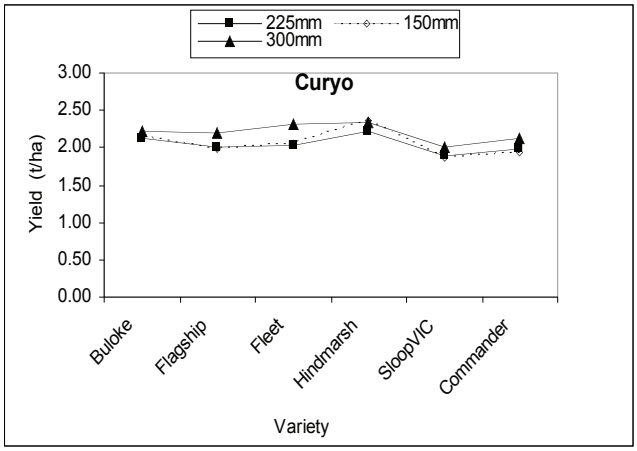


Figure 1. The influence of row spacing on grain yield of six varieties at Manangatang and Jil Jil and Curyo (See Table 2b for statistical information).

What was the effect of pre emergent herbicide?

The application of TriflurX™ (Manangatang and Jil Jil), TriflurX™ + Lexone® (Manangatang) or Boxer Gold® (Jil Jil) did not affect plant emergence, shoot densities, yield or quality (data not shown for quality) (Table 3). There was no significant interaction between herbicide treatment and row spacing or herbicide treatment and variety. Preliminary analysis investigating relationships between soil characteristics and treatments suggest that there may be interaction between subsoil constraints and the effect of herbicide treatment and row spacing but further investigation is required before firm conclusions can be drawn.

Table 3. Effect of herbicide on plant density at GS14 and shoot density at GS30-31 at Manangatang and Jil Jil. Mean of all variety and spacing treatments for each herbicide except where indicated.

Manangatang				Jil Jil			
Herbicide	**Plant density /m²***	**Shoot density /m²**	**Yield t/ha**	**Herbicide**	**Plant density /m²**	**Shoot density /m²**	**Yield t/ha**
Nil	126	554	2.02	Nil	135	503	0.64
TriflurX™ 1.5L/ha + Lexone® 140g/ha	123	556	2.04	BoxerGold® 2.5L/ha	128	527	0.64
TriflurX™ 1.5L/ha	122	558	2.01	TriflurX™ 1.5L/ha	131	517	0.67
P Value	NS	NS	NS	P Value	NS	NS	NS

**Mean excludes 150mm treatments*

What was the effect of nitrogen application and timing at Curyo?

There was only 69kg/ha of available nitrogen (0-100cm) measured at Curyo on 22 May and as a result Curyo was a nitrogen responsive site even after the application of 15kg/ha N via MAP at sowing. Applying an additional 40kg/ha N either prior to sowing or 50 percent prior to sowing and 50 percent at GS30 increased yield significantly. Interestingly, 20kg/ha N applied pre-sowing resulted in the same dry matter response as 40kg/ha pre-sowing when measured at GS30. Grain retention was reduced by N application but not affected by N timing. Grain protein was increased by applying N with the late N applications having higher protein compared to applying all N at sowing.

Yield response to N timing varied among varieties and variety response was influenced by row spacing (Table 4 and Figure 2). Commander did not respond to N at 150mm row spacing but did exhibit a yield response at wider row spacings. Fleet, Buloke and Sloop Vic were less responsive to N applied at GS30 regardless of row spacing. Flagship was N-responsive regardless of N timing or row spacing. The growth stage of all varieties was between GS30 and GS31 at the time of the 'GS30' N application.

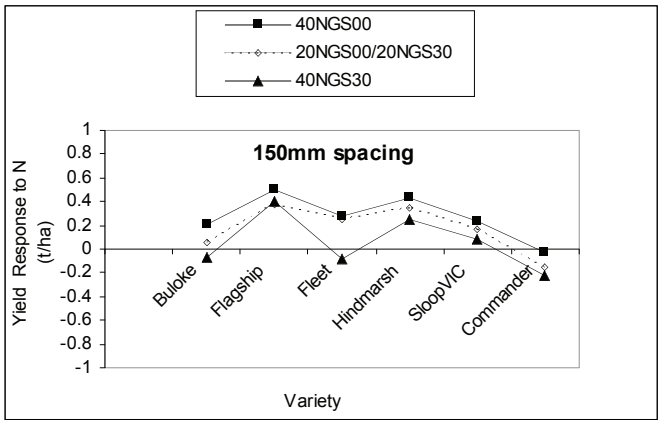
Table 4. Effect of nitrogen timing on plant density at GS14, shoot density and dry matter at GS30-31 and yield and quality at Curyo. Mean of all variety and spacing treatments for each timing.

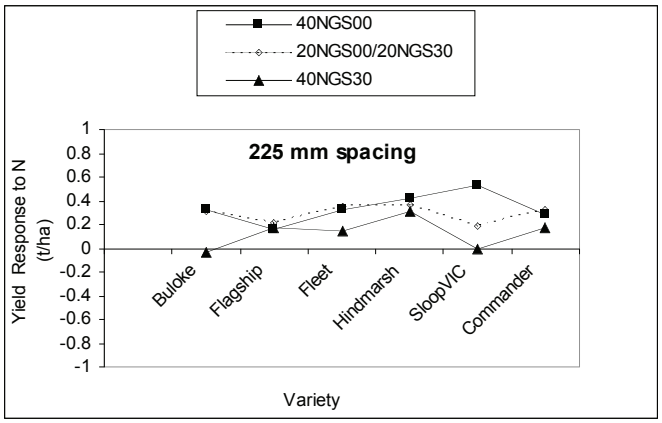
Nitrogen treatment	Plant density /m^2	Shoot density /m^2	Dry matter t/ha	Yield t/ha	Plump grain retention > 2.5mm %	Protein dry basis %
Nil	127	454	0.86	1.92	57.6	8.3
40 N pre-sow	135	533	0.95	2.23	43.3	9.9
20 N pre-sow + 20 N GS30	133	514	0.97	2.20	38.5	11.0
40 N GS30	132	463	NA	2.05	37.6	10.7
P Value Lsd (5%)	**NS**	**NS**	**<0.05 0.12**	**<0.005 0.16**	**<0.001 9.4**	**0.01 1.1**
N x row spacing	**P <0.05**	**NS**	**NS**	**NS**	**NS**	**NS**
N x variety	**NS**	**NS**	**NS**	**P<0.005**	**P <0.001**	**P <0.05**
N x variety x row spacing	**NS**	**NS**	**NS**	**P <0.05**	**NS**	**NS**

How did the varieties differ?

Plant establishment was generally close to the target density of 130 plants/m^2 but there were some differences between varieties. Hindmarsh, Commander and SloopVic emergence was excellent at all sites. Plant density of Flagship was lower at Manangatang but good at Jil Jil and Curyo, while Buloke had low plant density compared to other varieties at all three sites and Fleet was lower at Jil Jil and Manangatang. Hindmarsh appeared slower growing the first 28 days but this was no longer evident by mid-tillering.

Shoot densities also differed among varieties with Hindmarsh and Commander at the high end and Buloke at the lower end. Hindmarsh possesses a semi-dwarf gene, which causes its erect leaf habit and slower early growth, and is probably associated with more profuse tillering. Commander has a semi-prostrate early growth habit and tends to be shorter than other varieties. The lower shoot densities for Buloke may be due to the lower plant establishment; average numbers of shoots per plant were similar for most varieties, with the exception of Hindmarsh in which it was higher.





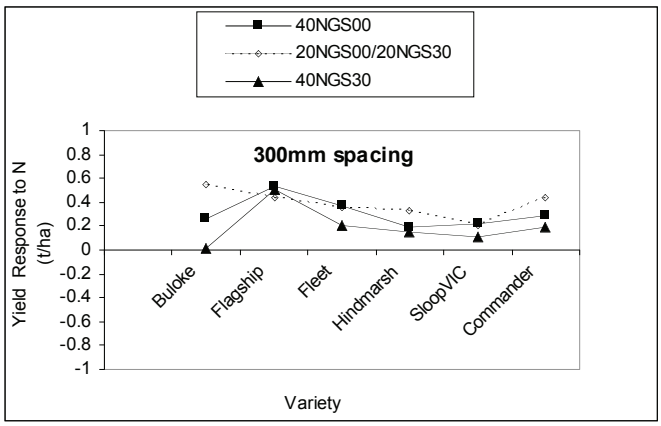


Figure 2. Grain yield response to N application for three N timings and six varieties at 150mm, 225mm and 300mm row spacing at Curyo.

Table 5a. Plant and shoot density for all varieties at three sites. Mean of all treatments for each variety except where indicated.

Variety	Plant density/m^2			Shoot density/m^2		
	Manang*	Jil Jil	Curyo	Manang*	Jil Jil	Curyo
Buloke	118	123	118	509	488	464
Flagship	116	141	138	551	510	506
Fleet	122	123	138	550	462	491
Hindmarsh	133	132	131	574	618	525
Sloop Vic	125	134	139	563	472	463
Commander	127	134	132	588	544	499
P Value Lsd (5%)	<0.05 11	<0.05 11	<0.01 8	<0.05 45	<0.05 46	0.001 34
Row spacing x variety	NS	NS	0.05	NS	NS	NS
Herb/N x variety	NS	NS	NS	NS	NS	NS
Row spacing x herb/N x variety	NS	NS	NS	NS	NS	NS

**Means exclude 150mm treatments*

As expected, grain yield differences among varieties were highly significant. Hindmarsh consistently yielded well. Fleet and Flagship were high yielding at Manangatang and Curyo but Fleet performed poorly at Jil Jil. Buloke was moderate yielding but consistent across all three sites. Sloop Vic and Commander yielded poorly – their later maturity did not suit the dry finish to the season. Variety interactions with other treatments were significant at Curyo but not at other sites. As discussed earlier,

these interactions may be influenced by soil type variability and secondary analysis may provide more answers.

Grain quality was poor with high protein at Jil Jil and Manangatang and low plump grain retention, particularly at Jil Jil and Manangatang. Fleet, Commander and Sloop Vic showed consistently higher grain size. Sloop Vic exhibited the highest protein at each site.

Table 5b. Grain yield of all varieties at three sites. Mean of all treatments for each variety.

Variety	Manang		Jil Jil		Curyo		% three-site mean (1.6t/ha)
	Yield t/ha	% site mean	Yield t/ha	% site mean	Yield t/ha	% site mean	
Buloke	1.99	99	0.75	114	2.16	103	103
Flagship	2.08	103	0.78	120	2.06	98	103
Fleet	2.22	110	0.53	82	2.13	102	102
Hindmarsh	2.33	116	1.17	179	2.31	110	122
Sloop Vic	1.62	80	0.45	69	1.92	92	84
Commander	1.85	92	0.24	37	2.02	96	86
P Value Lsd (5%)	**<0.001 0.08**	**<0.001 4**	**<0.001 0.07**	**<0.001 10**	**<0.001 0.06**	**<0.001 3**	
Row spacing x variety	**NS**		**NS**		**<0.005**		
Herb/N x variety	**NS**		**NS**		**<0.001**		
Row spacing x herb/N x variety	**NS**		**NS**		**<0.005**		

Table 5c. Grain quality for all varieties at three sites. Mean of all treatments for each variety

Variety	Plump grain retention > 2.5mm %			Protein dry basis %		
	Manang*	Jil Jil	Curyo	Manang*	Jil Jil	Curyo
Buloke	13.0	0.4	42.9	15.8	18.9	9.6
Flagship	10.0	0.3	17.4	15.3	19.6	9.9
Fleet	21.4	6.2	60.1	15.3	19.5	10.0
Hindmarsh	18.2	0.40	43.8	15.5	19.7	9.7
Sloop Vic	10.5	2.6	44.1	17.0	21.3	10.5
Commander	25.9	15.6	57.1	15.9	19.8	10.2
P Value Lsd (5%)	**<0.001 4.5**	**<0.001 1.9**	**<0.001 4.6**	**<0.001 0.56**	**<0.001 0.31**	**<0.001 0.35**
Row spacing x variety	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Herb/N x variety	**NS**	**NS**	**0.01**	**NS**	**NS**	**<0.005**
Row spacing x herb/N x variety	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Interpretation & Application

Row spacing

300mm row spacing in these trials reduced plant establishment and tiller numbers, but this did not result in lower yields for this treatment. This provides some confidence, at least in years with low spring rainfall, that the operational advantages of wider rower spacing (stubble handling, improved trifluralin safety and increased sowing speed) are not outweighed by potential reduction in yield due to reduced plant establishment and shoot counts. Conduct of these trials in a year with more favourable spring conditions is required to determine the long-term effects of reduced shoot densities on grain yield; historically, shoot density targets have been established according to growing season rainfall with higher shoot densities required for maximum yield in more favourable (higher rainfall) environments.

Increasing seed bed utilisation (SBU) (the proportion of area occupied by the crop) on wider rows (ie. increasing the seed spread across the row) may improve plant establishment due to reduced intra-row competition. The SBU of the BCG seeding system is very low for 300mm spacing (8.3 percent) compared to 16.6 percent and 11.1 percent for 150mm and 225mm spacing respectively. However, increasing seed spread could compromise the safe use of high rates of trifluralin.

Pre-emergent herbicides

While no adverse effects in terms of plant establishment or yield were detected this season for 1.5L/ha TriflurX applied prior to and incorporated by sowing on 150mm spacing, 2007 trials did find establishment to be affected and this practice is advised against. Lexone did not have an effect this year but the dry conditions around sowing time may have meant low activation of the metribuzin.

Nitrogen

Even in a very dry year, the addition of nitrogen was critical for yield optimisation at the Curyo site (however, profitability of N application will be dependent on the price of N and, given the high N fertiliser prices in 2008, it is unlikely that the application of 40kg/ha N would have been profitable). Early timings of N had the least impact on protein while optimising yield. The 50-50 approach is probably the lowest risk approach. Varietal response to N was varied with Flagship seemingly most responsive and Commander being less responsive (Figure 3). Although the varieties were all between GS30 and 31 at the time of the mid-season N application, the effect of differences in crop phenology on N response cannot be discounted. Further work is required to confirm varietal difference in N response.

Variety

Hindmarsh shows enormous promise as a variety and the wide scale adoption of this variety would have a large scale impact on total barley production, particularly if Hindmarsh gains malting status. BCG understands that the first of two years of commercial malting and brewing trials will be conducted during 2009, with a final decision on the classification of Hindmarsh for malting not expected until February 2011. The alternative feed variety, Fleet, does not appear to be as widely adapted as Hindmarsh. The new malting variety, Commander, is not well adapted to low rainfall environments in terms of grain yield although it does possess excellent grain plumpness. The existing malting variety Sloop Vic is outclassed.

Variety differences had a larger impact than other variables (row spacing, herbicide) on yield at Jil Jil and Manangatang, illustrating the value of good variety choice. At Curyo, both N management and variety were important.

Acknowledgements

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