New genotypes to improve the quality and yield of organic spelt

Spelt genotype evaluation trails at Yanco Agricultural Institutes Organic Research Site.

By Neeson, R.[1]; Burnett, V.[2]; Evans, J. [3]; Luckett, D.[3]; Taylor, H.[3]; Wellings, C[4]; Bowden, P.[5]

SPELT (*Triticum aestivum* var. *spelta*), is one of the oldest cultivated grains, preceded only by Emmer *(T. dicoccon)* and Einkorn *(T monococcum)*. Various historians trace spelt to origins in Egypt or Mesopotamia between 5,000 years and 9,000 years ago. From this putative origin, it made its way to Europe via the Black Sea and completed that part of its journey in Southern Germany and Switzerland probably about 1800 to 1200 BC.

Research in Europe and North America shows spelt as a relatively hardy, versatile grain that has many uses for human consumption and stockfeed.

However, while spelt has higher protein content than common wheat, with reported averages of 12.1 – 17.1% (Abdel-Aal & Hucl 2005), it also has inconsistent yields, low test weights, a limited range of adapted cultivars and requires an expensive de-hulling process (Boland 2003).

Some research suggests that spelt out-performs many traditional grains (such as wheat) under sub-optimal growing conditions (Ruegger et al 1990) and is able to better utilise nutrients when grown in a low-input system (Moudry and Dvoracek 1999), suggesting spelt could play a greater role in Australian organic cereal rotations.

In Australia, spelt grain production is currently estimated at 4,000 tonnes. The current estimated retail value of processed organic spelt products is $7.7 million.

Estimates suggest that markets currently exist for approximately 10,000 tonnes of organic spelt grain per annum with an on-farm value of $10 million (de-hulled), and retail value of $19.2 million.

While the greatest demand is for organically produced specialty grains, poor yields and market irregularities are frustrating industry expansion. Organic farmers may also strategically graze spelt crops during the growing season which may reduce grain yields.

Table 1. Key spelt attributes as identified by organic farmers and grain processors / millers.

Agronomy	Grain / Milling Quality
High yield /stable over time	Ease of de-hulling
Early seedling vigour	Baking quality
Disease resistance	Gluten solubility
Resistance to head shattering	High protein
Low input (fertiliser)	Mineral composition
Drought tolerance	By-product suitability for livestock

Organic Spelt Trials

A three-year project being conducted by researchers from the EH Graham Centre for Agricultural Innovation (a collaborative alliance between New South Wales DPI and Charles Sturt University) is aiming to develop more reliable, locally adapted cultivars of spelt for organic production.

Following screening of a collection of 88 spelt genotypes sourced from the Australian Winter Cereals Collection (Tamworth, NSW) and from organic farmers, 20 spelt genotypes were selected for evaluation in field trials.

In 2007, trials were conducted on organic crop production sites at Yanco and Cootamundra in NSW and Rutherglen in Victoria.

The spelt genotypes were evaluated alongside wheat (cv. Wedgetail), barley (cv. Urambie), Kamut® (*Triticum turanicum)* and triticale (cv. Speedie) for their agronomic and quality characteristics.

Organic farmers and grain processors were surveyed and requested to identify key attributes for future selections (Table 1).

2007 results

The 20 spelt genotypes evaluated in 2007 exhibited a wide variation in agronomic attributes (Table 2). The results presented here are from one year's evaluations and therefore should be cautiously interpreted. Trials are continuing with a selected number of genotypes in 2008.

There was a trend towards later maturing genotypes of spelt wheat yielding less than earlier maturing genotypes.

The yields of all lines tested generally increased under irrigation. The highest yielding spelt genotype (Line 19) yielded a mean aggregate (Yanco & Rutherglen) weight of 2.73 tonne/ha compared to wheat (3.77 tonne/ha) and barley (4.42 tonne/ha).

Days to anthesis across all spelt genotypes ranged from 133 days to 153 days, compared to 138 days for wheat and barley.

Increased tillering appeared to be correlated with lower yield in spelt lines (except for Lines 40 and 41) suggesting that the common practice of grazing spelt lines during the growing season should be carefully weighed up against the potential for grain yield loss.

Lines 40 and 41 could be suitable candidates for a grain and graze option as both produced good biomass and satisfactory grain yield.

A range of aluminium tolerances were scored from Very Susceptible (VS) to Tolerant (T) indicating some spelt lines may be a useful option for acidic soils (Table 2).

Disease response

Spelt lines grown in the field and glasshouse showed a range of responses to the cereal diseases stripe rust and stem rust. It was

Farmers inspect spelt genotypes during a field day at Yanco Agricultural Institutes Organic Research Site.

concluded that spelt genotypes 33, 43, 9a and 10ab posed an unacceptable risk due to their rust susceptibility.

Further field and glasshouse evaluations for disease response and an analysis of the genetic basis of resistance are being undertaken in 2008/09.

Spelt and phosphorus response

Preliminary glasshouse trials conducted in 2006 indicated that while the total P uptake (mgP/plant) is similar between traditional wheat and spelt, some spelt genotypes were able to produce a larger biomass. In 2007, a number of spelt genotypes and several varieties of wheat (Gregory, Wedgetail, ww12410) were grown in the glasshouse with P levels adjusted to provide P rates equivalent to 75, 150, 225, and 375 kg/ha of superphosphate.

Plots of anthesis dry matter versus plant P uptake resulted in segregation of spelt lines and wheat cultivars into three groups (Figure 1).

The mean maximal dry matter of Groups 1 and 2 were respectively 186% and 132% greater than Group 3.

Despite indications that spelt was capable of producing greater biomass under lower P levels there was no evidence to suggest that spelt was more efficient at converting P to grain than wheat cultivars.

Tiller number increased linearly with P; however this was not translated into greater grain yield. Later maturing spelt genotypes with a longer length of time to reach anthesis tended towards lower yield.

The wheat varieties, to the contrary, appear relatively high yielding. Lines 10, 18, 19 & 40 were within 80% of the mean yield (6.67 g/pot) of the wheat varieties; Lines 10, 18 & 19 had a dry matter & P uptake pattern similar to the wheats.

Lines 40 and 41 have high dry matter, yet comparatively good yield possibly as they commit less to tillering. Lines 18, 19 & 40 in addition to the industry standard will be included in further phosphorus response field trials in 2008.

Spelt grain quality assessments

An initial assessment of a range of quality attributes was undertaken for the 20 spelt lines evaluated in field trials in 2007 (Table 2). These initial results indicate there is scope for selection of spelt lines with dough characteristics suitable for specific end uses.

Grain characteristics

Spelt is reported to achieve high protein in comparison to wheat. In this experiment wheat and triticale produced grain at 15.7% and 13.7% protein respectively.

The spelt lines achieved (on average) 17.0% grain protein, with only two of the 20 lines achieving lower grain protein than the reference wheat.

The percentage of hull in the spelt lines ranged from 18% to 31%, with varying degrees of difficulty in removing the grain from the husk.

Several spelt lines produced naked grain, obviating the need for de-hulling. Spelt has a reputation for low test weight but several genotypes outperformed the wheat reference line for both test weight and kernel weight.

The SKCS hardness index (HI) (a measure of the force required to crush individual kernels) indicates that spelt shows a similar range of hardness values to bread wheat, but of the 20 selected genotypes, over half exhibited soft grain texture.

Table 2. Agronomic features of spelt selections evaluated in 2007.

Spelt ID	Combined yield data (Yanco, Rutherglen) t/ha	Days to anthesis	Head type	Hulled or Free-threshing	Aluminium tolerance score	Field stripe rust (Yanco)	Field stripe rust (Rutherglen)	Field stripe rust (Camden)	GH Stripe rust	Field Stem rust
2	1.73	145	awned	Hulled	T, T			R	S	MR
3	0.96	149	awned	Hulled	T, I			R	S	MR
4	0.97	149	awnless	Hulled	I, I			R	S	R
7	1.94	143	awned	Hulled	S, S	Yes	Yes	MR-MS	S	MR
9a	1.84	145	awned	Hulled	T, S	Yes	Yes	MR, VS	S	S
10 ab	2.43	135	awned	Hulled	I, S	Yes	Yes	MR	S	S
14	0.91	149	awned	Hulled	T, *		Yes	R-MR	S	MR
16	1.73	139	awned	Hulled	S, S			MR	R	R-MR
18	1.59	135	awned	Hulled	S, S			R-MR	R	R-MR
19	2.73	140	awned	Free	S, S			MR-MS	S	MR
22	0.85	151	awned	Hulled	I, T			R-MR	S	MR
23	0.68	153	awned	Hulled	T, I	Yes	Yes	MR	I	MS
29	1.87	145	awned	Hulled	I, T			R-MR	S	MR
39	0.72	147	awned	Hulled	I, T			R-MR	I	MS
40	2.40	135	awned	Hulled	S, VS			R-MR	S	MS
41	2.61	140	awnless	Hulled	S. S			R-MR	R	MS
43	2.50	133	awnless	Hulled	S, S	Yes	Yes	VS	S	MS
Barley	4.42	138								
Kamut®	1.34	138								
Triticale	3.05	133				Yes				
Wheat	3.77	138				Yes				
Yield	Mean	2.02806								
LSD (5%)		0.33217								

Selections being evaluated in 2008

Flour extraction data (FE) (yield of flour obtained in the milling process) identified several lines with comparable or better extraction rates than the reference wheat.

The two poorest performing lines were those with extremely hard grain, possibly indicating a higher conditioning requirement.

Starch pasting characteristics

Starch quality, particularly high paste viscosity, is important in producing marketable wheat for several end uses. All bar three of the spelt varieties had equal or higher peak viscosity than the reference wheat; however the time to reach peak viscosity for the spelt lines was consistently 30 to 60 seconds longer than for the reference wheat.

Dough mixing characteristics

For desirable bread-type flour good dough mixing tolerance is indicated by a dough being elastic after mixing as well as having moderately long mixing requirements (three to six minutes), strong gluten strength and good dough mixing tolerance.

The spelt genotypes exhibited characteristic of weaker doughs indicating low mixing requirements to develop the gluten and a short tolerance to over mixing.

Three lines did show greater mixing tolerance, with one of these exhibiting characteristics very similar to the reference wheat.

Conclusions and future research

Clearly spelt has an important role to play in broadacre organic crop and livestock enterprises. Our preliminary research indicates that some spelt genotypes may out-yield and have superior quality to those lines currently being commercially grown.

Furthermore, research has identified a range of agronomic attributes such as maturity, phosphorus response, disease and aluminium tolerance which will assist organic farmers to make informed decisions when determining their rotation options.

This current project concludes in mid 2009 however, further research funding is needed to determine:

- Which spelt genotypes are the most resource-use efficient (N, water)?
- Are some spelt genotypes better competitors than others against weeds?
- What are the best milling techniques and end-uses for spelt genotypes?
- What is the nutritional value of spelt and its by-products to livestock?
- What characteristics in spelt define its health benefits and how can these be substantiated?

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References

Abdel-Aal & Hucl, 2005. In: Specialty Grains for Food and Feeds. Eds. Abdel-Aal, E. and Wood, P. 2005. American Association of Cereal Chemists, Inc. St. Paul, Minnesota, USA.

Boland, M. 2003. Spelt Industry Profile. Department of Agricultural Economics Kansas State University.

Evans, J. 2008. Unpublished. Spelt wheat phosphorus study. EH Graham Centre for Agricultural Innovation, Wagga Wagga NSW.

Moudry, J, and Dvoracek, V. 1999. Chemical composition of grain of different spelt varieties (*Triticum spelta* L.). Rostlinna Vyroba 45:533:538.

Ruegger, A., Winzeler, H. Nosberger, J. 1990. Studies on the germination behaviour of spelt (*Triticum spelta* L.) and wheat (*Triticum aestivum* L.) under stress conditions. *Seed Sci. Technol. 8:311-320.*

[1] NSW Department of Primary Industries, Yanco, NSW, Australia
[2] Department of Primary Industries, Rutherglen, Victoria, Australia
[3] E H Graham Centre for Agricultural Innovation (NSW Department of Primary Industries and Charles Sturt University), Wagga Wagga, NSW, Australia.
[4] NSW Department of Primary Industries, Plant Breeding Institute, Camden, NSW Australia
[5] NSW Department of Primary Industries, Cootamundra, NSW, Australia.

Figure 1. Arbitrary classification of spelt and wheat lines into three groups according to relationship between dry matter (DM) production and uptake of phosphorus (P).

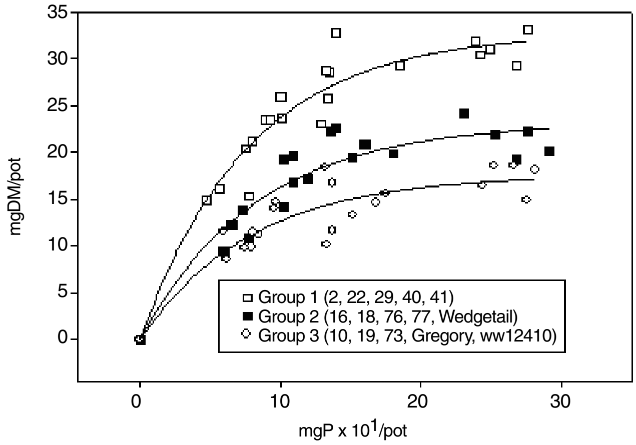

Table 3. Average grain quality and analysed flour extraction for all spelt entries

Sample ID	Grain Protein %	Test weight (kg/hL)	Av grain weight (mg)	SKCS Hardness Index	Flour Extraction %
2	17.6	75.3	39.0	25	69.8
3	17.2	79.4	32.0	33	70.1
4	17.2	79.1	33.4	43	69.3
7*	18.0	77.9	33.7	79	64.0
9a	16.3	75.8	34.9	25	59.9
10ab	14.9	75.2	35.2	32	64.8
14	17.1	79.2	30.7	34	68.1
16*	16.8	80.4	33.4	27	67.7
18	16.6	81.3	33.8	23	68.0
19*	15.7	77.4	36.8	62	67.0
22	17.3	78.8	32.1	33	69.5
23	18.7	78.7	31.8	57	64.6
29	17.5	76.4	39.9	30	71.3
39	17.9	77.6	36.9	22	72.9
40	17.1	75.1	51.5	17	61.0
41*	17.3	80.0	31.7	75	67.8
43	15.6	73.8	34.5	57	70.7
Spelt average	17.0	77.7	35.4	39.6	67.4
Ref. Wheat	15.7	75.0	37.3	60	69.8
Ref. Triticale	13.7	68.8	48.1	44	61.2

*Selections being evaluated in 2008