Irrigated durum benchmarked

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- High yielding, water efficient DR1 durum was achieved in ***most*** of the 18 benchmarked fields, in the Hillston irrigation district.
- Grain protein, hard vitreous kernels, test weight, 1000 grain weight, falling numbers, semolina colour and semolina yield were all within desirable limits.
- Dough strength was poor in the majority of samples, however this may have been due to seasonal conditions and/or varietal characteristics since the two samples of Caparoi performed better than most Bellaroi samples.
- Nutrition (sulphur) and irrigation management (time of last irrigation) seemed to influence grain protein in some crops, where added sulphur increased protein, and late irrigations decreased protein.
- Paddock rotation had a big effect on nitrogen fertiliser efficiency.

A benchmarking project has identified the agronomic practices that increase yield, water use efficiency and grain quality for irrigated durum wheat.

The project, carried out in the Hillston irrigation district in 2009, applied the most recent agronomy practices on a selected number of commercial fields.

The aim was to achieve:

- target yields
- target water use efficiencies
- DR1 quality grade.

The project also evaluated quality characteristics not currently measured in commercial situations.

The target specifications for three classifications of durum wheat in Australia are shown in Table 1.

The project

2009 was a very dry year, with only 97–168 mm of rain falling in the growing season in the benchmarked crops. Average growing season rainfall for the district is 220 mm, so this made irrigation essential for achieving high yields.

Table 1. Classifications for durum wheat in Australia

	DR1	DR2	DR3
Protein min (%)	13.0	11.5	10.0
Test weight min (kg/hl)	74	74	71
Screenings min (%)	5	5	10
HVK min (%)	80	70	no min
Falling number min	>300	>300	>200

Source: Grain Trade Australia

Temperatures were consistently warmer than average throughout the growing season, apart from a cool period in late October.

Harvest was only disrupted by one late rain event.

Eighteen commercial fields were benchmarked (including four smaller trial paddocks) and managed according to current agronomic best practice. Many crop measurements were taken so that comparisons could be made following harvest. These are shown in Appendix 1, and include most of the current 'checks' associated with the '8-tonne club' strategy.

The fields were sampled to obtain about 5 kg of grain. Samples were then sent to NSW I&I durum laboratory in Tamworth, where many quality aspects were analysed and evaluated. These are shown in Appendix 3, and include:

- test weight (chondrometer)
- weight of 1000 kernels (grain counter)
- percentage of hard vitreous kernels (300 grain count)
- wheat moisture (NIR)
- protein content (NIR)
- falling number (ground semolina)
- yellow pigment or colour (Minolta camera)
- semolina yield
- dough strength (mixograph and gluten index).

Results

Water use efficiency (WUE)

In irrigation systems, WUE is the key driver to productive and profitable farming. Because many crops have varying irrigation methods and target yields, WUE is the best way to measure crop performance.

In this project, WUE was calculated using the French-Schultz equation, where:

- 30% of fallow moisture was assumed available
- 100% of in-crop rainfall available
- 70% of irrigation water available
- 110 mm was subtracted for evaporation.

The evaporation figure would be deemed low for a year like 2009.

Soil moisture, rainfall, irrigation and water use efficiency figures for each crop are presented in Appendix 2.

Yield, protein and hard vitreous kernels (HVK)

Yield results for the 18 crops were between 6.0 and 11 t/ha (Appendix 1).

Yield is obviously the most important factor for profitable crops, however when targeting high quality DR1 grain, protein and HVK targets can sometimes be difficult to achieve. This was the case with only a few samples, and grain quality tests from the laboratory seemed inconsistent with some of the results from the silo at harvest. See further on for discussion on this.

All samples showed desirable test grain weights (TGW) as shown in Appendix 3.

Semolina yield (%)

The semolina yield (milling yield) of the samples ranged from 68.7% to 71% (Appendix 3). Seventy per cent is usually considered desirable.

Yellow pigment or colour

Most samples exhibited excellent colour as shown by the Minolta b* scores. Some samples were a bit lower, but not to the stage where pasta colour would be compromised.

Mixograph peak time (MPT) *and breakdown* (RBD)

In most cases (apart from a few Bellaroi samples and the two Caparoi samples), tests indicated that dough strength was weak. Nearly all MPT results were unfavourably low – ideally MPT should be between 3–4 minutes. The RBD levels followed a similar trend, indicating weak dough strength.

Agronomic information on individual crops could not explain why some samples were acceptable and others were not.

Gluten index (GI)

Most samples fell below the desirable level of greater than 50. Again only a few Bellaroi samples reached this level indicating weak sample strength but both of the Caparoi samples were greater than 50.

Discussion

Grain yield & WUE

Interestingly enough, high yields were very closely correlated to high WUE ($r^2 = 74$). Only about one third of samples reached the water use target of 15 kg/mm, however that is to be expected in such a hot dry season with high evaporation. Many crops were also sown a little later than ideal, causing them to flower in the warmer part of the season. Samples 15, 16, 17 and 18 were

Even plant establishment in the right rotation was essential for achieving high yield and quality durum. Using disc seeders on 25 cm spacings, following maize was consistent in achieving yield and quality targets.

all sown in the earlier part of the sowing window. Samples 3, 15 and 16 also had remaining soil moisture from the previous crop, which would have slightly increased WUE.

While there was a good mix of irrigation methods (flood, centre pivot and lateral move), no single irrigation system shined over another. This is again likely to be because of the lack of in-crop rainfall and high evaporation.

Various aspects of agronomy affected the yield and water use efficiency, however the major influences identified included paddock history and underlying nutrition (paddock rotation), sowing time, and irrigation scheduling. The interaction between many agronomic aspects was complex, and no single factor showed any extreme influence on yield and WUE, rather, a combination of various factors did.

Sample 14 was a 'semi-irrigated' field, and as a result of the dry season was one of the lowest yielding and WUE field.

Also of interest, the crops sown into fallow (samples 4, 5, 6, 8, 9 and 11) all were lower in WUE. This may be because they started with an extremely dry soil profile, and irrigation water was required to build up the profile.

Other paddocks may have had residual moisture from the previous crop (eg samples 3, 15 and 16), which followed corn/ maize, making WUE look unusually high.

Grain protein and HVK

Most samples that reached the 13% protein target also reached the HVK target of greater than 80%.

There were some exceptions to this, however tests performed within those fields at harvest time by grain receivers suggest otherwise, and many of those samples were classed as DR1. We can therefore only assume that in these cases the samples received and analysed by the lab in Tamworth may have varied to other samples taken within those fields. That is a reasonable assumption, as typically, fields vary quite dramatically.

Of interest however were the samples 17 and 18. These two samples were lower in HVK whilst still showing high grain protein. These samples were from typical heavy clay 'rice' soils, which are heavier in texture and tend to be lower in some nutrients. The lower HVK achieved has been anecdotally reported by some farmers growing durum on those soils, but further investigation is warranted.

Crops that were watered 'right out' also seemed to be slightly lower in protein, but interestingly not lower in HVK. Typical fields that fell in this category were 1, 2 and 9.

Crops that received sulphur in-crop (samples 2, 15 and 16) also appeared higher in protein than fields that could be adequately compared. This is not surprising as sulphur is essential for

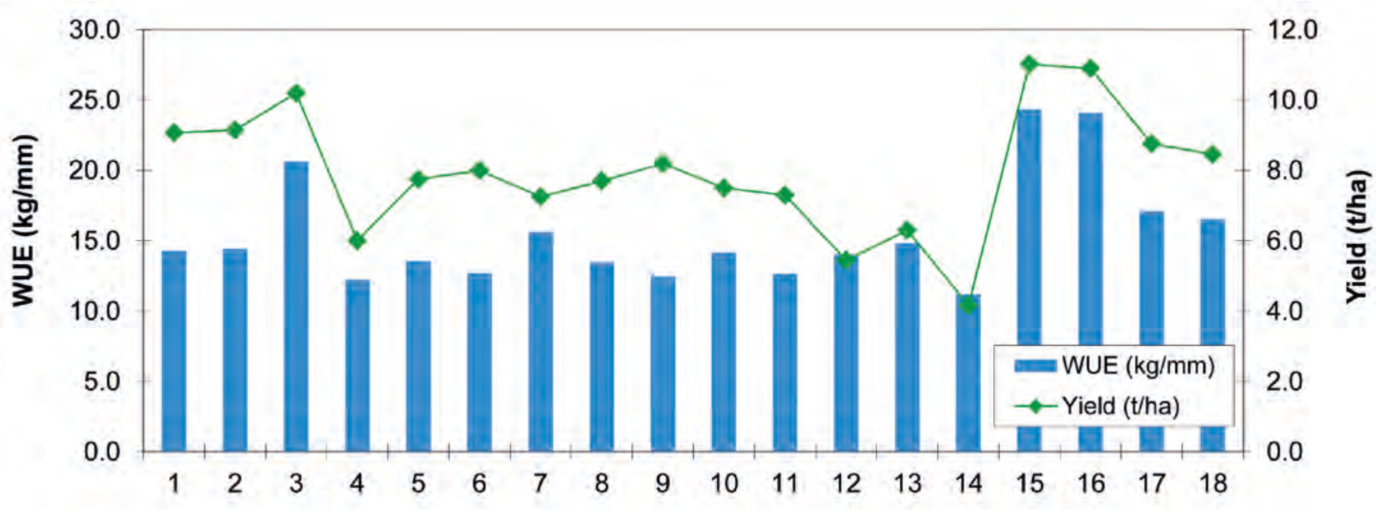

Figure 1. Water use efficiency of each benchmarked durum crop, Hillston, 2009

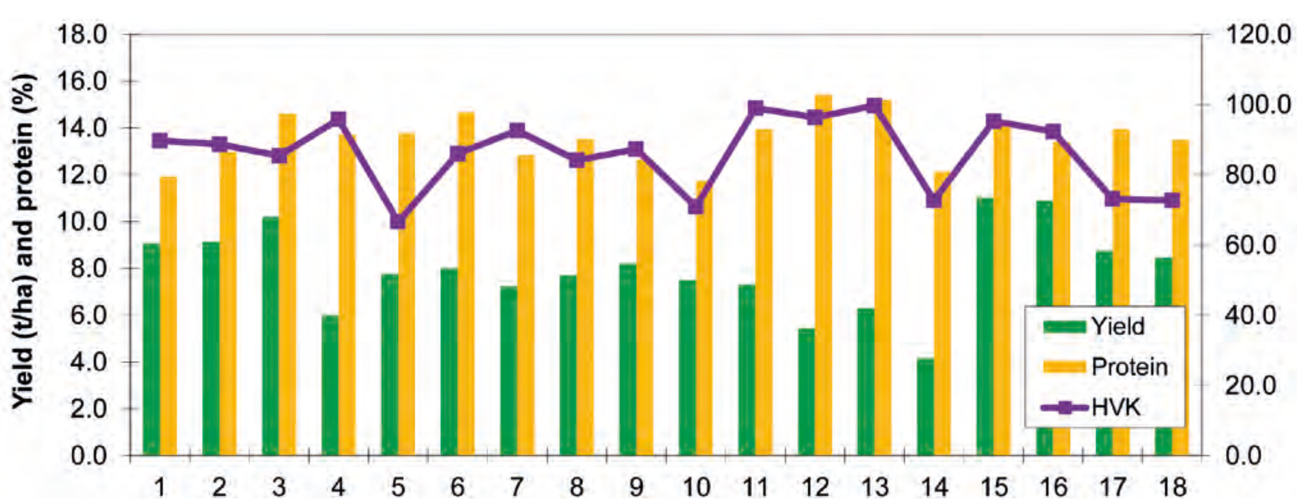

Figure 2. Yield, protein and HVK for the benchmarked fields

proper glutenin (a part of protein) formation. This also needs further investigation.

Crops following cotton (samples 1, 2, 7 and 10) all showed lower grain protein levels even though they were given a lot of fertiliser nitrogen. This was expected, as the cotton stubble that was incorporated would have tied up a lot of the residual nitrogen making it unavailable for plant use.

On the other hand, crops following fallow, corn and potatoes all reached protein and HVK targets. This highlights the underlying nutrition in these rotations, the mineralisation of nutrients, and also the absence of other things such as disease that can lower yield and quality.

Grain quality for pasta production

Grain size (hecto-litre weight), semolina yield (milling yield), falling numbers and colour all fell within favourable guidelines for producing high quality pasta.

Dough strength on the other hand was not so desirable, as indicated by the MPT, RBD and GI tests. This may be because of a number of environmental factors that may have occurred within the 2009 season, and to be certain further testing would be required. This issue may be totally different in another season and why testing over more than one year is desirable, preferably typical years matching conditions over five year average for the region. Conditions during grain filling can impact on glutenin formation and the ratio of glutenin to gliadin which impacts on dough rheological properties.

There is however a strong suggestion that Bellaroi seems inferior to Caparoi in terms of dough strength. Varietal differences are well known, and it may be necessary to undertake more varietal evaluation under high yielding irrigated durum in southern NSW to confirm this.

Recommendations

Further trial work needs to be performed in durum wheat under irrigation in southern NSW to evaluate the influence of:

1. commercial durum varieties on grain quality with particular emphasis to dough strength, protein and HVK
2. various nutritional strategies on grain quality with particular emphasis on nitrogen, sulphur and how that relates to various rotations.
3. irrigation scheduling on WUE and grain quality.

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Further information

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A crop of Bellaroi on beds that run north-south, a feature identified in the benchmarked crops critical for producing an even and uniform crop. This crop averaged over 10 t/ha.

Nutrition was identified as essential for high yielding, high quality durum. This photo shows the effect of a miss with nitrogen at sowing.

Appendix 1. Benchmarked agronomic characteristics for 18 durum crops, Hillston district, 2009

Sample	Variety	Expected N status	Soil nitrogen	Pre-plant fertiliser	Starter fertiliser	Total fertiliser added			Plant count	Tiller count	Head count	Grains /head	Estimated yield	Actual yield
			kg N/ha (0–60 cm)		kg/ha	kg N/ha	kg P/ha	kg S/ha	plants/ m^2	tillers/ m^2	heads/m^2		(t/ha)	(t/ha)
1	Bellaroi	Low	0	100 N gas	125 MAP	250.0	23.0	2.8	181	728	604	50	10.20	9.07
2	Bellaroi	Low	204	400 SOA + 50 N gas	125 MAP	282.5	23.0	97.5	174	717				9.15
3	Bellaroi	High	147	0	125 MAP	131.9	23.0	1.5	155	580	602	51	11.06	10.20
4	Bellaroi	High	196	0	115 MAP	107.0	21.0	1.0	154	669	481	34	5.87	6.00
5	Bellaroi	High	134	0	70 MAP	122.0	13.0	1.0	121	714	450	47	7.40	7.75
6	Bellaroi	High	470	150 urea	120 MAP	207.5	22.0	1.5	178	871	267	45	6.80	8.00
7	Bellaroi	Low	195	280 urea	120 MAP	187.0	22.0	1.5	170	769	420	45	7.40	7.25
8	Bellaroi	High	69	180 urea	100 MAP	139.0	18.6	1.0	137	822	430	51	7.71	7.70
9	Bellaroi	High	252	0	0	305.0	37.0	3.06	142	719	361	53	8.58	8.20
10	Bellaroi	Low	136	80 N gas	120 MAP	207.0	22.0	1.5	154	598	557	47	7.30	7.50
11	Bellaroi	High	101	165 urea	117 MAP	225.7	22.0	1.5	135	745	468	47	7.91	7.30
12	Bellaroi	High	0	0	50 DAP	55.0	10.0	1.0	225	623				5.45
13	Bellaroi	Low	0	100 urea	130 DAP	230.4	26.0	1.0	181	760	520	40	7.65	6.30
14	Bellaroi	High	238	0	80 MAP	123.0	17.5	1.0	79					4.16
15	Bellaroi	High	140	140 urea + 60 SOA	150 MAP	243.3	32.8	24.9	219	791	604	50	10.87	11.02
16	Caparoi	High	140	140 urea + 60 SOA	150 MAP	243.3	32.8	24.9	219	791	618	46	10.23	10.90
17	Bellaroi	Med	364	125 urea	150 MAP	164.5	32.8	2.0	195	553	426	44	0	8.76
18	Caparoi	Med	364	125 urea	150 MAP	164.5	32.8	2.0	195	553	337	44	0	8.46

Appendix 2. Benchmarked water supply and use characteristics for 18 durum crops, Hillston district, 2009

Sample	Variety	Total fallow rain	Growing season rainfall (R)	Water applied (I)	Total water use (I+R)	Effective rainfall[1]	WUE[1]	Grain protein[2]	HVK[2] (%)	Grade sold as
		mm	mm	mm/ha	mm	mm	kg/mm	%	%	
1	Bellaroi	61.8	125.9	700	844.44	634.44	14.30	11.9	89.7	DR2
2	Bellaroi	61.8	125.9	700	844.44	634.44	14.42	13.0	88.7	DR2
3	Bellaroi	61.8	125.9	500	644.44	494.44	20.63	14.6	85.4	DR1
4	Bellaroi	353.6	139.5	350	595.58	490.58	12.23	13.7	95.7	DR1
5	Bellaroi	353.6	139.5	468	713.58	573.18	13.52	13.8	66.6	DR1
6	Bellaroi	380.2	107.5	583	804.56	629.66	12.71	14.7	86.0	DR1
7	Bellaroi	34.4	97.0	510	617.32	464.32	15.61	12.9	92.6	DR1
8	Bellaroi	320.6	97.0	540	733.18	571.18	13.48	13.5	84.1	DR1
9	Bellaroi	303.5	127.75	630	848.8	659.8	12.43	12.6	87.3	DR1
10	Bellaroi	56.5	127.75	550	694.7	529.7	14.16	11.7	70.9	DR2
11	Bellaroi	267.9	125.9	530	736.27	577.27	12.65	14.0	99.0	DR1
12	Bellaroi	61.8	125.9	350	494.44	389.44	13.99	15.4	96.3	DR1
13	Bellaroi	61.8	125.9	400	544.44	424.44	14.84	15.2	99.7	DR1
14	Bellaroi	56.5	127.75	325	469.7	372.2	11.18	12.1	72.7	DR2
15	Bellaroi	61.8	125.9	440	584.44	452.44	24.36	14.1	95.3	DR1
16	Caparoi	61.8	125.9	440	584.44	452.44	24.09	13.4	92.3	DR1
17	Bellaroi	27.6	168.0	480	656.28	512.28	17.10	14.0	73.1	DR1
18	Caparoi	27.6	168.0	480	656.28	512.28	16.51	13.5	72.7	DR1

[1] assuming 70% effectiveness of irrigation water; [2] laboratory measurement

Appendix 3. Grain quality characteristics determined by laboratory analysis

Sample	Variety	Hecto litre weight	Test grain weight	hard vitreous kernels %	GM %	Grain protein CP @11.0%	Hardness SKHI	Semolina yield milling yield %	Semolina colour Minolta b*	Mixograph MPT	Mixograph RBD	Glutomatic % wet gluten	Glutomatic gluten index	Falling number
1	Bellaroi	83.4	49.6	89.7	10.4	11.9	86.2	70.7	31.07	2.81	65.1	29.9	28	525
2	Bellaroi	80.3	48.0	88.7	11.5	13.0	85.7	70.9	30.47	2.57	82.6	32.7	27	477
3	Bellaroi	80.0	50.8	85.4	11.1	14.6	86.3	70.2	29.57	1.80	87.3	37.1	39	502
4	Bellaroi	81.5	44.4	95.7	11.1	13.7	85.5	70.8	31.27	2.32	72.3	35.2	42	643
5	Bellaroi	78.4	48.4	66.6	10.9	13.8	83.0	70.0	30.31	3.46	38.6	34.9	42	566
6	Bellaroi	78.7	44.8	86.0	10.8	14.7	86.1	69.4	30.04	3.30	52.2	36.8	35	554
7	Bellaroi	82.4	49.2	92.6	10.0	12.9	89.0	70.8	31.21	3.13	62.6	30.2	14	524
8	Bellaroi	80.2	49.2	84.1	10.6	13.5	83.2	70.2	30.22	2.60	73.8	34.4	28	539
9	Bellaroi	81.0	50.0	87.3	10.6	12.6	83.7	70.6	30.33	2.58	70.0	32.3	41	543
10	Bellaroi	82.1	51.2	70.9	10.6	11.7	79.5	71.0	30.28	4.00	43.5	29.1	46	508
11	Bellaroi	81.1	48.8	99.0	10.7	14.0	89.5	70.5	30.88	1.91	67.0	35.9	38	553
12	Bellaroi	81.4	40.0	96.3	11.1	15.4	92.7	70.2	26.55	3.11	62.0	42.4	39	372
13	Bellaroi	82.5	46.8	99.7	9.8	15.2	80.1	70.7	27.92	3.25	52.8	41.9	41	551
14	Bellaroi	80.7	50.4	72.7	10.6	12.1	83.0	70.0	31.06	2.68	71.9	30.4	46	556
15	Bellaroi	81.6	48.4	95.3	11.4	14.1	90.3	70.5	30.60	2.39	61.8	35.0	58	604
16	Caparoi	84.1	50.0	92.3	11.7	13.4	96.1	70.5	31.20	3.98	51.6	32.0	52	584
17	Bellaroi	80.4	51.6	73.1	12.0	14.0	90.6	68.7	30.19	2.63	59.8	33.6	58	531
18	Caparoi	82.2	55.2	72.7	12.9	13.5	96.3	70.0	29.63	5.53	31.9	32.0	68	619