Variety specific agronomy for irrigated soybean crops in south-eastern Australia

Mathew Dunn, Research Agronomist, NSW DPI

Crop	Soybean – overhead irrigation
Irrigation area	Murray Valley, NSW
Location	Finley
Seasons	2014–15, 2016–17, 2017–18

Key findings

- Variety Djakal achieved the highest grain yield in all three seasons of this study.
- Variety Burrinjuck$^{\Phi}$ achieved the highest seed protein concentrations in all three seasons of the study.
- Higher plant density resulted in higher grain yields than the lower plant density in two out of the three seasons.
- Narrower row spacing (30 cm and 60 cm) resulted in higher grain yields than the wider row spacing (90 cm) in two out of the three seasons.
- Row spacing and plant density had no statistically significant effect on seed protein concentration and only a small and inconsistent effect on seed size.

Introduction

Soybean is a versatile crop that can provide many benefits to farming systems in the irrigated areas of southern NSW and northern Victoria. Suitability to a late sowing window, along with low input costs, nitrogen fixation and the disease break benefits that soybean crops provide, all improve farming system flexibility, particularly in double cropping situations.

Variety selection and agronomic management are essential aspects in the production of high yielding, high quality soybean crops. Ensuring that management decisions are matched to the geographical region and irrigation method maximises the potential to achieve high yielding, high quality soybean crops. This has been highlighted by previous soybean research and is confirmed with the outcomes of the 'Southern NSW Soybean Agronomy' project (DAN00192), which was a co-investment by NSW DPI and GRDC. The overall aim of this project was to increase the current average grain yield for irrigated soybeans in southern NSW and northern Victoria regions from 2.8 t/ha to greater than 3.25 t/ha.

Field experiments were conducted at Finley in the Murray Valley, for three seasons, 2014–15, 2016–17 and 2017–18. These experiments aimed to develop management packages to maximise soybean yield and quality in overhead irrigation layout systems. A number of key

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agronomic factors including variety selection, plant density and row spacing were examined and will be discussed in this report.

The soybean varieties examined included the current industry standards Djakal, Snowy⏀ and Bidgee⏀ and the recently released variety Burrinjuck⏀. The varieties Burrinjuck⏀, Snowy⏀ and Bidgee⏀ are clear hilum varieties with seed quality characteristics targeted for the higher value human consumption markets. The variety Djakal has a dark coloured hilum with low levels of protein.

Experiment site

Field experiments were located in the same paddock for all three seasons (Figure 1). Site details are described in Table 1.

Table 1: Site details for the overhead irrigation soybean experiments at Finley NSW in 2014–15, 2016–17 and 2017–18.

Site detail	Description
Location	Finley NSW
Soil type	Red–brown, fine, sandy–clay loam over light clay
Fertiliser	125 kg/ha legume starter (N = 13.3%, P = 13.3%, S = 9%, Zn = 0.81%)
Inoculation method	Peat slurry in-furrow injection
Paddock layout	Flat ground with overhead irrigation
Sowing dates	21 November 2014, 12 December 2016 and 29 November 2017

Figure 1: Soybean agronomy field experiment at Finley, NSW.

Treatments

The response of three soybean varieties, two target plant densities and three row spacings was examined across three seasons (Table 2).

Table 2: Experiment treatment details across the three seasons.

Season	Varieties	Target plant densities	Row spacings
2014–15	Djakal, Burrinjuck[PBR], Bidgee[PBR]	25, 40 plants/m^2	30, 60, 90 cm
2016–17	Djakal, Burrinjuck[PBR], Snowy[PBR]	25, 40 plants/m^2	30, 60, 90 cm
2017–18	Djakal, Burrinjuck[PBR], Snowy[PBR]	25, 40 plants/m^2	30, 60, 90 cm

Results and discussion

As treatments were not identical across years, each year/experiment was analysed independently using the analysis of variance (ANOVA) procedure in GenStat (Version 18, VSN International Ltd, UK).

In each season, plant density treatments were sown at rates to establish the two target plant densities, 'low' and 'high' (25 and 40 plants/m^2 respectively). The rates were determined using an industry standard calculation, taking into account seed size, germination percentage and estimated establishment percentage. In all three seasons the actual plant densities established were consistently lower than the target plant densities (Table 3). Plant establishment in each season did not reach the target density due to poor seed placement as a result of difficult sowing conditions.

Table 3: Relationship between target plant density and established plant density at Finley in the 2014–15, 2016–17 and 2017–18 seasons.

Target plant density	Established plant density (plants/m^2)		
	2014–15	2016–17	2017–18
Low – 25 plants/m^2	21	20	16
High – 40 plants/m^2	31	28	25

Analysis of the grain yield data identified a number of statistically significant main effect differences between treatments, however, few statistically significant interactions were found.

Grain yields varied significantly between varieties in the 2014–15 and 2017–18 seasons, however, no statistically significant difference between them was detected in the 2016–17 season (Table 4). Variety Djakal yielded the highest in both 2014–15 and 2017–18 seasons. Variety Burrinjuck[PBR] achieved similar yields to Djakal in the 2014–15 season, however, yielded statistically significantly lower than both Djakal and Snowy[PBR] in the 2017–18 season.

Grain yield varied significantly between target plant densities in the 2014–15 and 2016–17 seasons, however, no statistically significant yield difference between them was detected in the 2017–18 season (Table 4). The higher plant density treatments resulted in higher grain yields than the lower plant density treatments in both 2014–15 and 2016–17 seasons, with grain yield increases of 0.51 t/ha and 0.31 t/ha respectively (Table 4).

Grain yields varied significantly between row spacing treatments in the 2014–15 and 2017–18 seasons, however, no statistically significant difference in grain yield was observed between the different row spacing treatments in the 2016–17 season (Table 4). Narrower row spacing resulted in higher grain yields in 2014–15, with statistically significant increases in grain yield occurring between each decrease in row spacing. A similar trend occurred in the 2017–18 season with the 90 cm row spacing treatment resulting in a lower grain yield than the 60 cm and 30 cm row spacing treatments. However, no statistically significant difference in grain yield was found between the 60 cm and 30 cm row spacing treatments (Table 4).

Assessment of lodging severity was conducted; however, in all three seasons, only very low levels of lodging were detected.

Table 4: Grain yield response to soybean variety, plant density and row spacing in 2014–15, 2016–17 and 2017–18 seasons. Only main effect results displayed. Treatments with the same letter are not statistically significantly different ($P = 0.05$).

		Grain yield (t/ha)		
		2014–15	**2016–17**	**2017–18**
Variety	**Bidgee**	3.12[b]	–	–
	Djakal	4.02[a]	2.72[a]	2.74[a]
	Burrinjuck	3.82[a]	2.53[a]	1.99[c]
	Snowy	–	2.59[a]	2.36[b]
	l.s.d. ($P = 0.05$)	0.200	n.s.	0.221
Plant density	**Low**	3.40[b]	2.46[b]	2.30[a]
	High	3.91[a]	2.77[a]	2.42[a]
	l.s.d. ($P = 0.05$)	0.163	0.217	n.s.
Row spacing (cm)	**30**	4.03[a]	2.64[a]	2.39[a]
	60	3.62[b]	2.65[a]	2.59[a]
	90	3.30[c]	2.55[a]	2.10[b]
	l.s.d. ($P = 0.05$)	0.200	n.s.	0.221

Soybean seed protein concentration and seed size are quality characteristics of significant importance, particularly in human consumption markets (e.g. soymilk and tofu) where the potential for large price premiums exist. Analysis of seed protein concentration results found a number of statistically significant differences between varieties, however, there were few statistically significant differences between plant density, row spacing and interactions (Table 5).

Variety Burrinjuck[PBR] achieved the highest seed protein concentration in all three seasons, statistically significantly higher than all other varieties (Table 5). Both varieties Snowy[PBR] and Bidgee[PBR] achieved a seed protein concentration slightly lower than Burrinjuck[PBR], while, Djakal consistently achieved the lowest seed protein concentrations. No statistically significant differences in seed protein concentration were found between either plant density or row spacing treatments.

A number of statistically significant differences in seed size between treatments were found, however, few statistically significant interactions were found (Table 6). In all seasons, Burrinjuck[PBR] and Snowy[PBR] achieved statistically significantly larger seed sizes than either Djakal and Bidgee[PBR]. In 2014–15 and 2016–17, Burrinjuck[PBR] achieved the largest seed size while in 2017–18, Snowy[PBR] achieved the largest seed size.

Table 5: Seed protein concentration response to soybean variety, plant density and row spacing in 2014–15, 2016–17 and 2017–18. Only main effect results displayed. Treatments with the same letter are not statistically significantly different (*P* = 0.05).

		Seed protein concentration (%)		
		2014–15	**2016–17**	**2017–18**
Variety	**Bidgee**	45.2[b]	–	–
	Djakal	42.2[c]	41.1[c]	41.1[c]
	Burrinjuck	46.1[a]	44.5[a]	45.4[a]
	Snowy	–	43.9[b]	44.1[b]
	l.s.d. (*P* = 0.05)	0.682	0.575	0.381
Plant density	**Low**	44.2[a]	43.3[a]	43.5[a]
	High	44.8[a]	43.0[a]	43.6[a]
	l.s.d. (*P* = 0.05)	n.s.	n.s.	n.s.
Row spacing (cm)	**30**	44.4[a]	42.8[a]	43.8[a]
	60	44.4[a]	43.3[a]	43.2[a]
	90	44.7[a]	43.4[a]	43.6[a]
	l.s.d. (*P* = 0.05)	n.s.	n.s.	n.s.

Table 6: Seed size response to soybean variety, target plant density and row spacing in 2014–15, 2016–17 and 2017–18. Only main effect results displayed. Treatments with the same letter are not statistically significantly different (*P* = 0.05).

		Seed size (g/100 seeds)		
		2014–15	**2016–17**	**2017–18**
Variety	**Bidgee**	19.8[c]	–	–
	Djakal	21.9[b]	18.9[b]	19.2[c]
	Burrinjuck	24.4[a]	22.8[a]	22.4[b]
	Snowy	–	22.4[a]	22.8[a]
	l.s.d. (*P* = 0.05)	0.534	0.740	0.338
Plant density	**Low**	22.0[a]	21.7[a]	21.6[a]
	High	22.1[a]	21.0[b]	21.3[b]
	l.s.d. (*P* = 0.05)	n.s.	0.301	0.276
Row spacing (cm)	**30**	21.9[a]	20.8[b]	21.3[a]
	60	21.8[a]	21.6[a]	21.7[a]
	90	22.4[a]	21.7[a]	21.4[a]
	l.s.d. (*P* = 0.05)	n.s.	0.369	n.s.

Summary

Results from the multi-season experiments demonstrate the importance of variety selection and agronomic management for the production of soybeans in overhead irrigation systems. Both target plant density and row spacing, in combination with variety selection, are key management factors that can influence the grain yield and grain quality of soybean crops produced under overhead irrigation systems.

Variety choice is a key aspect of maximising the productivity and profitability of soybean production. Variety Djakal performed well, consistently achieving the highest yields in all three seasons. However, its low protein concentration, small seed size and brown coloured hilum restrict its opportunity for use in many higher value human consumption markets.

The recently released variety Burrinjuck$^{\phi}$ performed well in the 2014–15 and 2016–17 seasons, achieving only slightly lower yields than Djakal. However, in the 2017–18 season it yielded statistically significantly lower than both Djakal and Snowy$^{\phi}$. Variety Snowy$^{\phi}$ performed similarly to Burrinjuck$^{\phi}$; but, with lower seed protein concentrations in both 2016–17 and 2017–18 seasons. Varieties Burrinjuck$^{\phi}$ and Snowy's$^{\phi}$ high seed protein concentration, large seed size and clear hilum allow access into human consumption markets, often attracting price premiums.

The higher plant densities resulted in higher yields than the lower target plant densities in two out of the three seasons. However, it should be noted that the achieved plant densities were considerably lower than the target in each season. Plant density had no statistically significant effect on seed protein concentration during the study; however, a small but statistically significant effect on seed size in two of the three experiments was detected. Row spacing had no statistically significant effect on seed protein concentration and only one small, but statistically significant effect on seed size was found in only one season.

The project

This variety specific agronomy package (VSAP) is an output of the 'Southern NSW Soybean Agronomy' project (DAN00192; 2014–2018). It summarises the research outcomes for experiments that were conducted in this location on this crop type.

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Further information

Mathew Dunn
NSW Department of Primary Industries
Email: mathew.dunn@dpi.nsw.gov.au
Mobile: 0447 164 776

Alan Boulton
NSW Department of Primary Industries
Email: alan.boulton@dpi.nsw.gov.au
Mobile: 0427 656 763

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