OPTIMISING IRRIGATED GRAINS
FOCUS PADDOCK
Southern Farming Systems

Investigating the opportunities for offsetting yield losses in late sown spring barley by increasing plant density

Key Learnings

Results from the trial into investigating the opportunities for offsetting yield losses in late sown spring barley by increasing plant density, show that in the 2023 season at the Hagley Farm School site the time of sowing treatments were the most important factor for yield and therefore profitability. There was a difference in the total mm of water each time of sowing treatment received which may have impacted yield results.

Despite different sowing rates, establishment counts showed consistent plant numbers across all plant density and time of sowing treatments. The plant density treatments showed no significant differences in yield or grain quality results. The time of sowing treatments showed statistically significant differences in yields with the second time of sowing the highest yield at 6.68 t/ha.

The third time of sowing treatment had the lowest yield and poorest grain qualities by statistically significant margins. Interactions indicate that the time of sowing treatments had greater effect on yields and gross margins than the plant density treatments. Treatments sown at the third time of sowing did not yield high enough to break even in their gross margins.

Focus Paddock Summary

The trial was designed to investigate the interaction between plant densities sown in spring barley and the time of sowing of them.

There was a difference in the total mm of water each time of sowing treatment received which may have impacted yield results.

Despite different sowing rates, establishment counts showed consistent plant numbers across all plant density treatments.

The plant density treatments showed no significant differences in yield or grain quality results.

The time of sowing treatments showed statistically significant differences in yields with the second time of sowing the highest yield at 6.68 t/ha.

The third time of sowing treatment had the lowest yield and poorest grain qualities by statistically significant margins.

Interactions indicate that the time of sowing treatments had greater effect on yields and gross margins than the plant density treatments.

Treatments sown at the third time of sowing did not yield high enough to break even in their gross margins.

Background and Aims

The design of this trial came about following difficulties experienced at the end of the 2022 growing season. October 2022 saw 91.2 mm of rain, with a further 58.2mm falling in November. This heavy rainfall was highly unusual for the area and posed complications in spring sowing opportunities.

Discussions with growers outlined standard practice for the area is to sow spring barley crops throughout September and October, however the heavy rainfall restricted access to paddocks and growers were soon in December and only just beginning their spring sowing program. At this time several farmers in the group made the decision to increase their seeding rates at sowing in the hope that this would offset potential losses from the late seeding. Harvest in early 2023 alluded to the possibility that they were correct, but without replicated data no one could say for sure.

Initial research into the area revealed very few relevant articles to explain the opportunities and risks to late sowing spring barley in Tasmania, particularly under irrigation, looking at barley's ability to compensate in these conditions. The group therefore decided that the opportunity presented through funding from the Irrigation Farmers Network would best be utilized looking into this area for future proof against similar weather events. Hence, the spring barley time of sowing by plant density trial was developed.

Focus Paddock Details

The trial was held at the Hagley Farm School trial site run by Southern Farming Systems. The trial itself was a fully replicated plot trial comprising of 12 treatments. The treatments were designed to investigate the interaction between the four plant densities and the three times of sowing chosen. RP22054 was the barley variety used for this trial.

Plant Density

Standard practice for local growers is a plant density of 175 pl/m^2, which roughly equates to between 90-110 kg/ha of seed, the seed sown in this trial had a high thousand seed weight and the corresponding rates can be seen in Table 1. The treatments were then increased incrementally in order to plot compensation and yield differences.

There were four plant densities chosen for comparison, shown in Table 1.

Table 1. Plant density treatments and their corresponding sowing rate.

Treatment	**Plant density (pl/m^2)**	**Sowing rate (kg/ha)**
Plant density 1	400 pl/m^2	265 kg/ha
Plant density 2	300 pl/m^2	199 kg/ha
Plant density 3	225 pl/m^2	149 kg/ha
Plant density 4	175 pl/m^2	116 kg/ha

Time of Sowing

Three times of sowing (TOS) were selected for comparison shown in Table 2.

Table 2. Time of sowing treatments sowing and harvest dates.

Treatment	Sowing date	Harvest date	Growing time
Time of sowing 1	18 October 2023	29-February 2024	134 days
Time of sowing 2	10 November 2023	29 February 2024	111 days
Time of sowing 3	12 December 2023	22 March 2024	101 days

These dates were selected as they provide an excellent spread from ideal timing (October) to the latest timing feasible (December) for spring sowing.

General Trial Management

Due to the multiple times of sowing trial management differed slightly in practicality, however best management practices for all treatments were followed.

TOS 1 and 2

The first and second times of sowing had very similar practices as their phenology coincided with inputs closer than the third time of sowing. The inputs for TOS 1 and 2 can be seen in Table 3, as you can see, the only difference between the two times of sowing is the application of MAP, which occurred at sowing in both cases.

Table 3. Trial management for the TOS 1 and 2 treatments.

	Date	Product	Rate/ha	Time of sowing
Fertiliser	18-Oct	MAP	120 kg	TOS 1
	10-Nov	MAP	120 kg	TOS 2
	1-Dec	Urea	200 kg	TOS 1 & 2
Herbicide	15-Nov	Mateno Complete	1 L	TOS 1 & 2
	28-Nov	MCPA	75 mL	TOS 1 & 2
	28-Nov	Lontrel Advance	1 L	TOS 1 & 2
	10-Dec	Paradigm	25 g	TOS 1 & 2
	10-Dec	MCPA LVE	500 mL	TOS 1 & 2
Fungicide	10-Dec	Radial	840 mL	TOS 1 & 2
Seed Treatment	17-Oct	Pontiac	400 mL/t	TOS 1 & 2

TOS 3

The third tome of sowing received slightly different inputs, however as mentioned previously these inputs lined up with the same phenological timings of TOS 1 and 2, and best practices for the crop itself. Table 4 shows the details.

Table 4. Trial management for TOS 3 treatments.

	Date	Product	Rate/ha
Fertiliser	12-Dec	MAP	120 kg
	25-Jan	Urea	200 kg
Herbicide	6-Dec	Sprayseed	2 L
	25-Jan	Paradigm	25 g
	25-Jan	MCPA LVE	500 mL
	12-Feb	Crucial	1.5 L
Fungicide	25-Jan	Radial	840 mL
Seed Treatment	17-Oct	Pontiac	400 mL/t

Rainfall and Irrigation

Throughout the growing season, each time of sowing treatment received differing amounts of rainfall and irrigation. Table 5 and Figure 1 outline the irrigation provided to the trial and the cumulative rainfall data for each treatments season. The first irrigation of the trial occurred on the 15th of November, soon after the second time of sowing this also means that the third time of sowing only received 50 mm of irrigation for the season as opposed to the 100 mm that the other two treatments received.

Irrigation Date	Irrigation Rate
15 November 2023	50 m
5 January 2024	50 mm

Figure 1 also shows that there was a disparity in total moisture received for each treatment with TOS 1 having the highest at a total of 287.4 mm between sowing and harvest. TOS 2 had the second highest with 265.8 mm, and TOS 3 the lowest with 203.2 mm between sowing and harvest.

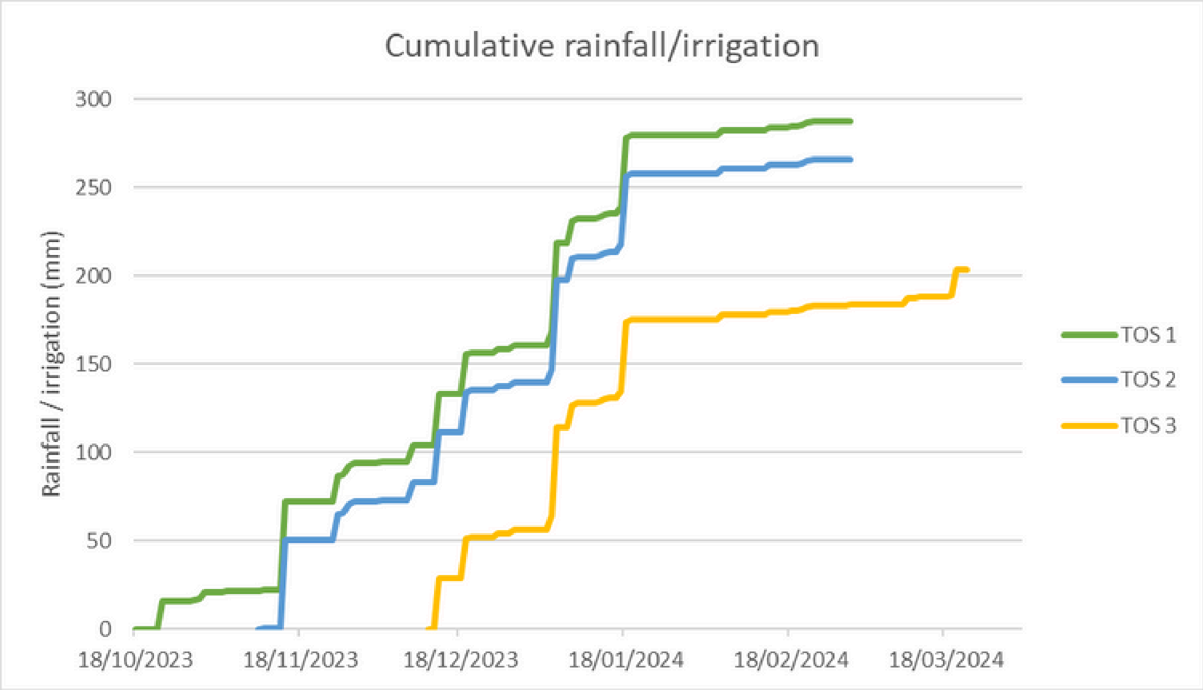

Figure 1. Cumulative rainfall and irrigation on the different time of sowing treatments based on growing season for each one, irrigation events are circled in red.

Agronomic Results

Plant Density

Establishment assessments for the plant density treatments, shown in Figure 2, found that despite the differences in sowing rate it did not make a statistically significant difference in the number of plants that germinated and established between the treatments.

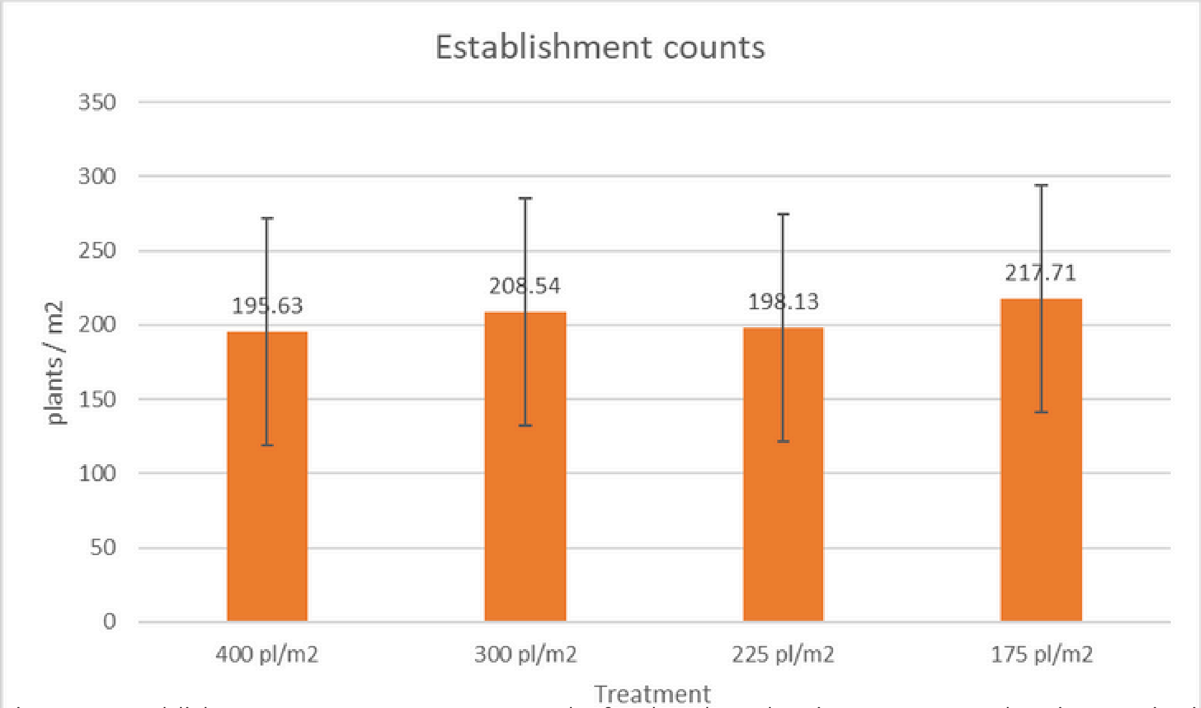

Figure 2. Establishment count assessment results for the plant density treatments showing no significant differences.

In season assessments consisted of biomass cuts and tiller assessments being taken at harvest maturity. The results, seen in Table 6, show no statistically significant difference in the biomass cuts or the tiller numbers per plant with an average of 8.36 t of dry matter per hectare produced in each plant density treatment and an average of 3.08 tillers per plant.

Table 6. In season assessment results for the plant density treatments.

	Biomass cuts		Tillers / m^2		Tillers / plant	
	t DM/ha		tl/ m^2		tl/pl	
400 pl/ m^2	8.36	-	604.30	a	3.60	-
300 pl/ m^2	8.52	-	609.70	a	3.00	-
225 pl/ m^2	8.31	-	524.20	b	2.80	-
175 pl/ m^2	8.23	-	518.30	b	2.90	-
LSD P=.05	1.14		49.59		1.27	
P-value	0.95		0.003		0.56	
CV	14.80		9.52		44.57	

Means followed by the same letter do not significantly differ (p>0.05)

There was a statistically significant difference in the number of tillers per square meter, with the 400 pl/m^2 and 300 pl/m^2 treatments having statistically higher numbers than the 225 and 175 pl/m^2 treatments, on average 607.00 pl/m^2 and 521.25 pl/m^2 respectively. The difference of 85.75 pl/m^2 is a function of the establishment counts by the number of tillers per plant, which while not significant, does show a trend towards lower tiller numbers in the lower plant density treatments.

Yield and grain quality results from the plant density treatments showed no statistically significant differences. The averages for yield and grain quality across all four treatments were 5.04 t/ha in yield, 14.15 % protein, test weight of 68.65 kg/hL, retention of 92.65%, and screenings of 1.64%. The full results for each treatments are displayed in Table 7.

Table 7. Yield and grain quality results for the plant density treatments.

	Yield		Protein		Test Weight		Retention		Screenings	
	t/ha		***%***		***kg/hL***		***%***		***%***	
400 pl/ m^2	5.07	-	14.06	-	68.63	-	92.26	-	1.85	-
300 pl/ m^2	5.07	-	14.22	-	68.84	-	93.38	-	1.44	-
225 pl/ m^2	5.08	-	14.13	-	68.40	-	91.66	-	1.80	-
175 pl/ m^2	4.95	-	14.19	-	68.71	-	93.32	-	1.48	-
LSD P=.05	**0.25**		**0.55**		**0.59**		**3.51**		**0.68**	
P-value	**0.64**		**0.92**		**0.43**		**0.64**		**0.44**	
CV	**5.38**		**4.23**		**0.94**		**4.11**		**44.65**	

Means followed by the same letter do not significantly differ (p>0.05)

Time of Sowing

As with the plant density treatments, the time of sowing treatments showed no statistical difference in the establishment count assessments, with an average of 205 pl/m^2. As is shown in Table 8, there was also no statistically significant difference in the tillers per plant or tillers/m^2 with an average of 3.10 tl/pl and 564.10 tl/m^2 respectively.

Table 8. In season assessment result for the time of sowing treatments.

	Establishment Counts		Biomass cuts		Tillers / m^2		Tillers / plant	
	pl/m^2		t DM/ha		tl/m^2		tl/pl	
TOS 1	212.03	-	8.94	a	570.80	-	3.10	-
TOS 2	193.91	-	9.84	a	563.80	-	3.30	-
TOS 3	209.06	-	6.28	b	557.70	-	2.90	-
LSD P=.05	29.93		1.14		67.67		1.06	
P-value	0.35		0.0006		0.90		0.62	
CV	16.88		15.75		13.87		39.63	

Means followed by the same letter do not significantly differ (p>0.05)

There was, however, a statistically significant difference in the biomass assessments between the TOS treatments. Shown in Figure 3, the TOS 2 treatment produced the highest biomass at 9.84 t DM/ha, this was statistically similar to the TOS 1 treatment which produced 8.94 t DM/ha.

The TOS 3 treatment produced statistically less than the other two treatments, with only 6.28 t DM/ha being produced. As seen earlier in the report, this may have been due to the shorter growing season and limited water available in comparison to the other two treatments.

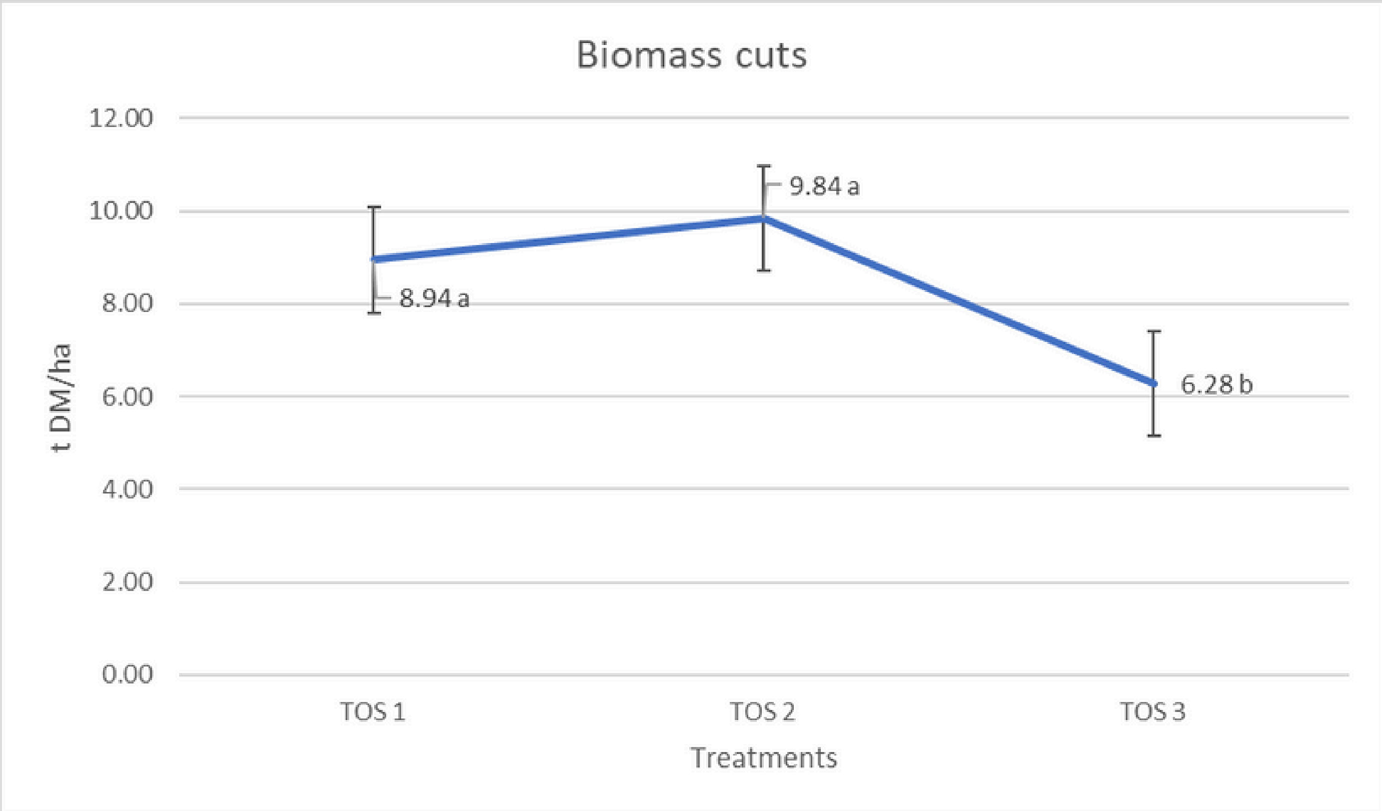

Figure 3. Biomass assessment results for the time of sowing treatments.
Means followed by the same letter do not significantly differ (p>0.05)

The time of sowing treatments showed statistically significant differences in both yield and grain qualities as seen in Table 9. The TOS 2 treatment produced the highest yield of 6.68 t/ha, TOS 1 the second highest yield of 5.76 t/ha, 0.92 t/ha lower, and TOS 3 the lowest yield of 2.68 t/ha, a further 3.08 t/ha lower than TOS 1. All of these results were statistically significant.

Table 9 shows that the delayed sowing time of TOS 3 had a statistically significant effect on the grain qualities the treatment produced. Grain qualities for the TOS 1 and 2 treatments were statistically similar across all assessments with the TOS 3 treatment statistically different. Protein for TOS 3 was 1.11% higher than the average for the TOS 1 and 2 treatments. Test weight was 5.48 kg/hL lower; retention was 17.49 % lower, and screenings were 2.89 % higher.

Table 9. Yield and grain quality results for the time of sowing treatments.

	Yield		Protein		Test Weight		Retention		Screenings	
	t/ha		*%*		*kg/hL*		*%*		*%*	
TOS 1	5.76	b	13.97	b	70.40	a	98.59	a	0.65	b
TOS 2	6.68	a	13.58	b	70.55	a	98.37	a	0.71	b
TOS 3	2.68	c	14.89	a	64.99	b	80.99	b	3.57	a
LSD P=.05	0.90		0.70		0.56		2.74		0.59	
P-value	0.00		0.01		0.00		0.00		0.00	
CV	20.70		5.74		0.94		3.42		41.19	

Means followed by the same letter do not significantly differ (p>0.05)

Figure 4 illustrates the difference between growth stages for the different time of sowing treatments in late January of 2024. These differing growth stages at this time may explain the statistical differences seen in the TOS 3 treatments. The retention and screenings assessments are likely a function of reduced moisture during grain-fill, and as seen in Figure 1 previously, the lack of rainfall events from the 18th of January 2024 onwards would correspond with grain-fill for the TOS 3 treatment.

Figure 4. Differing growth stages between TOS 1 (foreground), 2 (midground) and 3 (background) treatments on the 24th of January 2024. Photo credit: Ashley Amourgis

Interaction

As can be seen in Figure 5, there was a yield interaction between the plant density and time of sowing treatments. The distances between the lines displayed in the graph indicate that the time of sowing treatments had a larger impact on the yields than the plant density treatments. The time of sowing 2 treatment saw the highest yields at all plant densities by a statistically significant margin, except for the 175 pl/m^2 treatment which was statistically similar to the TOS 1 175 pl/m^2 treatment.

The time of sowing 3 treatments yielded lower by a statistically significant margin, implying that sowing at the ideal time, for this location and year, was more important to the yields in this trial than the plant density sown. However, there was also a statistically significant increase in yields in the TOS 3 treatments between the 175 and 400 pl/m^2 treatments. It can be conjectured that the increase in plant density in the TOS 3 treatments had a positive impact on yield, but without similar trends seen in the TOS 1 and 2 treatments this cannot be conclusively assumed.

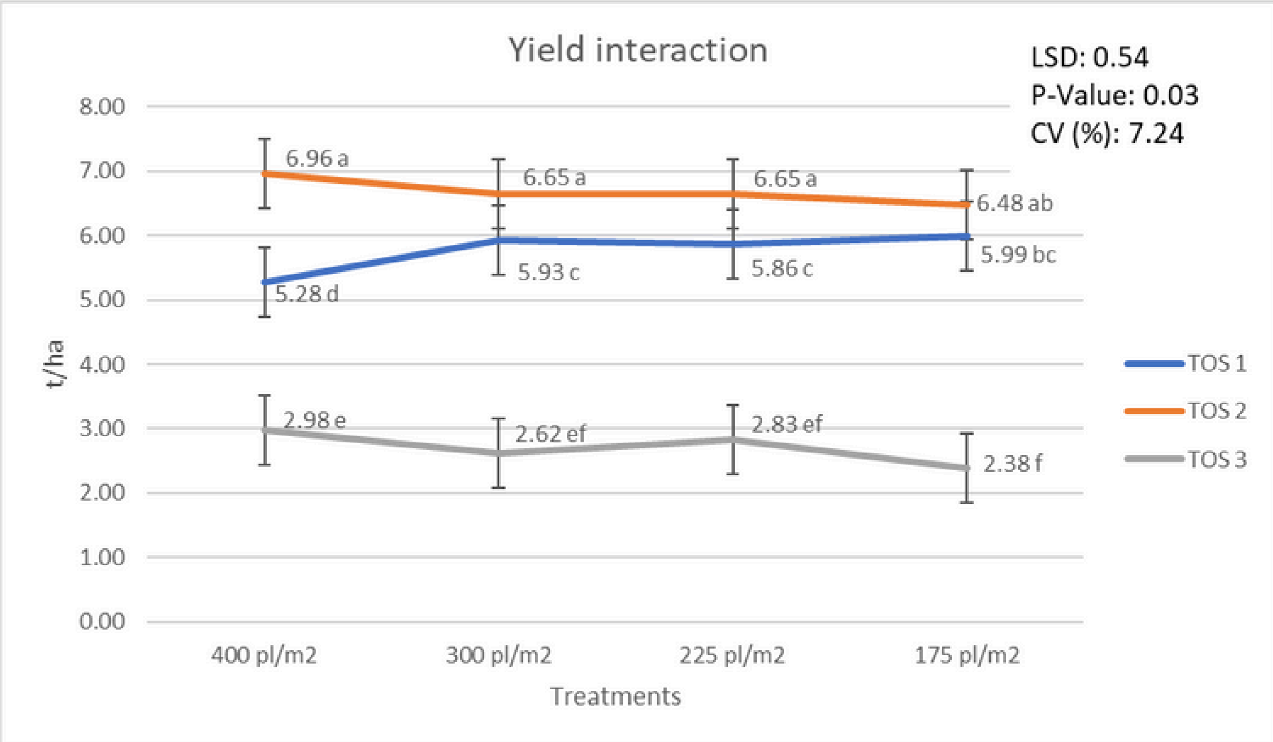

Figure 5. Yield interaction between the plant density and time of sowing treatments. Means followed by the same letter do not significantly differ (p>0.05)

Economic Results

Gross margin analysis was run on every plot in the trial, allowing for the statistical analysis of the economic returns for each treatment. The gross margins were calculated using the inputs described in the general trial management section of this report and include.

- contract machinery operation
- freight costs for grain and fertiliser
- insurance
- state levies
- GRDC levies, and
- irrigation and water costs

The sale price for the barley produced was set at $320/t.

Plant Density

As can be seen in Table 10, there was no statistical difference found between the plant density treatments. An average return of $470.57/ha was found across all plant density treatments.

Table 10. Gross margin results for the plant density treatments.

	Gross Margin	
	$/ha	
400 pl/m2	436.96	-
300 pl/m2	469.03	-
225 pl/m2	496.85	-
175 pl/m2	479.45	-
LSD P=.05	68.81	
P-value	0.31	
CV	15.83	

Means followed by the same letter do not significantly differ (p>0.05)

Time of Sowing

The time of sowing treatments gross margin results, seen in Table 11, show statistically significant differences between them. The TOS 2 treatment returned the highest profit of $921.79/ha. The TOS 1 treatment returned the second highest profit of $669.13/ha, $252.66/ha less than the TOS 2 treatment. The TOS 3 treatment had the lowest gross margin of -$179.21, $848.34/ha less than the TOS 1 treatment.

The negative gross margin from the TOS 3 treatment can be seen to be a direct result of the yields achieved. As shown earlier in the report, the TOS 3 treatment achieved yields of 2.68 t/ha, however, the breakeven yield required for the treatment was 3.24 t/ha.

Table 11. Gross margin results for the time of sowing treatments.

	Gross Margin	
	$/ha	
TOS 1	669.13	b
TOS 2	921.79	a
TOS 3	-179.21	c
LSD P=.05	248.11	
P-value	0.0001	
CV	60.94	

Means followed by the same letter do not significantly differ (p>0.05)

Interaction

Similar to the yield interactions seen earlier, there was also a gross margin interaction between the plant density and time of sowing treatments. As can be seen in Figure 6, the distances between the plotted lines on the graph once again indicates that the time of sowing treatment had a greater impact on the gross margin results than the plant density treatments. With the yield differences seen earlier in the report strongly impacted by the time of sowing treatments the gross margin results follow similar trends.

The TOS 2 treatments had statistically higher returns than the other two TOS treatments, although the TOS 2 300 pl/m2 and TOS 2 175 pl/m^2 were statistically similar to the TOS 1 175 pl/m^2 treatment.

In the TOS 1 treatments, as the plant density increases, there is a decreasing trend to the profits obtained in the gross margin results. . As the yields for the TOS 1 treatments decrease, seen in Figure 4 previously, so too does the gross margin drop. This is further exacerbated by the variable costs of sowing with higher sowing rates costing more for the increased seed requirements. This is further exacerbated by the variable costs of sowing with higher sowing rates costing more for the increased seed requirements.

The TOS 3 results show no statistical difference between plant density treatments and all results are statistically lower than any other treatment. As stated earlier, this can be seen as a direct result of the yields achieved not meeting breakeven requirements to cover the variable costs of the gross margins.

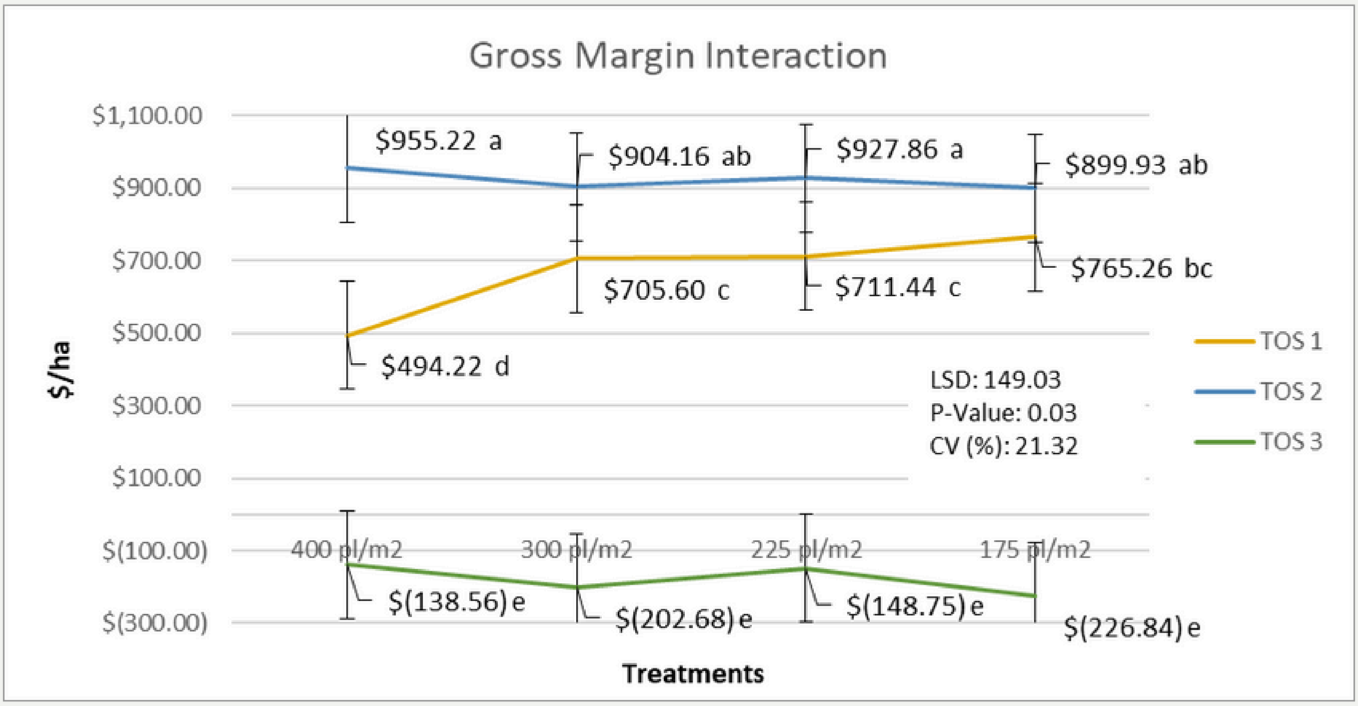

Figure 6. Gross margin interaction between the plant density and time of sowing treatments. Means followed by the same letter do not significantly differ (p>0.05)

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Acknowledgements
Ted Jones, Hagley Farm School
Brett Davey, Southern Farming Systems
Greta Duff, Southern Farming Systems
Regan Parkinson, Southern Farming Systems

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

The Optimising Irrigated Grains project is part of the GRDC investment in ICF2308-001SAX , which is led by the Irrigation Farmers Network