Optimising benefits from soil amelioration using pulses and oilseeds

Grace Williams, DPIRD

Key messages

- Crop establishment, biomass, yield and harvest index of wheat was largely unaffected by break crop rotation from the previous two seasons.
- Wheat yield was above district average for both the light and heavy soil site which was not expected on the average decile 4 rainfall.
- Grain produced from wheat following a pulse-canola rotation had higher protein content compared to the canola-chickpea rotation.

Aims

To evaluate the rotational benefit of different sequences of pulses and canola after soil amelioration when transitioning back into cereal cropping following amelioration.

Background

Growers in the eastern wheatbelt are ameliorating increasing areas of soil each year by deep cultivation as a means of correcting soil compaction and, when paired with lime application, acidity issues. When the amelioration is performed in a fallow year growers can achieve the added benefits of reducing troublesome weed populations and providing residual soil moisture to the crop grown in the subsequent year reducing the risk of poor crop performance.

Significant areas of pulses have not been grown in the low rainfall eastern wheatbelt since the late 1990s and early 2000s. Factors leading to the decreasing popularity of pulses in the eastern wheatbelt, included poor disease and herbicide tolerance, fragile stubbles, narrow soil type adaptation and variable yields (Seymour et al. 2012). However in the past twenty years there have been considerable improvements in varieties of the main pulse species chickpea, lentil, field pea, and lupin in disease and herbicide tolerance, harvestability and yield potential and stability have. The narrow soil type preferences of lentil may also have been broadened; however, it is unlikely that a single pulse species would be adaptable across a whole farm due to the range of soil types in Western Australia.

These advancements open new potential for the inclusion of a pulse phase in crop rotations in the eastern wheatbelt. It is therefore important to investigate the pulse species and rotations which prove most beneficial to growers as a break crop. This includes growing pulses in the years following soil amelioration.

Warrakiri Farms in South Burracoppin, at which these trials are located, currently follow the amelioration year with canola before returning to wheat. This gives an extra year to reduce grass weed populations as well as reduce the production risk of canola. However, soil N levels continue to decline under this system which is one of the contributing factors to declining grain protein levels in WA wheat (Lemon 2007). Incorporating a pulse phase into the system would give an opportunity for grass weed control and cereal disease break as well as increasing soil N (Seymor et al. 2012, Harries et al. 2015).

Research in 2018 showed economically viable yields of pulses across a range of soil types after soil amelioration at Warrakiri Farms. These trials were continued in 2019 with mixed results due to seasonal conditions, however soil N was significantly higher in plots that had either field peas or chickpeas in 2018. In 2019 chickpeas following canola proved to be a risky choice with low yields and biomass.

In the final year of 2020 all plots were sown to wheat to assess whether any residual rotational effects persist into a third year. These will help determine the best canola/pulse sequence to sow after amelioration prior to transitioning back into cereals.

Method

Three small plot trials were established at Warrakiri Farms in South Burracoppin in 2018. The trials were each located on different soil types classified as light, medium and heavy soil to determine the best rotation options on varying eastern wheatbelt soil types.

In 2018 the three locations contained nine treatments with three replicates —two varieties each of lentil, chickpea, lupin and field pea, and one of canola. In 2019 these were reduced to five treatments — four canola (*Brassica napus* cv. ATR Bonito) sown over the pulse species from the previous year and one chickpea (*Cicer arietinum* cv. PBA Striker) sown over the canola from the previous year (Table 1). In 2020 all were sown to wheat to evaluate the effect of the previous double break crop rotations.

Table 1. Species and variety sown each year

Treatment no.	2018 Crop	2019 Crop	2020 Crop
1	Chickpea cv. Striker Chickpea cv. Neelam	Canola cv. Bonito	Wheat
2	Field Pea cv. Gunyah Field Pea cv. Butler	Canola cv. Bonito	Wheat
3	Lentil cv. Bolt Lentil cv. Hurricane	Canola cv. Bonito	Wheat
4	Lupin cv. Jurien Lupin cv. Leeman	Canola cv. Bonito	Wheat
5	Canola cv. Bonito	Chickpeas cv. Striker	Wheat

Trial measurements in 2020 consisted of crop establishment counts, biomass cuts, harvest index cuts, grain yield and grain quality. Data was analysed with Genstat 19th edition using AVOVA’s with Fishers Unprotected LSD tests (LSD significance level 5%, P=0.05).

Results

No treatment on any soil type achieved an optimal plant density (150 plants/m^2) for wheat in a low rainfall zone (Figure 1). Crop establishment of wheat, regardless of treatment, was significantly higher on the medium soil site with 9–10 plants/m^2 more than the light or heavy soil; however, there was no significant difference between treatments overall. Wheat establishment (plants/m^2) following the lupin-canola rotation was very consistent over the three soil types, suggesting this rotation may provide a safe option for paddocks with variable soil types. However, between soil types it was not statistically better or worse than any other treatment.

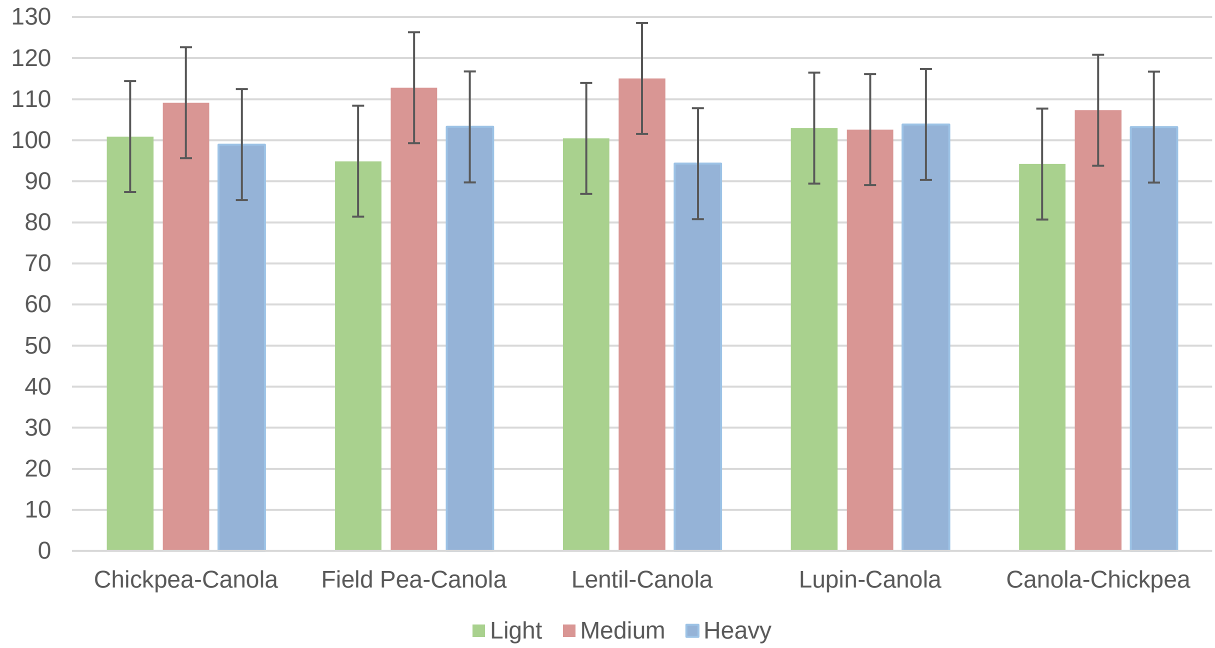

Figure 1. Crop establishment (plants/m^2) of wheat following different double break rotation treatments on light, medium and heavy soils. Error bars represent LSD ($P<0.05$).

Biomass cuts of the wheat plants were taken at anthesis (flowering), dried and then weighed. Plant biomass was significantly higher on the heavy soil site compared to both the light and medium soil. There was, however, no significant difference in biomass between treatments at the heavy soil site (Figure 2). On the light and medium soil site, the canola-chickpea rotation had the highest biomass, however these were statistically similar to all other treatments and no treatment was significantly better or worse than the others.

Wheat yield was significantly different over the three soil types, with the light soil yielding more than the medium and heavy site, likely due to better root access to stored soil moisture (Figure 3). The light soil treatments yielded on average 3.4 t/ha which is well above the district average. The heavy site also yielded above average and was largely consistent between treatments. The Medium site generally yielded average and is reflective of the average decile 4 rainfall received during the growing season. When assessing the soils individually, no treatment yielded significantly better than the rest. The canola-chickpeas rotation produced a slightly higher yield at the light and medium soil site and though not significantly, this equated to a yield benefit of 445 kg/ha on the light soil and 525 kg/ha on the medium soil over the lowest yielding rotation (field pea-canola on both sites).

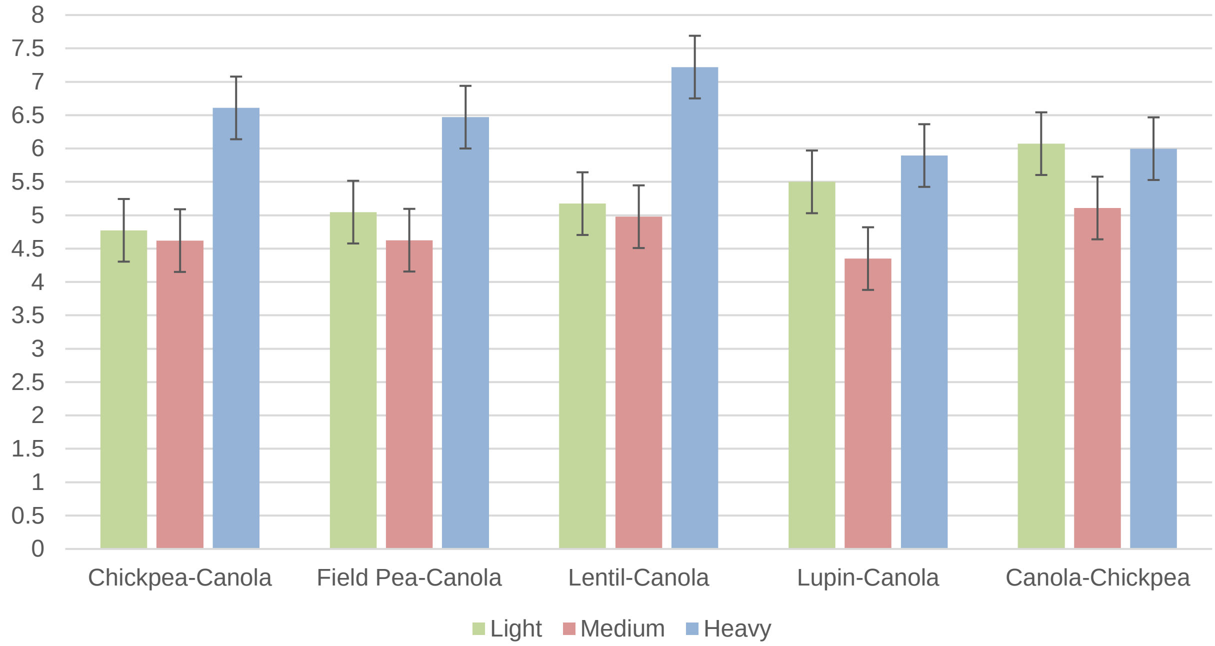

Figure 2. Crop biomass (t/ha) of wheat at flowering following different double break rotation treatments on light, medium and heavy soils. Error bars represent LSD (P<0.05).

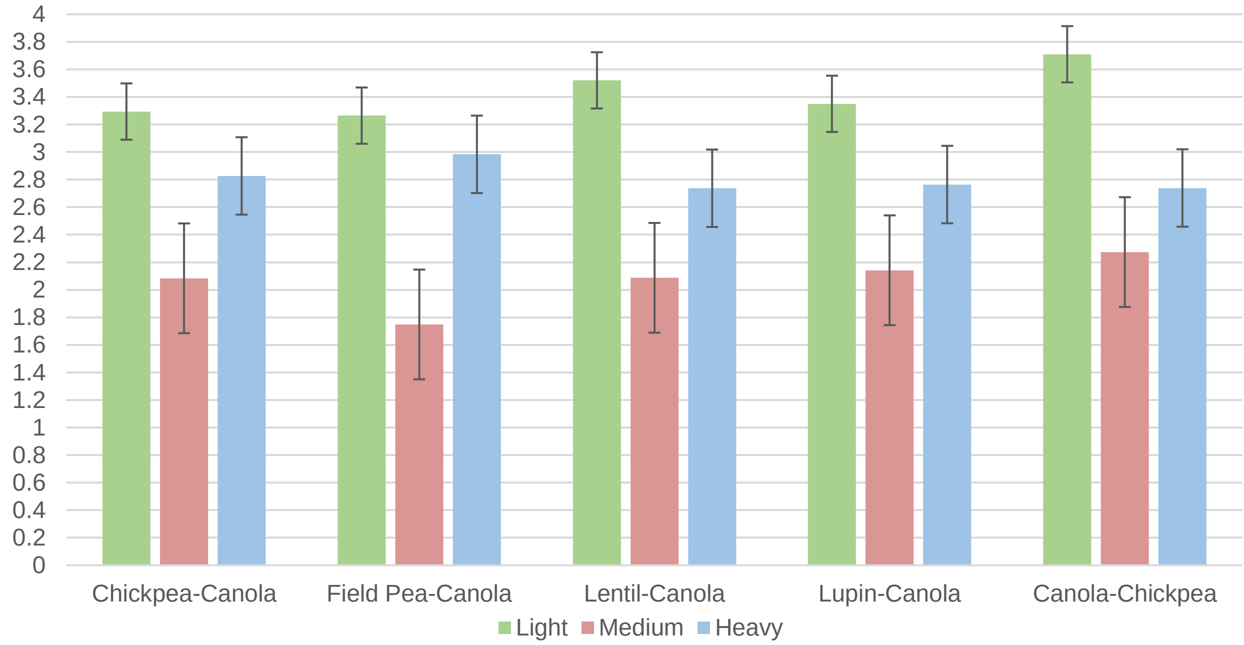

Figure 3. Grain yield (t/ha) at harvest of wheat following different double break rotation treatments on light, medium and heavy soils. Error bars represent LSD (P<0.05).

Harvest index of wheat for different rotations (Table 1) supports the yield results. Harvest index is a measure of the how efficiently a plant converts biomass into grain. All treatments had their poorest harvest index results at the medium soil site which was significantly lower than both the light and heavy soil overall. Wheat grown on the light soil had the highest efficiency for biomass conversion with an average harvest index of

51.4%, again supporting the yield data. In general, there was little significant difference between treatments on any soil type.

Table 1. Harvest index of wheat following different double break crop rotations on light, medium and heavy soil types.

Treatment No.	Rotation	Harvest Index (%)		
		Light	Medium	Heavy
1	Chickpea-Canola	51.5	40.5	46.9
2	Field Pea-Canola	51.9	38.2	45.4
3	Lentil-Canola	51.1	38.3	44.2
4	Lupin-Canola	50.9	33.3	45.3
5	Canola-Chickpea	51.5	43.0	45.8
	Overall	51.4	38.2	45.5

Table 2: Grain protein (%), screenings (%) and 1000 seed weight (g) of wheat following double break crop rotations on light, medium and heavy soil sites. Quality parameters have also been presented with the three soil types combined (‘Overall’). LSD = P<0.05.

	Treatment No.	Rotation	Protein (%)	Screenings (%)	1000 Seed Weight (g)
Light Soil	1	Chickpea-Canola	9.85	1.59	36.71
	2	Field Pea-Canola	9.97	1.68	37.40
	3	Lentil-Canola	10.38	1.63	34.98
	4	Lupin-Canola	9.93	1.52	37.29
	5	Canola-Chickpea	9.43	1.47	38.80
		LSD	0.973	0.5523	2.923
Medium Soil	1	Chickpea-Canola	13.67	6.39	28.20
	2	Field Pea-Canola	13.02	7.72	25.30
	3	Lentil-Canola	14.15	7.24	27.33
	4	Lupin-Canola	13.94	7.94	27.00
	5	Canola-Chickpea	12.83	5.16	29.68
		LSD	1.856	4.955	4.725
Heavy Soil	1	Chickpea-Canola	11.57	1.26	36.09
	2	Field Pea-Canola	12.18	1.40	35.06
	3	Lentil-Canola	11.87	1.47	36.34
	4	Lupin-Canola	12.57	1.50	34.73
	5	Canola-Chickpea	11.43	1.62	36.37
		LSD	1.723	2.123	2.123
Overall	1	Chickpea-Canola	11.70	3.11	33.67
	2	Field Pea-Canola	11.72	3.60	32.59
	3	Lentil-Canola	12.14	3.44	32.88
	4	Lupin-Canola	12.15	3.64	33.01
	5	Canola-Chickpea	11.23	2.75	34.95
		LSD	1.494	1.377	3.277

On average, wheat from the medium soil site had the highest protein levels (13.6%), with wheat from the light soil having the lowest at only 9.97% (Table 2). The medium site also had significantly more screenings than either the light or heavy site. Wheat following the canola-chickpea rotation had the lowest protein content at all three sites and, although not always significant, it did contribute to a lower receival grade (as specified by the 2019/2020 Wheat Receival Standards Limits from the CBH Group) compared to the best performing wheat following pulse-canola rotations. Consequently, wheat following the canola-chickpea rotation had the highest 1000 seed weight at all three sites although again this was not always significant.

All treatments at the medium soil site had very high screenings with an average of 7.08% screenings compared to 1.43% and 1.59% at the heavy and light site respectively. Due to these high screening levels, all treatments at the medium site would only achieve a low receival grade, despite high protein content. A combination of the high protein and low screenings in wheat following a pulse-canola rotation at the heavy soil site contributed to a potential receival grade of Hard2, which would achieve a premium price at sale.

Conclusion

There was no significant difference between any treatment in number of plants/m^2 at crop establishment on any of the three soil types. Crop establishment was significantly higher on the medium soil site.

Crop biomass was significantly higher on the heavy soil site compared to the light and medium soil, however at each soil site there was no significant difference between treatments.

Wheat from all treatments yielded above or well above average on the heavy and light soils respectively. These results were supported by harvest index data. No significant difference was observed between individual treatments at the three soil sites.

Grain produced from wheat following a pulse-canola rotation had higher protein content and generally fell into a higher receival grade compared to grain produced following the canola-chickpea rotation.

References

Harries, M, Anderson, GA and Hüberli, D 2015, ‘Crop sequences in Western Australia: what are they and are they sustainable? Findings of a four-year survey’, Crop & Pasture Science, vol. 66, pp. 634-647.

Lemon, J 2007, ‘Nitrogen management for wheat protein and yield in the Esperance port zone’, Department of Agriculture and Food, Western Australia, Perth. Bulletin 4707

Seymour, M, Kirkegaard, JA, Peoples, MB, White, PF and French, RJ 2012, ‘Break-crop benefits to wheat in Western Australia – insights from over three decades of research’, Crop & Pasture Science, vol. 63, pp. 1-16.

Acknowledgments

The research was funded through the “Building crop protection and crop production agronomy research and development capacity in regional Western Australia” project (DAW00256), a co-investment of GRDC and DPIRD. Thank you to Bob French and

George Mwenda for their work on the trial as well as the Merredin Research Support Unit for their assistance. Lastly, thankyou also to Tony Murfit and Warrakiri Farm for hosting the trial.

Important disclaimer