Ameliorating poorly drained loamy soils with subsoil constraints for improved lentil production at Yeelanna

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Highlights

- Rainfall in the 2024 season was not sufficient to dissolve applied gypsum and move into the soil profile, and there were not significant responses from increasing the rate of gypsum application in this year.
- Disturbance from the ripping treatment resulted in poorer establishment compared to unripped treatments, which saw reduced biomass in the first-year post ripping.
- High rates of gypsum can result in some highly localised salinisation around the seed, which in lower rainfall years can impact crop establishment and growth.

Background

Wet conditions in 2022 caused waterlogging in some lower EP lentil paddocks. Sampling areas of good and poor lentil growth was undertaken on six paddocks in the Cummins, Yeelanna and Ungarra districts (including this site at Yeelanna).

Results from these tests showed elevated exchangeable sodium (ESP) which can indicate high capacity for clay dispersion. Additionally, several sites had elevated exchangeable potassium (K) which can affect clay dispersion, but not to the same degree as sodium. High concentrations of exchangeable potassium are common in soils on Eyre Peninsula and are often overlooked when assessing soil for potential dispersion.

Surface gypsum applications can be useful to mitigate dispersion when these soils are located on/or very near to the surface, but field responses have been variable. Soils which have well-structured loamy topsoils but overlay a shallow highly dispersive clay B horizon, which are common in the district and include this site, are even more difficult to treat. On these soils it is desirable for direct delivery or incorporation of gypsum into the dispersive layer, but difficult to do without incurring a risk of bringing high amounts of the dispersive clay to the surface.

Results from this site showed high concentrations of Na and K throughout the profile in the poor production zone and elevated K in the moderate and good production zones. Additionally, this site had elevated salinity (EC1:5) in subsurface layers of the poor production zone.

Table 1. Results of in crop soil analysis at the Yeelanna site in 2022.

Production zone	Sample depth	Exchangeable Sodium	Exchangeable Potassium	ESP+0.6K	Salinity EC 1:5
	cm	%	%		dS/m
Good	0-10	0.4	4	2.8	0.17
Good	10-30	1	1.9	2.14	0.16
Good	30-60	7.5	2.7	9.12	0.29
Moderate	0-10	0.7	5.8	4.18	0.16
Moderate	10-30	1.1	2.6	2.66	0.16
Moderate	30-60	4.4	3.3	6.38	0.22
Poor	0-10	2.2	7	6.4	0.26
Poor	10-30	2.2	4.5	4.9	0.23
Poor	30-60	4.9	3.7	7.12	0.25

Therefore, this experiment had treatments which compared different rates of surface applied gypsum and ripping to try and move gypsum into the sodic subsoil layer.

Table 2. Site and experiment description

Site name	Modra Deep Ripping Lentil Field Demonstration	
Location	Yeelanna	
Soil type	Shallow loam/clay loam on poorly structured red clay	
Treatments	Nil vs Ripped	Gypsum rate (0, 3, 6, 12 and 18 t/ha, surface applied prior to ripping)
Row spacing	37.5 cm	
Sowing date	1 June 2024	
Seasonal break occurrence	31 May 2024	
Sowing machinery, fertiliser rate	John Deere double disc seeder, 15" (37.5 cm row spacing), 100 kg/ha DAP	
Plot size	Farmer scale (6 m x 25 m x 2 reps)	

Seasonal conditions

The 2024 seasonal break occurred on 31 May with showers between 31 May and 5 June bringing around 7mm to the site. Although the site received above average rainfall in June and July, well below average (Decile 1) rainfall in April and May and below average rainfall in August, September and October resulted in well below average rainfall for the growing season (234 mm compared to an average of 330 mm) (Figure 1).

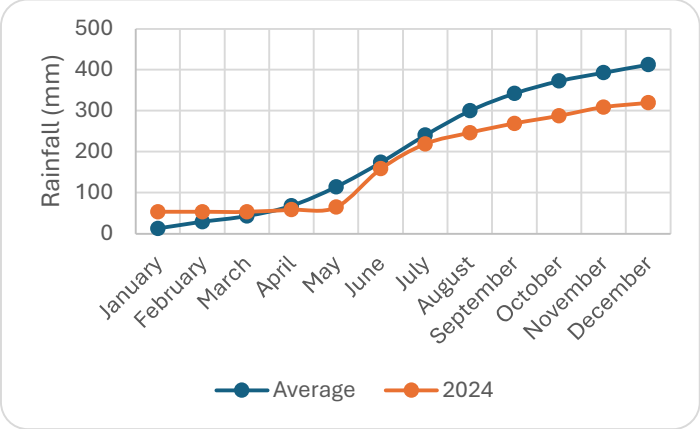

Figure 1. Cumulative average rainfall, and 2024 rainfall at Yeelanna (BOM Station: 018099).

How was it done?

The landholder has identified low surface pH as an issue for lentil production on this paddock and spread lime at 2.5 t/ha across the whole site. Surface applications of gypsum we applied at treatment rates (0, 3, 6, 12 and 18 t/ha) using a Marshall spreader on 24 April. The landholder used a 3 m wide (5 tyne) Yeoman's Keyline plough to implement ripping treatments across the gypsum treatments.

An initial test strip targeted a ripping depth of 30-35 cm below the soil surface (Deep rip), with the intention of loosening the whole clay layer by ripping into the soft carbonate layer below. This was observed to bring up and deposit too much of the sodic B horizon material on the soil surface so the target working depth was adjusted to rip at 20-25 cm below the soil surface. Whilst this reduced the amount of clay, ripping still brought up large soil clods and created an uneven surface for sowing. The landholder utilised a flat land roller to try and flatten the ridges left by the ripping operation (Figure 2).

Figure 2. Ripped plot after rolling with flat steel land roller.

What happened?

Crop establishment

Mean plant density at establishment was 58 plants/m^2. There was a significant establishment penalty (P<0.001, LSD 17.4) from ripping into dry soil at this site with shallow ripped treatments only having 48 plants/m^2 on average at establishment compared to 71 plants/m^2 on average in the unripped control, and only 28 plants/m^2 on the deep ripped treatment (Table 3). There was no establishment benefit from applying gypsum in this year's crop (P>0.05).

Table 3. Mean plants/m^2 at establishment 13 June 2024.

Treatment	Plants/m^2
NO RIP+0T	65
NO RIP+3T	70
NO RIP+6T	72
NO RIP+12T	78
NO RIP+18T	70
RIP+0T	44
RIP+3T	45
RIP+6T	47
DEEP RIP+3T	28
RIP+12T	56
RIP+18T	53
LSD	*20.9*
P	*<0.001*
Rip Treatment	
NIL	70.9
RIP	48.4
RIP (DEEP)	27.6
LSD	*17.4*
P	*<.0001*

Mid-season surface cover

The establishment penalty observed at emergence was also observed in assessments of surface cover in late winter (21 August). Most unripped plots had estimated surface cover of around 40% at this time, whilst uneven germination and growth on ripped plots (Figure 2) resulted in estimated surface cover between 26 and 33% (Table 2).

Table 4. Estimated Surface cover (%) at establishment (Canopeo), 21/08/24.

	Ripping treatment	
Gypsum rate (t/ha)	**NIL**	**RIP**
0	45	34
3	33	26
6	37	31
12	39	28
18	41	26

Figure 3. Lentil growth in late winter on 3 t/ha gypsum treatments (Left - Not ripped, Middle - Shallow ripped, Right - Deep ripped), 21 August 2024.

Biomass and harvest

Poorer establishment and growth observed early in the season continued through to harvest biomass and grain yields. Ripped treatments had generally less biomass than unripped treatments, with the untreated plots (unripped, nil gypsum) having the highest biomass and grain yields overall (P=0.009, LSD 0.41). Harvest index was significantly lower on ripped plots compared to unripped (0.51 compared to 0.54, LSD 0.04), indicating some late season stress on the ripped plots.

Deeper ripping (30-35 cm) resulted in 14-21% less biomass than shallow ripped treatments (and up to 33%) less than the unripped treatments (P=0.004, LSD 0.54). Grain yields were also significantly less on the deep rip plots compared to unripped plots or shallow ripped treatments (1.98 t/ha compared to 2.35-2.60 t/ha, P<0.0001, LSD 0.32).

Treatment	**Grain Yield (t/ha)**	**Biomass (t/ha)**	**Harvest Index**
NO RIP+0T	2.90	5.58	0.53
NO RIP+3T	2.28	4.25	0.54
NO RIP+6T	2.53	4.83	0.53
NO RIP+12T	2.65	4.90	0.55
NO RIP+18T	2.68	4.68	0.57
RIP+0T	2.40	4.80	0.50
RIP+3T	2.38	4.63	0.51
RIP+6T	2.35	4.65	0.51
DEEP RIP+3T	1.98	3.85	0.51
RIP+12T	2.30	4.35	0.53

RIP+18T	2.33	4.53	0.52
LSD	*0.41*	*0.65*	*0.03*
P	*0.009*	*0.002*	*0.008*
Gypsum Rate (t/ha)			
0	2.65	5.19	0.51
3	2.21	4.24	0.52
6	2.44	4.74	0.52
12	2.48	4.63	0.54
18	2.50	4.60	0.54
LSD	*0.33*	*0.51*	*ns*
P	*0.07*	*0.006*	
Rip Treatment			
NIL	2.60	4.92	0.54
RIP	2.35	4.67	0.51
RIP (DEEP)	1.98	3.98	0.51
LSD	*0.32*	*0.54*	*0.04*
P	*<.0001*	*0.004*	*0.04*

What does this mean?

Ripping on this soil type resulted in a very uneven seedbed compared to the unripped area. It also brought some dispersive clay up to the surface. These factors combined resulted in a 35-52% reduction in plant numbers at establishment, with up to 35% lower surface cover in late winter, on ripped plots compared to unripped plots.

Traditional rules of thumb are that it takes 100 mm of rainfall to dissolve 1 tonne of gypsum. Given a Decile 1 growing season, where only 234 mm was recorded compared to an average of 330 mm, there would have been very little opportunity for the surface applied gypsum to go into solution and result in a change in the soil profile.

Early season differences in plant establishment and early vigour on the unripped plots compared to ripped carried through significant differences in biomass production and grain yield.

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