Longevity of deep ripping and topsoil inclusion in soils under traffic farming; evidence from the second season

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Key messages

The yield benefit of deeper ripping persists on the sandy soils in the second season following ripping, although the responses of lupins need further investigation.

Topsoil slotting when deep ripping continues to increase yields on soils with sodic clay subsoil as well as Morrel soils with saline clay subsoil.

The current design of the topsoil slotting plates can compact some deep sandy soils during deep ripping at Binnu and Moora. This needs further investigation, especially on other soil types.

Deeper ripping below 300mm seems to reduce risk of yield loss in extreme conditions including heat shock during grain fill and shallow waterlogging during wetter seasons.

Aims

The primary aim of these eight trials is to test increasing the economic viability of deep ripping by improving its longevity using controlled traffic and the addition of topsoil and ameliorants to the subsoil. This report investigates the effectiveness of deeper ripping and topsoil slotting in the second year after ripping, with and without initial top-dressing of ameliorants for crop production on deep sand, duplex or clay soils at a range of locations in the WA grainbelt.

Method

In 2015 the DAFWA 3.5m trial ripper was used to investigate ripping to depths greater than 300mm to remove the deeper compaction(Blackwell et al, 2016). It had parabolic, shallow leading tines and deeper following tines, allowing for a greater depth of penetration with less draft and reduced cloddiness. Inclusion plates had been attached to the rear, deeper tines for incorporation of topsoil to depth behind the tine, a technique known as topsoil slotting. Tines were spaced at 500mm. Topsoil inclusion plates had an inside separation measurement of about 130mm. Once ripping treatments were established in 2015 the site has been sown, managed and harvested within each grower's own controlled traffic system.

Measurements were taken from trials established in 2015 (Table 1). The manure treatments of 10t/ha of pelletised composted chicken manure were applied to increase the organic matter content of the soil. The intention of burying the topsoil is to incorporate organic matter and surface applied ameliorants to the depth of ripping to improve soil condition and help increase the longevity of ripping. Soil structure and structural stability is improved with increased organic matter (Moore 2004). Lime or gypsum treatments were also top-dressed at the sites, according to soil type and constraints.

Results presented in Table 2 were analysed using a simple linear mixed model, REML, to compare incomplete factorial layouts of the treatments.

Each site has its own peculiarities and those of note are Beacon, Broomehill and Moora. The trials at Beacon in 2015 were inadvertently driven across with a header, compacting the soil and impacting on the longevity of ripping. Reduced ripper tine pressure saw tines 'ride back' at Broomehill influencing the efficacy of topsoil slotting. Harvest windrow effects are present in treatments at Moora and have been analysed to account for this (Table 2).

Table 1. Summary of sites, ripping and topsoil treatments and known constraints.

	Binnu Dune	Binnu Swale	Moora	Munglinup	Broomehill	Beacon Morrel	Beacon York gum	Ongerup
Soil	Pale yellow sand	Loamy yellow sand	Loamy yellow sand	Sand over gravel duplex	Sandy loam over clay	Calcareous loamy earth	Deep sandy duplex	Gritty grey clay
Crop	Lupin, Coromup	Lupin, Coromup	Barley, Bass	Barley	Barley	Wheat, Mace	Wheat, Mace	Barley, Latrobe
Rainfall (mm)	300 GSR 75 Jan - Mar	300 GSR 75 Jan - Mar	321 GSR 38 March	362 GSR 250 Jan-Mar		200 GSR 92 Jan - Mar	200 GSR 92 Jan - Mar	277 GSR 172 Jan - Mar

	Binnu Dune	Binnu Swale	Moora	Munglinup	Broomehill	Beacon Morrel	Beacon York gum	Ongerup
Topdressing 2015	Nil, 5t/ha limesand, 10t/ha manure pellets	Nil, 5t/ha limesand, 10t/ha manure pellets	Nil, 5t/ha limesand	Nil, 10t/ha limesand, 5t/ha limesand	Nil, 5t/ha ground limestone, 10t/ha manure pellets	Nil, 5t/ha gypsum, 10t/ha manure pellets	Nil, 5t/ha limesand	Nil, 5t/ha gypsum, 10t/ha manure pellets
Depth of ripping (mm)	Nil, 500, 500TS, 300	Nil, 500, 500TS, 300	Nil, 500, 500TS, 300, 300Spd	Nil, 600, 600TS, 300	Nil, 500, 500TS, 300	Nil, 450, 450TS, 300	Nil, 450, 450TS, 300	Nil, 400, 400TS, 300.
Depth of hard pan, 2015 (mm)	350	350	400	450	350		350	
$EC_{1:5}$ dS/m^2 2015						0.49-0.59 (200-400mm)		0.15 (300-500mm)
Exc. Na %								>16 (300-500mm)

Note TS=topsoil slotting, Spd=spading

Results

Table 2. Yield results, t/ha, from the eight trials with respective topdressing and ripping depth treatments. 10% LSD shown to account for complexity of trial interpretation, rip*tpdrs for comparison between ripping and topdress treatments, tpdrs for comparison of yield within a topdressing treatment.

		Topdress				
	Ripping	Nil	Lime 5t/ha	Manure 10t/ha	Lime 10t/ha	% LSD 10
Moora	Nil	1.43	1.23			rip*tpdrs: 0.53
Barley	Nil + W	1.42	1.09			tpdrs: 0.39
	300	1.44	1.36			
	300 + Sp	1.90*	1.81*			
	550	1.90*	2.43*			
	550 + W	1.99*	1.92*			
	550 + TS	2.08*	1.51			
	550 + TS + W	2.19*	2.03*			
Binnu Swale	Nil	2.05	1.98	2.13		rip*tpdrs: 0.63
Lupin	300	2.14	2.05	2.22		tpdrs: 0.36
	550	2.50	2.09	2.33		
	550 + TS	1.77	1.96	1.78		
Binnu Dune	Nil	1.00	1.13	1.07		rip*tpdrs:0.38
Lupin	300	1.04	1.22	1.24		tpdrs: 0.19
	550	1.18	1.12	1.38*		
	550 + TS	1.00	1.13	0.99		
Munglinup	Nil	2.19	2.44		2.75	rip*tpdrs 0.60

Barley	300	2.70*	2.95*		3.64*	tpdrs:0.30
	600	3.03*	3.25*		3.12*	
	600 + TS	3.17*	3.72*		2.99	
Broomehill	Nil	2.68	2.35	2.98		rip*tpdrs: 1.46
Barley	300	2.53	2.55	3.03		tpdrs: 0.80
	550	2.91	2.51	2.67		
	550 + TS	3.10	2.42	2.43		

		Topdress				
	Ripping	Nil	Lime 5t/ha	Manure 10t/ha	Lime 10t/ha	% LSD 10
Beacon York gum	Nil	1.60	1.81			rip*tpdrs: 0.44
Wheat	300	1.13*	1.49*			tpdrs: 0.27
	450	1.21*	1.40*			
	450 + TS	1.45	1.74			
			Gypsum 5t/ha			
Beacon Morrel	Nil	1.79	1.87	2.16		rip*tpdrs: 0.53
Wheat	300	1.96	1.88	2.13		tpdrs: 0.31
	450	1.81	1.72	2.03		
	450 + TS	2.10*	2.12	2.41		
			Gypsum 5t/ha			
Ongerup	Nil	2.77	2.41	3.37		rip*tpdrs: 1.07
Barley	300	3.43*	2.49	3.43		tpdrs: 0.65
	450	3.18	2.53	3.52		
	450 + TS	3.85*	3.23*	3.75		

Note: TS topsoil slotting, Spd spading, W windrow, *90%prob of greater or less than unripped within topdressing,

Moora

This trial has been analysed to account for windrow effects, because Nil and 550mm ripping treatments had lupin and canola harvest windrows within plots during 2014 and 2015. Ripping below 300m has shown a yield response in the second year after ripping. When ripping to 550mm topsoil, topsoil slotting provided an additional 0.9t/ha. There is some evidence of organic stabilisation of this higher clay content yellow sand, which is prone to self-settlement by wetting and drying after ripping, even without cropping traffic compaction.

The biomass and heads/m^2 measured at anthesis were lower across all treatments in the area topdressed with lime when compared to the Nil topdressing, potentially due to a nutrient constraint from increased surface pH. Some unreplicated preliminary canopy temperature measurements using infrared temperature loggers indicated large temperature differences between Nil ripping and deep ripped to 550mm with topsoil slotting treatments. The plants in the deep ripped soil were 0.59°C (se 0.36) cooler than those in the unripped soil. Such temperature differences indicate the plants in the deeper ripped soil had better access to soil moisture. Further investigation is required to understand this interaction. There were trends to greater biomass and head number in the 550mm topsoil slotting treatment but fewer grains per head when compared to the Nil treatment.

Binnu Swale

Unlike 2015, where yield responses to deeper ripping in wheat were about 1t/ha, the 2016 lupin yields showed little or negative response to deeper ripping or topsoil slotting. The negative response of lupins to deep ripping and topsoil slotting was also observed at a nearby trial site south of Binnu in 2016 (Isbister, pers comm. Data to be published). Plant emergence was 55 plants/m^2 and was similar across all treatments. Anthesis biomass of the plants in the topsoil slotted plots was significantly lower than other treatments in spite of sufficient plant emergence.

Soil strength measurements using a RIMIK digital cone pentrometer in moist conditions for the topsoil slotted plots indicate strength above 2MPa beginning at 200mm depth between the tines. The topsoil slotting plates have recompacted this soil between the tines while leaving the rip line soft and accessible. In comparison the 550mm ripping without topsoil slotting plates reaches 2MPa between 520 and 540mm. Further penetrometer testing is required to isolate the impact of the slotting plate on soil strength between the tines. For ripping depths 300 and 550mm lupin yield does not differ from the Nil ripping treatment. Ripping to 550mm with topsoil slotting reduced biomass while increasing seed size. The highest yield in 2015 was from topsoil slotted plots which was an additional 1.8t/ha over Nil treatments. Such a yield increase may have mined nutrients from these treatment plots that were not compensated for with fertiliser application at sowing.

Binnu Dune

In this poorer soil type on the dune the yield response was only observed at 550mm deep ripping with topdressed manure. The addition of topsoil slotting plates had had no impact on yield. Lupin response to lime has been insignificant irrespective of ripping. Similar soil strength patterns were observed when comparing the Dune site with the Swale site. Soil strength increases rapidly from a shallow depth intended to be fractured and of low strength after ripping. In the dune soil with 550mm topsoil slotting the strength between tines reaches 2MPa at 160mm and 3MPa at 200mm. There was no ripping treatment or topsoil slotting influence on biomass or seed weight for lupins in 2016.

Munglinup

Record rainfall at the site saw a number of plots submerged or showing signs of waterlogging during the season. Depth to gravel is inconsistent across the site from 15 to 55cm. In Nil and 5t/ha lime topdress treatments increasing ripping depth increased yield response. Neither ripping nor topsoil slotting altered the severe water repellence of the 0-5cm surface soil. The soil strength measurements at Munglingup were different to the Binnu and Moora sites. At Binnu and Moora, soil strength rose rapidly from a shallow depth where clay in this siliceous sand helps cement the sand when compacted. At Munglinup soil strength between the tines of the topsoil slotted plots does not increase above 2MPa until a depth of 520mm. Correspondingly the score for number of roots in the soil negatively correlates with the penetrometer measurements (r^2=0.57). Ripping 600 and 600 + TS had significantly more roots deeper in the profile than ripping 300 and Nil treatments, though not significantly different from each other. At this site it appears ripping has provided a drainage benefit as root number increases with ripping and ripping depth. Waterlogging above the pan would restrict the active roots and reduce access to soil water during high temperatures inducing yield reducing heat damage.

Broomehill

The site has distinct soil variations occurring throughout the trial which has provided large variation in yield results (high lsd). Consistent yield responses are not present and further analysis is being undertaken. It may be possible to isolate plots with similar soil type using the gamma radiometrics, EM38 and yield maps that have been captured from the paddock. Deeper ripping to 550mm in the absence of topdressing, tended to provide positive yield response. Plots with lime topdressing are lower in the landscape and treatments in this area may have been influenced by frost. Analysis of frost induced sterility will be undertaken. Gravel stones are present and make penetrometer readings challenging. The penetrometer data indicated some loosening of the soil in the ripping to 550mm but no impact of ripping to 300mm. Efficacy of the topsoil slotting plates was reduced as hardpan, gravel and reduced machine hydraulic pressure combined to lift tines out of the ground irregularly throughout the trial. With current data topsoil slotting results cannot be effectively interpreted.

Beacon York Gum

Both Beacon sites were impacted by harvest compaction during the 2015 harvest and it is likely that there has been a reduction in yield response. This soil type has not responded positively to deep ripping. Yield is negatively influenced by ripping without topsoil slotting. Unlike ripping at 300 and 450mm, the 450 with topsoil slotting treatment has not reduced yield. While this response hasn't been positive it could be a stabilisation effect of organic matter from the topsoil in the ripping line. It appears that lime was also necessary to reduce yield loss. The penetrometer data, sampled outside of harvest compaction, indicates the ripped soil has returned to strength levels at depth equivalent to that of the unripped treatment. Further, soil strength levels in the 450 and 450+TS ripping are higher than the unripped treatment below 300mm, so the 2016 crop could be using old root channels from the 2015 crop to access the high strength soil. Soil chemistry and particle size distribution in the sub-surface is likely to have increased the soil strength after disturbance of their equilibrium from the ripping tine.

Beacon Morrel

This site was impacted by harvest compaction during harvest of 2015 and it is likely that there has been a reduction in yield response to ripping as a result. Despite that, ripping to 450mm with topsoil slotting has provided a positive yield response in 2016 but is only significant without topdress treatments. The yield differences between topdressing treatments are not statistically significant. Although an increasing trend of up to 0.37 and 0.31t/ha exists between Nil and gypsum treatments respectively when compared to the manure treatment. Deep ripping has not benefited yield unless topsoil slotting has been included. Ripping to 450mm with topsoil slotting, without topdressing was the only significant result when compared to the unripped. This observation of improved yield with topsoil slotting was also made in the first year of ripping and supports the idea that the stabilised saline clay subsoil has enabled salt flushing by large rainfalls such as 100mm in July 2015 and a wet year in 2016 for this site. The salt flushing has likely reduced salinity enough for more root exploration of the subsoil, resulting in more available water to help yield. Unlike the 2015 season for 2016 there was no discernible influence of treatment on screenings, seed weight or grain quality. Frost may have confounded treatments with average frost induced sterility of 22% across all plots. There was no influence of treatment on level of frost induced sterility throughout trial.

Ongerup

The soil is sodic and dispersive below 300mm. Ripping below 300mm has tended to reduced yield in the absence of ameliorant or topsoil slotting. Topsoil slotting increased yield in gypsum and Nil topdressed treatments in 2016. Yield in the topsoil slotting plus manure also increased though to a lesser extent and not significantly differently from the Nil ripping. The combination of these results indicates a stabilisation of sodicity by the addition of organic matter allowing roots deeper in the profile to increase yield.

A mild season finish, large volumes of early rainfall and frost have had a large influence on the results of the trial. The sandy clay duplex, suffered from inundation of water through May and early June. A dry period during July allowed drainage and infiltration of water. The waterlogging response of the crop was not sufficient to give visual symptoms. The clay content of the soil is high enough to slow the rate of infiltration during the period of inundation allowing ripping lines and natural gradient of the paddock to drain the water. Deep ripping does assist drainage and may have increased the volume of water in the subsoil for biomass production and grain fill late in the season. The mild spring combined with deeper access to soil moisture enabled plants to recover from frost with late tillers providing grain that would not have filled in a season with a warmer finish.

Conclusions

Yield response to deep ripping below the compaction layer at Moora and Munglinup are still evident in the sandy soils two years after the treatment was applied. The response of the lupins in the sandy soil at Binnu was inconsistent and requires further investigation, particularly where lupin yield is reduced with topsoil slotting treatments, possibly due to nutrient depletion from very high yield in 2015.

Deeper ripping below 300mm seems to reduce yield risk in extreme conditions of heat shock and waterlogging. A heat shock during grain fill in 2015 was buffered by deeper ripping where roots had access to deeper moisture. Observations from this ‘wetter’ season suggest that ripping and topsoil slotting provide drainage in waterlogged sodic clay and sand over gravel soils, as observed at Ongerup and Munglinup respectively. As such deeper ripping could be used as a management strategy in paddocks susceptible to waterlogging particularly where there is a hard compact layer reducing drainage.

To maximise the value of deep ripping a thorough understanding of the subsoil is important. There is the threat of damaging the sub soil with ripping and reducing yield potential when ripping sodic soils. These trials, and others (Parker et al 2017), have shown positive yield response in sodic soils with the inclusion of organic matter. Topsoil slotting plates should be fitted if ripping these soils. Two years of results suggest that ripping York Gum soils may not be beneficial and should be considered on a case by case basis, dependant on the geomorphological features present at each site. Some gravel soils do respond well to ripping after the first season where the ripper is able to penetrate and loosen the gravel layer. There is some evidence from grower experience that altering the topsoil slotting plate orientation can increase the effectiveness in some soils and this is an area of further investigation

On the Binnu yellow sand the topsoil slotting has caused a recompaction of soil between the tines. The 50cm tine spacing means that there is 370mm between outside plates. It would appear the current shape of slotting plate is not sufficient to allow for soil breakout between plates and the ‘inter-plate’, inter-row soil is being compressed as the plates pass. Soil particle size distribution, moisture conditions, depth of ripping, depth of topsoil slotting plate, width between plates, plate angle will determine the degree to which this occurs. Design of topsoil slotting plates requires further investigation to ensure inter row compaction is minimised while retaining the capacity to bury topsoil organic matter. The addition of winged points to the tine may be sufficient to increase breakout and loosen a greater volume of soil for the plates to pass through.

Table 3. Return on investment (ROI) over the first two seasons of deeper ripping, with topsoil slotting and topdressed ameliorants for Binnu and Munglinup sites. Table provides only a guide to possible return on investment using numbers generated from the trial and assumed costs and prices.

Topdress	Nil			Lime 5t/ha				Manure 10t/ha			
	300	550	550TS	Nil	300	550	550 TS	Nil	300	550	550TS
Binnu Dune											
Year 1	-1	6	7	-1	-1	0	1	-1	-1	-1	-1
Year 2	-0.5	7	7	-0.5	-0.5	0.5	1	-1	-1	-1	-1
Binnu Swale											
Year 1	-5	2	9	-1	-1	0	2	-1	-1	-1	-1
Year 2	-4	3	7	-1	-1	0	1	-1	-1	-1	-1
Munglinup								Lime 10t/ha			
	300	600	600TS					Nil	300	600	600TS
Year 1	-1	-1	3					-0.7	-0.73	-1	-0.4
Year 2	3	4	8					-0.5	0	-0.5	0

The response of the crop to ripping is variable depending on rainfall and temperatures during the season. It is important to consider the economics over a number of seasons. At Binnu, in the absence of topdressing manure, the responses from ripping to 550 were sufficient to cover the investment in the first year. Deeper ripping remains economic in year two, though topsoil slotting has reduced the value of this return with a decreased yield response. At Munglinup the value of the ripping without topsoil plates investment was realised in year two, with topsoil slotting improving the ROI of year 1. The lime investment at Munglinup is a longer term investment and is likely to provide positive ROI by year 5, providing more than $100/ha in extra value than the Nil topdress.

Key words

Topsoil slotting, deep ripping, compaction, controlled traffic farming, sodic clay, sandy soils.

References

Blackwell P, Isbister B, Riethmuller G, Barrett-Lennard E, Hall D, Lemon J, Hagan J, Ward P, (2016) Deeper ripping and topsoil slotting to overcome subsoil compaction and other constraints more economically: way to go!, Proceedings GRDC Grains Research Updates 2016, available at http://www.giwa.org.au/2016researchupdates

Moore G, (2004) Soil Guide: a handbook for understanding and managing agricultural soils. Department of Agriculture Bulletin 4343,

Parker W, Isbister B and Blackwell P. (2017) Deep ripper tine spacing for increased profitability, Proceedings GRDC Research Updates 2017, Burswood Conference Centre, Perth, 27-28th February 2017.

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