COMPACTION MITIGATION OPTIONS FOR GROWERS IN THE ALBANY AND KWINANA WEST PORT ZONES

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Compaction mitigation options for growers in the Albany and Kwinana West port zones

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COVER: Aerial view of Rob Dempster's property.
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Foreword

A significant volume of research, development and extension has been undertaken to address subsoil compaction issues in the Northern Agricultural Region, where compaction has long been considered an issue. Significantly less research, development and extension (RD&E) on compaction has been conducted further south in WA.

Regional Cropping Solutions Networks (RCSNs, now known as Grower Networks) in the Albany and Kwinana West port zones both identified compaction as an issue to be addressed in their area in 2015. This and other investments by GRDC flowed as a result of that request by growers and advisers for more RD&E on the topic.

This case study booklet was produced as part of the RCSN-funded 'Compaction mitigation options for growers in the Albany and Kwinana West port zones' project (AVP1702-001WCX).

A number of deep ripping trials and demonstrations in both the Albany and Kwinana West port zones were monitored during the 2017 and 2018 growing seasons and the results of these can be found on the Online Farm Trials website (search for 'agVivo' on www.farmtrials.com.au). This booklet contains case studies of six growers who have trialled one or more ways of overcoming subsoil compaction on their property.

The team at agVivo and MapIQ would like to thank all the collaborating growers, grower groups and researchers involved in the trials and demonstrations, and journalist Jo Fulwood for writing these case studies.

Philip Barrett-Lennard and Tim Boyes, agVivo
Joel Andrew (previously agVivo and MapIQ)
December 2021

Executive Summary

Background

The majority of agricultural soils in Australia have developed subsoil physical constraints, in particular compaction. An estimated 13 million hectares (70 per cent) of Western Australia's agricultural soils have moderate to high susceptibility to subsurface compaction (Department of Agriculture and Food Western Australia, 2006).

Subsurface compaction is caused by compression from agricultural machinery traffic with the compacted layer forming between 10 and 40 centimetres. In contrast, compaction from stock trampling is confined to the surface 15cm of soil. In addition to compaction, hard layers can form as a result of natural soil packing and chemical cementation processes, and these can occur throughout the soil profile. These hard layers slow or, in extreme cases, prevent root growth and restrict root access to water and nutrients (www.soilquality.org.au).

Soil compaction is widespread, but the exact severity and trend is unknown. The annual cost of compaction as lost production is estimated at $333 million, with additional losses associated with soil structure decline. Subsoil compaction holds back crop growth on WA soils by restricting root growth and increasing the risk of waterlogging in the soil profile. Compacted soils can also restrict healthy activity of soil biology. These effects can reduce grain yield and increase costs.

Optimum compaction management strategies include traffic control and deep ripping. Previous RD&E, with investment from GRDC, WA Department of Primary Industries and Regional Development (DPIRD) and Northern Agricultural Catchment Council (NACC), have reported yield benefits of about 10 per cent ($60 per hectare benefit for a 2 tonne/ha yield and $300/t price). They also report better quality from a controlled-traffic farming (CTF) system on deep sand with suitable amelioration of compaction, and 20 to 30 per cent grain yield increase by deep ripping without a hard finish to the season.

DPIRD research shows that deep ripping is most effective in deep sandy-textured soils where roots need to grow deeper to access subsoil moisture. Deep ripping is of particular benefit when it is used to break through a compacted pan or distinct constraining layer, allowing root access to unconstrained soil water beneath this layer. If the soil below the depth of ripping contains other constraints, such as acidity, poor structure from sodicity or subsoil salinity, the benefit of deep ripping will be limited. The addition of soil ameliorants such as lime or gypsum may be required to stabilise the soil. It is possible to inject lime into acidic subsurface soil behind deep ripping tynes; however, this is a slow operation and difficult to implement at a large scale (shallow leading tyne rippers are ideally suited to this).

Growers in the Albany and Kwinana West RCSN port zones identified compaction as an issue. Questions raised by growers in these port zones were:

- What was the impact and extent of soil compaction on profitability?
- What was the value of variable-rate technology (VRT) to their business?
- What are the yield-limiting factors on their soil types?
- What cropping techniques and practices can they use that will maintain or improve their soil structure and increase the profitability of cropping on difficult soils, particularly compacted, acidic, potassium-deficient and non-wetting soils?

Objectives

The major aim of the project was to develop best-bet management options for growers of the Albany and Kwinana West port zones on:

1. compaction and mitigation options for a range of soil types; and
2. how best to move into CTF technology for their farming situation.

The project had a mix of research, demonstration and extension activities on soil compaction in the Albany and Kwinana West port zones.

Nine deep ripping trial and demonstration sites were monitored in 2017 and 2018. These trials and demonstration sites were mostly on-farm sites established in previous years but had not been properly monitored. One of the sites was a fully replicated trial site.

Yield responses to ripping were observed at eight of the nine trial and demonstration sites in 2017. Depth of ripping had an impact on the yield response at some sites; however, the response was variable (sometimes positive, sometimes negative).

TRIAL AND DEMONSTRATION SITES

The tables on page 6 show the growers, locations, trial descriptions, collaborators and measurements for the trial and demonstration sites that were monitored as part of this project. Most of these were existing sites set up by growers or researchers in previous years and were monitored as part of this project.

Yield responses to ripping were observed at eight of the nine trial and demonstration sites. Depth of ripping had an impact on the yield response at some sites; however, the response was variable (sometimes positive, sometimes negative).

Table 1: Albany port zone growers.

Grower	Location	Trial description	Collaborators	Measurements
Josh Goad (see case study)	Kojaneerup -34.517549, 118.330308	Ripping to 350mm, 700mm and 1200mm Replicated plots	Stirlings to Coast Farmers DPIRD	UAV NDVI Penetrometer Plant counts Grain yield Soil coring
Reece Curwen	South Stirling -34.637966, 118.182461	Ripping to 300mm and 600mm Demo strips, unreplicated	Stirlings to Coast Farmers DPIRD	UAV NDVI Penetrometer Plant counts Grain yield Soil coring
Scott Thompson (see case study)	Broomehill -33.866079, 117.677218	Ripping to 450mm Replicated plots	N/A	UAV NDVI Penetrometer Plant counts Grain yield Soil coring
Simon Zacher	Kojonup -33.796780, 116.927073	Ripping to 350mm, 350mm + inclusion plates, 550mm Heliripper to 600mm Offset disc to 150mm Scarifier to 200mm Replicated plots	Southern Dirt DPIRD	UAV NDVI Penetrometer Plant counts Grain yield Soil coring
Ben Hobley (see case study)	Nyabing -33.758761, 118.155712	Deep rip to 500mm 5 paddocks, demo strips, unreplicated	N/A	UAV NDVI Penetrometer Plant counts Grain yield

Source: MapIQ

Table 2: Kwinana West port zone growers.

Grower	Location	Trial description	Collaborators	Measurements
Adam Smith	Beverley -32.110678, 117.134029	Deep ripping to 500mm Demo Strips, unreplicated	N/A	UAV NDVI Penetrometer Plant counts Grain yield Soil coring
Warakirri Cropping	Quairading -31.943134, 117.565520	Helirripper to 700m + spading Demo strips, unreplicated	N/A	UAV NDVI Penetrometer Grain yield Soil coring
Ty Fulwood (see case study)	Northam -31.630399, 116.879672	Helirripper to 700mm 3 paddocks, demo strips, unreplicated	N/A	UAV NDVI Penetrometer Plant counts Grain yield Soil coring
Rob Dempster (see case study)	Goomalling -31.416670, 116.892112	Deep ripping to 500mm, 500mm + Inc Helripper to 700mm, delving to 1000mm Plozza plough to 300mm Replicated trial	agVivo	UAV NDVI Penetrometer Plant counts Grain yield Soil coring
Tim Cusack (see case study)	Narembeen -32.106696, 118.679867	3t/ha lime 6t/ha lime Lime with disc incorporation Lime with deep ripping incorporation Lime with deep ripping and spading Disc only Deep ripping only Deep ripping and spading only	N/A	UAV NDVI Penetrometer Plant counts Grain yield Soil coring
Craig Jesperson	Yealering -32.781490, 117.631323	Prilled lime at 100kg/ha Top dressed lime at 2t/ha Deep rip + lime at 2t/ha Deep ripping + spade + lime at 2t/ha	Facey Group	UAV NDVI Penetrometer Plant counts Grain yield Soil coring

Source: MapIQ

Location of trial and demonstration sites

Albany port zone summary of grower results

Josh and Tony Goad, 'A.D, Goad', Kojaneerup

In 2014, 16 strips were ripped to a depth of 350 millimetres on alternative run lines using a Grizzly Deep Digger. In 2016, four of the original strips were re-ripped to a depth of 700mm using a Heliripper with 500mm tyne spacings and an additional four strips were re-ripped to a depth of 1200mm using a bulldozer with 1000mm tyne spacings.

Soil compaction was measured and in the undisturbed plots increased steadily from the surface to peak at around 3000kilopascals at approximately 250mm, with this value being maintained to at least 600mm. The 350mm ripping treatment showed a reduction in soil compaction to approximately 300mm and then increased to peak and maintain 2600kpa to 600mm. Both the 700mm and 1200mm ripping treatments were much less compacted to 600mm, with neither treatment having levels greater than 2000kpa in any measurement location.

Previous research has found 2500kpa to be the level of compaction where plant root growth begins to be inhibited, so it is expected that the strips not ripped and those ripped to 350mm will continue to experience compaction as a soil constraint at this site, and this may help explain the yield differences observed.

The 700mm ripping treatment provided a significant average yield increase of 710 kilograms per hectare more grain than the control plots. The 1200mm ripping treatment provided a significant average yield increase of 420kg/ha over the 700mm ripping treatment and 1130kg/ha over the control plots. The 350mm ripping treatment provided a slight average yield increase over the control plots, although this was not significant. In canola, a marginal, albeit significant, average yield increase of 70kg/ha was provided by the 1200mm ripping treatment, with all other treatments and the control showing no significant yield differences. The trial site experienced waterlogging and frost towards the end of the 2017, which impacted on the yield from the site.

Returns of deep ripping

The net benefit of all ripping was positive or neutral for all treatments, with all of the major benefits coming after the first year and then quickly falling away. It is thought that only the 700mm ripping depth provided an acceptable return on investment over this time period.

The 350mm ripping treatment only just broke even between 2016 and 2018, giving back a total of $1/ha. The 700mm ripping treatment returned $128/ha and was likely to be economically viable. Though the 1200mm treatment gave the largest yield increase and released a $283/ha benefit in 2016, the results were not continued, and the high cost of treatment reduced the economic benefit achieved (see Table 3).

The 1200mm ripping treatment has provided the greatest yield advantage at this site, although as it was carried out using a bulldozer it is unlikely to be practical to implement on a larger scale. It does encourage further work to see how ripping deeper than 700mm can be achieved in a cost-effective manner.

Conclusion

There have been positive yield and economic responses seen in each season since the deep ripping treatments were established in 2015. The cumulative yield increase provided a positive return on investment to the farm business for the 700mm ripping depth, though not for the other treatments.

Key messages from the Goads were that the strips ripped to a depth of 700mm continue to provide a significant yield increase five years after treatment and that the largest benefits from the ripping treatments were seen in the lower production zones.

Table 3: Economic return of each treatment show varied results across the ripping depths and seasons.

Treatment	Treatment cost ($/ha)	Amortised treatment cost over three years ($/ha/yr)	Net benefit from ripping 2016 ($/ha) barley at $250/t	Net benefit from ripping 2017 ($/ha) canola at $500/t	Net benefit from ripping 2018 ($/ha) barley at $250/t	Accumulated return costs over three years ($/ha)
Control	-	-	0		0	0
Rip 350mm	40	13	25	-10	26	1
Rip 700mm	60	20	178	0	10	128
Rip 1200mm	200	67	283	35	-28	89

Source: agVivo/DPIRD

Reece Curwen, 'Tooraweenah Pastoral Company', South Stirling

A key message from the Curwens is that deep ripping demonstrations provide a tool to assess potential yield gains across various soil types.

The Curwen's deep ripping demonstration site was established in 2016 and consisted of deep ripping strips at working depths of 350mm and 700mm, installed across gravel and sand soil types. The ripping was undertaken using a Heliripper. Undisturbed plots were left around the ripped strips.

The 350mm ripping treatment showed a reduction in soil compaction to a depth of approximately 300mm and then increased to peak and maintained 5000kpa at 600mm. While the 700mm ripping treatment showed less compaction to a depth of 600mm, soil strength levels greater than 2500kpa were still observed.

The overall site had improved yields when compared to the control plots. In 2016, barley yields were increased by 750kg/ha and 370kg/ha in the 350mm and 700mm treatments, respectively. In 2017, canola yields from the gravel soil type showed a 280kg/ha yield increase from 350mm ripping and 110kg/ha yield increase from 700mm ripping.

In 2018, the site was in pasture and visual differences in the greenness of the ripping strips were clearly seen.

Returns of deep ripping

The net benefit of both ripping depths was positive for the sand and gravel soil types and looks to be sustained over the two years of data available. The 350mm ripping depth gave the greatest average benefit of $164/ha in the gravel soil and the highest overall return of $278/ha, after costs had been removed (Table 4).

The higher cost of the 700mm ripping depth was not balanced by increased yield gains and was therefore not as profitable as the less costly 350mm treatment.

The longevity of the treatment effect will determine how cost-effective deep ripping is in this environment and on these soil types.

Conclusion

There have been positive yield and economic responses seen in each season at the Curwen's since the deep ripping treatments were established and the effects seem likely to continue. The cumulative yield increase provided a positive return on investment to the farm business and the 350mm ripping depth was more profitable than other treatments.

Table 4: Economic return of each treatment.

Treatment	Treatment cost ($/ha)	Amortised treatment cost over three years ($/ha/yr)	Net benefit from ripping 2016 ($/ha) barley at $250/t	Net benefit from ripping 2017 ($/ha) canola at $500/t	Accumulated return costs over three years ($/ha)
Control gravel	-	-	0	0	0
Rip 350mm gravel	50	17	188	140	278
Rip 700mm gravel	80	27	93	55	68
Control sand					
Rip 350mm sand	40	13	55	-	47
Rip 700mm sand	60	20	80	-	68

Source: agVivo/DPIRD

Tim Cusack, 'Maysville Farm', Mount Walker

A lime by tillage trial located on a poor performing acidic, deep-yellow sand soil type was established by the Cusack family in April 2016 to assess the impact of tillage treatment and lime application on crop yield. The treatments were applied in 2016, with canola planted in 2017, followed by wheat in 2018.

The trial was designed as a fully randomised block trial consisting of 50 plots, each 18 metres wide and 250m in length with different lime rates and tillage treatments applied. There were four replicates of 11 treatments plus control. Lime was spread at a 9m width, deep ripping was carried out at a 450mm working depth and spading was done after the plots had been deep ripped.

The paddock was sown to peas in June 2016 (spray topped in September 2016 and brown manured in April 2017), canola in May 2017 and wheat in May 2018.

Soil and plant measurements

Soil strength was reduced in the deep ripping and spaded plots compared to the plots that did not receive deep ripping and this was maintained into the 2018 season. The 'control' plots consistently reached 2500kpa between 100 to 150mm soil depth and increased to peak at 4000 to 5500kpa at 200mm depth. Deep ripping plots were maintained at compaction levels below 2500kpa to 700mm depth.

The trial plots were soil tested in February 2019 in the same locations as sampled pre-treatment to examine soil pH changes against the benchmark values. Soil pH had changed in the lime treatments proportional to rates of lime applied. The high rates of lime had an interaction with tillage treatments, with ripping and ripping plus spading treatments showing increases in soil pH below the top 20cm of soil. All samples 0 to 10cm soil pH above pH5.5 though all remain severely acidic (pH <4.5) below 30cm.

Crop establishment and yield

The 2017 canola crop was negatively impacted by the dry start resulting in very different crop establishment across the trial. The biggest differences were in the spaded plots, which had significantly less canola plant density than all other plots, averaging only three plants per square metre. Some ripped plots had a reduced number of plants than the control although density was still high enough to deliver a reasonable yield. Site inspection in June 2017 showed that the canola in the spaded plots was planted deeper than the other plots in a layer of dry soil. No difference in plant density was seen in the 2018 wheat crop.

Significant yield differences were seen in the 2017 yield data. The ripping and ripping plus lime treatments returned the highest yield increases when compared to the control. The spaded treatments, with or without lime, gave the lowest yields, averaging 350kg/ha less than the control treatment. Ripping plus 6t/ha lime treatments delivered the largest yield increase with an average 800kg/ha in yield.

In 2018, the highest yielding treatment was the ripping plus 6t/ha lime, which had similar average yields to the rip only and rip plus spade only treatments and provided 970kg/ha more wheat than the control. There was no difference in yield between the control

Table 5: Economic return of the treatments for the 2017 and 2018 season.

Treatment	Treatment cost ($/ha)	Amortised treatment cost over three years ($/ha/yr)	Net benefit from ripping 2017 ($/ha) canola at $500/t	Net benefit from ripping 2018 ($/ha) barley at $350/t	Net return minus costs of investment over two years ($/ha)
Control	0	0	0	0	0
3 t/ha lime	189	94	25	-92	-256
3 t/ha lime + disc	200	100	100	-29	-129
3 t/ha lime + rip	227	114	325	212	310
3 t/ha lime + rip + spade	302	151	-175	232	-245
6 t/ha lime	377	189	25	-30	-382
6 t/ha lime + disc	388	194	100	-82	-370
6 t/ha lime + rip	416	208	375	483	442
6 t/ha lime + rip + spade	491	245	-150	136	-505
Disc only	11	6	100	-25	64
Rip only	39	19	275	418	655
Rip + spade only	114	57	-150	337	73

Source: agVivo/DPIRD

and any of the non-tillage or disc tillage treatments. The ripped or ripped plus spaded treatments performed significantly better than the non-tillage or disced treatments. Soil compaction was likely to be the main constraint at this site and not soil acidity as first thought.

Returns of deep ripping

Overall economic returns from the treatments varied greatly. The largest benefit was $655/ha for the rip only treatment and the greatest loss of -$505/ha was from the rip plus spade plus 6t/ha lime treatment (Table 5). The surface-applied lime treatments and lime with discing or spading treatments made an average loss of approximately -$300/ha. The only limed treatments delivering a positive return were combined with ripping, which gave an average $376/ha benefit. The very high cost of the treatments meant the yield benefits needed to be high in both trial years to return a profit.

Conclusion

The result of deep ripping was varied and demonstrated the risk of carrying out high cost amelioration activities. A key message is that lime previously applied onto the surface over a number of years can provide immediate benefits when incorporated into the soil.

Ongoing yield increases from deep ripping are likely to continue and will provide a positive return on investment. The longevity of the deep ripping effect will determine how large the economic benefit will become, although it has already provided a profit.

Scott Thompson, 'Nardlah Grazing Company', Broomehill

Scott Thompson put down three deep ripping demonstration plots in late February 2015. Undisturbed 'control' plots were left either side of the treatment strips, creating a replicated trial design. Four passes of a 3m-wide Grizzly Deep Digger with 500mm tyne spacings was used at a working depth of 450mm to create 12m-wide plots. These plots were aligned to fit with the existing 12m CTF system.

Within the trial site, areas of gravel were found and this limited the number of accurate penetrometer readings able to be obtained. Where soil penetrometer recordings could be made, it was found that there was a reduction in soil resistance within the ripped plots when compared to the control plots, particularly in the soil layers between 100 and 300mm. It was also found that the reduction in soil resistance in the ripped plots gave an overall average reading that was less than 2500kpa, which previous research has found to be the compaction level at which plant root growth begins to be inhibited.

In comparison, the average measurements in the control plots peaked at above 3000kpa, which indicate that there may be a soil constraint at this site caused by compaction. The severity of the constraint may not be all that large as the soil strength drops below 2500kpa after 250mm soil depth.

Since the beginning of the trial in 2015 there have been significant yield increases between the ripped and control plots in each subsequent crop. The largest yield increase was seen in the 2016 canola crop, where an average 310kg/ha yield increase was recorded in the ripped plots over the control. Lower yield increases were seen in the 2015 barley and the 2017 lupin crops, where yield increases of 157kg/ha and 90kg/ha, respectively, were recorded in the ripped plots when compared to the control plots. Seasonal conditions were thought to contribute to this outcome.

Returns of deep ripping

The net benefit of all ripping was positive for deep ripping at this location and provided an average annual return of $72/ha over the 2015–17 period (Table 6). The plant biomass difference in 2018 would also likely have resulted in a yield and economic benefit, although this cannot be measured.

The 2017 season saw the smallest yield difference between treatment and control plots, which may be due to a lupin crop being less responsive to deep ripping than barley or canola, or may be a result of the deep ripping effect being reduced with time.

The yield responses to deep ripping may continue to be monitored to see if the treatment effects continue. The longevity of the treatment effect will determine how cost-effective deep ripping is in this environment and on these soil types.

Conclusion

There have been positive yield and economic responses seen in each season since the deep ripping treatments were established in 2015. The cumulative yield increase of 560kg/ha of grain across the 2015, 2016 and 2017 seasons has provided an additional $177/ha to the farm business.

The yield response from the upcoming 2019 season will give an indication as to the longevity of the deep ripping effect and therefore how likely it is an ongoing economic advantage will be realised from the practice.

Table 6: Economic benefit for deep ripping was positive and sustained over the three-year period.

Treatment	Treatment cost ($/ha)	Amortised treatment cost over three years ($/ha/yr)	Net benefit from ripping 2015 ($/ha) barley at $250/t	Net benefit from ripping 2016 ($/ha) canola at $500/t	Net benefit from ripping 2017 ($/ha) lupin at $250/t	Accumulated return costs over three years ($/ha)
Control	-	-	0		0	0
Deep rip	40	13	39	155	23	177

Source: agVivo/DPIRD

The Thompsons now understand the impact that subsurface soil compaction has been having on their crop production, and the removal of this compaction via deep ripping can lead to large yield increases.

Simon Zacher, 'Parahills Farm', Muradup

In 2016, a ripping trial was established approximately 20kms north-west of Kojonup by farmer Simon Zacher, Southern Dirt and DPIRD to assess the effect of deep ripping. Replicated plots ripped to 350mm with and without inclusion plates, and at 550mm without inclusion plates, were set up along with additional cultivation treatments added to the edge of the trial. These additional treatments included a scarifier working at 250mm, offset discs working at 150mm and a Heliripper working at 600mm, and aimed to provide a contrast against the other treatments.

A significant yield difference was observed only in the 350mm ripping treatment in 2016, which gave a 260kg/ha increase. There was a non-significant yield difference of approximately 200kg/ha for the other ripping treatments in 2016. The offset disc and scarifier treatments indicated a yield increase over the nil plots and the Helripper treatment suggested a yield decrease. Yield data in 2017 showed an overall decrease in yield in all ripping treatments when compared to the nil treatment, except in the unreplicated Heliripper treatment, which had a similar yield.

Soil strength measurements were not collected from the shallow cultivation treatments or below 600mm in the other treatments. Many locations had too much gravel to measure compaction accurately and were discarded from the dataset.

The average soil strength was found to be reduced in the deep ripping plots to the depth of working, then increased. The control plots consistently reached 2500kpa between 150 and 200mm soil depth and increased to peak at 4500 to 5000kpa at 400mm depth. Deep ripping plots generally maintained compaction levels below 2500kpa to 400mm depth, then increased to levels similar to the control plots.

Returns of deep ripping

An economic analysis of the advantage of deep ripping at this site can only be carried out for the 2016 cropping season due to the 2017 yield being compromised and the 2018 data not being available.

All deep ripping treatments returned a positive yield and economic benefit, with the exception of the Heliripper 600mm treatment, which ended giving $108/ha less than the control (Table 7). The ripping 350mm and 550mm treatments provided similar benefits of $54/ha and 50/ha, respectively. The ripping 350mm plus slotting treatment returned $108/ha, indicating the use of slotting plates doubled the effectiveness of the deep ripping at this depth.

The yield responses from shallower ripping treatments provided an average economic increase of $79/ha, suggesting that the yield response may be caused by something other than subsoil compaction.

The longevity of the treatment effect will determine how cost-effective deep ripping is in this environment and on these soil types.

Conclusion

Ongoing yield increases, like the positive result from barley in 2016, are likely to have provided a positive return on investment to the farm business. The yield response from subsequent crops will give an indication of the longevity of the deep ripping effect and therefore how likely it is that an ongoing economic advantage will be realised from the practice.

The Zachers found that the deeper ripping treatments and the use of topsoil slotting plates did not improve canola yield in 2017.

Table 7: Economic return of the treatments for the 2016 season.

Treatment	Treatment cost ($/ha)	Amortised treatment cost over three years ($/ha/yr)	Net benefit from ripping 2016 ($/ha) barley at $250/t	Accumulated return costs over three years ($/ha)
Control	-	-	0	0
Rip 350mm	40	13	68	54
Rip 350mm + slotting	45	15	123	108
Rip 550mm	55	18	68	50
Helripper 600mm	70	23	-85	-108
Offset discs 150mm	15	5	98	93
Scarifier 250mm	15	5	69	64

Source: agVivo/DPIRD

Ben and Fiona Hobley, 'Compass Agriculture', Nyabing

A series of deep ripping strips were placed in six locations that covered similar soil types across the Hobley family's farm south of Nyabing. Treatment strips were set up in January 2017 using a six-metre Ausplow at a working depth of 400mm. The plots were 36m wide and aligned with existing traffic lines.

After the treatments were undertaken in 2017, the soil strength was reduced in the deep ripping plots when compared to the adjacent control plots, and this was maintained into the 2018 season over the majority of the site. However, measurements undertaken in 2018 showed that the level of compaction on the southern rip treatment had increased and the plot had more variation when compared to 2017. It is unclear if this represents a return to pre-ripping soil strength levels or if seasonal conditions (that is, drier soil profile) are the cause of this change. There were no differences observed in the northern ripped treatment.

The control plots consistently reached 2500kpa between 150 and 300mm soil depth and increased to peak at 4500 to 5000kpa at 400 to 500mm depth. Deep ripping plots generally maintained compaction levels below 2500kpa to 400mm depth in the southern rip strips, and then increased to levels similar to the control plots. The penetrometer could not be pushed in further than 350mm in the northern rip strips and were also similar to the adjacent control strips. The ripped plots in the northern trial maintained higher levels of compaction than at the southern trial in both years.

Yield increases were recorded in all ripping treatment plots when compared to the adjacent control plots and ranged from 44 to 556kg/ha.

Returns of deep ripping

There was an average net benefit of $106/ha from the deep ripping treatment in this paddock over the control. The southern trial strip provided higher returns in both years of the trial, with an average benefit of $91/ha over the two seasons. The northern trial had similar returns each season and averaged $55/ha (Table 8).

These results are economically significant and make the deep ripping practice worth the effort, especially if the yield benefits continue over time. The longevity of the treatment effect will determine just how cost-effective deep ripping is in this environment and on these soil types.

Conclusion

The significant yield increases have made deep ripping economically profitable in the two seasons this trial has run. Ongoing yield increases are likely to continue and will provide a positive return on investment to the farm business. The longevity of the deep ripping effect will determine how large the economic benefit will become though the results from this site have already provided a profit.

Table 8: The annual gross margin for each treatment and cumulated return over the two years examined.

Treatment	Treatment cost ($/ha)	Amortised treatment cost over two years ($/ha/yr)	Net benefit from ripping 2017 ($/ha) wheat at $300/t	Net benefit from ripping 2018 ($/ha) barley at $250/t	Return on Investment over two years ($/ha)
Control	-	-	0	0	0
Deep rip north	40	20	54	56	69
Deep rip south	40	20	65	117	143
Average	-	-	60	87	106

Source: agVivo/DPIRD

Kwinana West port zone summary of grower results

Adam Smith, 'Ferndale Farming Company', Beverley

An 11ha section of a 50ha paddock was ripped with a six-metre Agrowplow at a 500mm working depth in January 2017. The treatment area covered varying soil types, although it is dominated by a deep coarse sand, a sand over deeper gravelly clay and a sand over shallow loamy clay. Cropping production zones are defined by these soil types, with the deep coarse sand area having low production, the sand over deeper gravelly clay being of medium production and the sand over shallow loamy clay of high production.

The control plots reached 2500kpa between 300 and 400mm soil depth and increased to peak at 3500 to 4000kpa at 400 to 500mm, with the exception of the unripped deep sand, which had a high reading just below 2500kpa.

Deep ripping plots generally maintained compaction levels below 2500kpa to 400mm depth and then increased to levels between 2500 and 3000kpa to 600mm. The northern sand over shallow clay plot reached the same soil strength as the adjacent control plot at 400mm soil depth.

The deep ripping treatment plots had an overall yield increase of approximately 300kg/ha higher than the unripped areas, although this was dependant on soil type. Results ranged from a loss of 140kg/ha to a 470kg/ha yield gain across the treatment plots.

Returns of deep ripping

There was an average net benefit of $51/ha from deep ripping in this paddock over the 2017 and 2018 cropping seasons (Table 9).

The sand over shallow clay soil type that was associated with the high-production zone provided the highest returns in both years of the trial with an average benefit of $87/ha. The deeper sands of the medium and northern low-productions zones had a negative result with a cumulative loss of $55/ha and $67/ha, respectively. The southern low-production zone provided positive returns in both years and averaged $82/ha benefit from ripping.

These results are economically significant and make the deep ripping practice worth the effort in the sand over shallow clay and deep sand soil types. The longevity of the treatment effect will determine just how cost-effective deep ripping is in this environment and on these soil types.

Conclusion

Deep ripping provided mixed results on the variable soil types found in this paddock and the results suggest that it will be profitable only on the sand over shallow clay and deep sand soil types. The significant yield increases in these zones were profitable, although the benefit was negated by the loss incurred in the soil types of the medium and low-production zones. This

Table 9: The annual benefit for each treatment and cumulated return over the two years examined.

Treatment	Treatment cost ($/ha)	Amortised treatment cost over two years ($/ha/yr)	Net benefit from ripping 2017 ($/ha) wheat at $300/t	Net benefit from ripping 2018 ($/ha) barley at $250/t	Return on investment over two years ($/ha)
Control north	-	-	0	0	0
High rip north	45.0	22.5	83.3	32.5	70.8
High control south	-	-	0	0	0
High rip south	45.0	22.5	120.5	112.5	188.0
Med control south	-	-	0	0	0
Med rip south	45.0	22.5	-12.0	-10.0	-67.0
Low control north	-	-	0	0	0
Low rip north	45.0	22.5	-42.1	32.5	-54.6
Low control south	-	-	0	0	0
Low rip south	45.0	22.5	103.4	60.0	118.4
Average	-	-	50.6	45.5	51.1

Source: agVivo/DPIRD

indicates that deep ripping should be restricted to the higher production zones that have sand over shallow clay, or to the low-production zones that have deep sand, and avoiding the deep sand over gravelly clay that make up the medium-production zones.

Ongoing yield increases are likely to continue and will provide a positive return on investment to the farm business. The longevity of the deep ripping effect will determine how large the economic benefit will become, though it has already provided a profit.

Warakirri Cropping, Quairading

This trial was started in February 2017 in a 100ha paddock north-east of Quairading, WA. The treatments included deep ripping using a four-metre Heliripper with a maximum working depth of 700mm, and spading with a four-metre Farmax Spader working between 250 and 300mm.

The average soil strength was found to be reduced in the deep ripping and spaded area when compared to the adjacent unripped soil. The control strips consistently reached 2500kpa between 200 and 250mm soil depth and increased to peak at more than 4000kpa at 400mm. The data indicates that there is a natural reduction in compaction in soil deeper than 400mm as the soil strength reduces to just above 2000kpa at 750mm.

Deep ripping plots generally maintained compaction levels below 2500kpa to 750mm depth. Previous research has found 2500kpa to be the compaction level at which plant root growth begins to be inhibited and indicates that deep ripping fully removes compaction as a constraint in the sandy soil types.

Large yield differences between ripped and spaded and control areas were seen across all soil types. The largest difference was recorded in the deep yellow sand where yield increased by 1148kg/ha – almost a 108 per cent benefit to deep ripping and spading. A similar yield increase of 1107kg/ha, a 68 per cent benefit, was recorded in the sand over gravel duplex soil type, and in deep white sand where an increase of 451kg/ha, or 68 per cent, was observed.

The unmanned aerial vehicle normalised difference vegetation index also captured localised areas within the control strips that showed very poor growth. This was thought to be due to severe, localised non-wetting that was not picked up in the molarity of ethanol droplet (MED) test for soil disease. This effect was not seen in the treated areas and indicates that yield increases seen in this site may be due to more than just the removal of compaction as a soil constraint.

Conclusion

As this site was only monitored for one year, it was not possible to gather further results from penetrometer testing or yield differences between the control and treatment plots. Return on investment data is also not available for this site, although as there were very large positive yield responses to the deep ripping and spading, the treatment is likely to have provided a positive return on investment to the farm business.

Ty Fulwood, 'Mount Noddy Farming', Northam

Treatment strips were established in early 2017 using a 3.5m-wide Heliripper to a depth of 700mm. Plots were aligned to fit with the existing 12.2m controlled traffic system, although four passes of the Helripper were used and created 14m-wide ripped plots that extended uniformly into the control plots. This is likely to have increased yields in the control plots, reducing the relative difference between treatment and control.

The average soil strength was found to be reduced in the deep ripping plots and did not exceed severe levels of compaction (that is, 2500kpa) to the depth of 750mm. The control plots were found to be more compact than the deep-ripped plots, with severe soil compaction being measured between 500mm and 750mm soil depth. This indicates that the deep ripping created a less compact soil profile when compared to the control and removed compaction as a constraint below 500mm across the trial site.

The deep ripping treatment provided a 446kg/ha increase in the wheat yield in 2017 and 340kg/ha increase in the barley yield in 2018 when compared to the control plots. When entire plot lengths were compared, large variations across the trial site were observed; however, after analysis it was found that the yields were significantly different in both seasons.

Returns of deep ripping

This trial showed an average annual net benefit of $99/ha from deep ripping over the control. The larger yield increase and higher prices of the 2017 wheat crop provided the largest economic benefit of $156/ha. The additional $102/ha increase from the 2018 barley crop brings the two-season cumulative benefit of deep ripping to $198/ha, after the $60/ha treatment cost has been deducted (Table 10). These results are economically significant and make the deep ripping practice worth the effort, especially if the yield benefits continue over time. The longevity of the treatment effect will determine just how cost-effective deep ripping is in this environment and on these soil types.

Conclusion

The significant yield increases have made deep ripping economically profitable in the two seasons this trial has been run. Ongoing yield increases are likely to continue and will provide a positive return on investment to the farm business. The longevity of the deep ripping effect will determine how large the economic benefit will become, though it has already provided a profit.

Rob and Dan Dempster, 'Adair Farm', Goomalling

In 2017, a fully replicated trial site was established comparing the following treatments:

- deep ripping;
- very deep ripping;
- mouldboard ploughing;
- modified one-way disc ploughing;
- delving;
- spading; and
- combinations of the above with and without lime and inclusion plates.

Machines used for the tillage treatments included an Agrowplow deep ripper, Helripper very deep ripper, Farmax rotary spader, Alpler five-furrow reversible mouldboard plough, a modified Chamberlain Plozza system one-way plough and a custom-built clay delver. All of the tillage treatments were applied and rolled prior to seeding and implemented in the first year only.

Subsoil acidity was an issue for the Goomalling site, with an average pHCa of 4.5 or lower in the depth increments of 20 to 30cm, 30 to 40cm and 40 to 50cm. The spading, one-way plough and mouldboard plough treatments can mix and bury the lime and less-acid topsoil; however, it is recommended that follow-up soil testing to depth be undertaken to ascertain the pH change attributed to the lime and soil inversion treatments.

Water repellence in the control plots was moderate, based on the laboratory MED test result. The deep ripping treatment exacerbated the expression of water repellence, whereas spading, one-way ploughing and mouldboard ploughing decreased the repellence of the topsoils.

Yield increases were 500 to 800kg/ha when very deep ripping was employed, 400 to 600 kg/ha when mouldboard ploughing was employed, but only 0 to 100kg/ha when standard ('shallow') deep ripping and conventional ploughing were employed.

Statistically significant treatment effects were:

- Helripping (very deep ripping to 700mm) (93 per cent change);
- very deep ripping with inclusion plates (63 per cent);
- very deep ripping plus spading (74 per cent);
- one-way ploughing plus very deep ripping (84 per cent);

Table 10: The annual benefit for each treatment and cumulated return over the two years examined.

Treatment	Treatment cost ($/ha)	Amortised treatment cost over two years ($/ha/yr)	Net benefit from ripping 2017 ($/ha) wheat at $300/t	Net benefit from ripping 2018 ($/ha) barley at $300/t	Return on investment over two years ($/ha)
Control	-	-	0	0	0
Deep ripping	60	30	156	102	198

Source: agVivo/DPIRD

Table 11: Estimated economic benefits over control for a range of deep tillage treatments.

Treatment	Treatment cost ($/ha)	Gross benefit ($/ha)	Net benefit ($/ha) wheat at $231/t	Years to break-even (sustained)	Years to break-even (declining)
Deep ripping	45	3	-42	>10	>10
Deep ripping with inclusion plates	50	14	-36	4	>10
Deep ripping and spading	150	21	-129	7	>10
Very deep ripping	90	172	82	1	1
Very deep ripping with inclusion plates	95	128	33	1	1
Very deep ripping and spading	190	137	-53	2	2
Very deep ripping and one-way plough	140	155	15	1	1
Very deep ripping with inclusion plates and spading	195	155	-40	2	2
One-way plough	50	28	-22	2	3
Mouldboard plough	120	102	-18	2	2
Mouldboard plough and very deep ripping	200	139	-61	2	2

Source: agVivo/DPIRD

- very deep ripping with inclusion plates plus spading (84 per cent);
- mouldboard ploughing plus very deep ripping (76 per cent); and
- mouldboard ploughing (55 per cent).

Liming appeared to have no impact on grain yield responses in 2017.

Returns of deep ripping

The year to break-even (Table 11) is estimated by assuming either a sustained trajectory (economic returns generated in 2017 are sustained through time) or a declining trajectory (economic returns halve each year). Only the very deep ripping, very deep ripping with inclusion plates, and one-way plough plus very deep ripping covered their costs in the first season. With a pessimistic declining trajectory of returns, all of the treatments covered their costs in the second season except for the one-way plough and standard deep ripping treatment plus or minus the inclusion plates and with spading.

Conclusion

On deep yellow sand at Goomalling, repellence removal was important to achieve better crop establishment and subsequent tiller numbers. Deep compaction removal below a working depth of 400mm, particularly in a dry season, was important to improve root access to more of the moisture in the profile and deliver yield benefits.

Craig Jesperson, 'Stretton Farms', Yealering

The trial was initially set up in 2015 to assess the impact of lime and tillage on duplex soils with the site having both shallow sandy loam over clay and deep white sand over clay duplexes. Gravel content in both soil types increased with depth to 40 per cent by 40cm. The trial was made up of five treatments in a randomised and replicated strip design. All treatments were aligned with existing run lines. Trial plots were 11m wide and 180m long and separated by a 3.5m buffer on the spraying run lines.

Treatment summary

The control strips were left untreated with no lime or tillage applied and therefore had no application cost. A prilled lime product (Omya Calciprill) was applied with the fertiliser below the seed at seeding with the airseeder at 100kg/ha. Limesand was applied to the surface (that is, top-dressed) via a spreader to all other treatment plots, and nothing else was done to the top-dressed limesand plots. After lime application, a deep ripper was used on the deep ripping and ripping plus spaded plots prior to the spader going over the spaded plots to loosen the soil and allow the spader to achieve a maximum working depth of 250mm.

Soil penetrometer testing showed soil strength in the shallow duplex increased steadily from the surface and peaked at around 5000kpa at approximately 300mm, at which point it could not be pushed further into the soil. The deep duplex measured a reduced soil strength with the penetrometer recording maximum average values of 2500 to 3000kpa at 500mm depth. These results, however, have been influenced by the presence of gravel within the soil profile and the figures may be incorrect.

To overcome the gravel influence, 3D-scanning bulk density cores were collected 50 metres in from the western edge of replicate plots and were all within the deep duplex soil type. Although statistical differences cannot be determined, as only one replicate was sampled, bulk density increased with depth across all treatments and followed a similar pattern to that of the penetrometer readings (Table 12). There was a decrease in bulk density in the 40cm layer of the deep rip plus spaded plot, though no other observations indicated a reduction in bulk density across the other treatments.

The yields from the site in 2015 (canola) and 2016 (wheat) were not significantly different in any treatments. The only significantly different yield at the site was seen in 2018 when canola yielded 530kg/ha on the rip and spaded plots, providing an additional 123kg/ha of canola over the control.

In 2018, the control and deep ripping plots recorded the lowest average yield of 407 and 408kg/ha, respectively, with the Calciprill and top-dressed lime plots measured slightly higher.

Returns of deep ripping

The cost of treatments, except prilled lime, has been amortised over three years as it is expected that the impact of the treatment is not constrained to a single year. The prilled lime treatment is marketed as an annual application and so the cost of the treatment has been applied to each of the three seasons (see Table 12).

None of the treatments recorded a positive return on investment, indicating that all investment in lime and tillage cost the grower money in this situation.

The prilled lime treatment gave the smallest loss at -$28.5/ha; the largest was the top-dressed lime, which cost $145/ha. Though the deep rip plus spade treatment showed a significant increase in yield in 2018, the lack of yield differences in previous years and the high cost of treatment resulted in none of the tillage treatments returning an increased return over the control with losses ranging from $128/ha for the deep rip plus spade treatment and approximately $52/ha for the deep rip and top-dressed treatments.

Conclusion

Though there may have been a positive yield increase from some of the ripping treatments, the high cost of lime, deep ripping and spading did not made the practices economically viable in this situation. The trial was located on a poor-performing part of the paddock and it was difficult to establish a crop even in ideal circumstances, and this may have been the cause of the lack of return on investment. Though the benefits of tillage may continue over time, it seemed unlikely that an acceptable return would be realised in the near future.

Table 12: The annual gross margin for each treatment and cumulated return over the three years examined.

Treatment	Treatment cost ($/ha)	Amortised treatment cost over two years ($/ha/yr)	Net benefit from treatment 2015 ($/ha)	Net benefit from treatment 2016 ($/ha)	Net benefit from treatment 2018 ($/ha)	Return on investment over three years ($/ha)
Control	-	-	-	-	-	-
Prilled lime at 100kg/ha	57	57	16	117	9.5	-28.5
Top-dressed lime at 2t/ha	86	29	2.5	-72	10.5	-145
Deep rip + lime at 2t/ha	126	42	-8.5	102	-19.5	-52
Deep rip + spading + lime at 2t/ha	256	85	-11.5	78	61	-128.5

Source: agVivo/DPIRD

FEATURED GROWER CASE STUDIES

Josh, Shannon and Tony Goad

SNAPSHOT

Growers: Josh and Shannon Goad

Location: Kojaneerup South, Western Australia

Farm name: Iffy Downs

Size: 1100 hectares

Enterprise: Cropping

Crops grown: Barley, canola, wheat and faba beans

Average annual rainfall: 450 millimetres

Kojaneerup grower Josh Goad will continue to deep rip his paddocks, despite trials showing short-term gains only, as he believes there is enough upside in these early yield responses to warrant the investment. Photo: Evan Collis

Deep ripping trials point to short-term gains on sandy soils

Results from deep-ripped trials in deep white sand in Western Australia's south coastal region have revealed short-term crop yield increases only, suggesting growers with this soil type should not anticipate long-term profits from deep ripping.

However, growers could still consider investing in deep ripping, as long as their return on investment calculations are based on projected results from just one or two years.

The GRDC-invested paddock trials, overseen by the WA DPIRD, have been running since 2014 on the Kojaneerup property of Josh and Shannon Goad.

The Goad property is typical of the south coastal region, with deep white sand over gravel and clay, and has the twin soil constraints of water repellency and a compaction layer at depth.

The Goads have been claying their paddocks for many years in an attempt to alleviate this water repellency challenge.

While Josh says the longer-term yield responses from the trials were disappointing, the significant short-term results make the investment (machinery costs, fuel and time) worth his while and he will continue to deep rip paddocks every few years to alleviate compaction.

Yield benefits

In fact, Josh believes he achieved a return on investment from deep ripping in just one year.

"Until we are running a fully controlled-traffic farming (CTF) system, we will continue to deep rip to 700 millimetres every two years prior to a cereal crop," he says.

"This is because the strategy provides enough return for us to warrant spending money on it."

In 2014, Josh shallow-ripped treatments down to a depth of 350mm, but found the crop yield results were not substantial.

Table 13: Economic return of each treatment show varied results across the ripping depths and seasons.

Treatment	Treatment cost ($/ha)	Yield benefit from ripping 2016 ($/ha) barley at $250/t	Yield benefit from ripping 2017 ($/ha) canola at $500/t	Net benefit from ripping 2018 ($/ha) barley at $250/t	Accumulated return costs over three years ($/ha)
Control	-	0	0	0	0
Rip 350mm	40	65*	0	0	25
Rip 700mm	50	178	0	0	1218
Rip 1200mm	200	283	40	0	123

* Yield benefit from 2014 ripping used as treatment was not ripped in 2016 as other deep ripping.

Source: agVivo/DPIRD

In 2015 and 2016, he deep-ripped further treatments to depths of 700mm and 1200mm to see if this would have a more significant impact on yields.

The 1200mm deep-ripped treatments were completed using a bulldozer and, while perhaps not practical for application across an entire broadacre property, the results were particularly interesting from a research point of view.

DPIRD senior research officer Jeremy Lemon says yield responses in the deep and very-deep-ripped treatments were significant in the first year after the amelioration – up to 1.4t/ha over the control in the treatment (which was ripped to a depth of 1200mm).

But, while there was still a yield response in the second year, the improvements were less than expected.

By the third year, Mr Lemon says, there was no remaining yield benefit from the deep-ripped treatments.

"We think this short-term result was because of a number of reasons, including waterlogging, frost and multiple vehicle tracks across the paddocks," he says.

Controlled-traffic farming system plans

Seeing this level of re-compaction in the soils, not only after the waterlogging event but also after each annual spraying and spreading program, has inspired Josh to progress his plan to move to a fully CTF system.

The Goads recently purchased a new sprayer and, over the next five years, they plan to change a tractor and a spreader over to 12m widths, with wheel tracks on 3m centres, to better protect their deep ripping investment.

"Our business is constantly changing and adapting to new challenges and we will continue to try new ways to reduce our major constraints of water repellency and compaction," Josh says.

Fast return on investment

Yield data from the Goad's trial has been analysed as part of a further GRDC-invested project, managed by agricultural consultants agVivo and DPIRD. The aim is to better understand not only the yield responses, but also the return on investment of the different deep ripping treatments.

In 2018, GroundCover™ reported on the Goad's outstanding 1.4t/ha yield increases on the first-year barley crop in the deep-ripped treatment using a bulldozer to 1200mm.

But the recent agVivo economic analysis shows a very different story.

The most profitable outcome over the three years of data collection came from the treatment ripped to a depth of 700mm, suggesting there is little value in ripping beyond the hardpan compaction layer.

The 700mm ripping treatment returned $128/ha across the three years of data and, even though the 1200mm treatment gave the largest yield increase with a $283/ha benefit in 2016, the high yield results were a one-off occurrence and the high cost of treatment reduced the overall return on investment.

Josh Goad harvesting a canola crop at his Kojaneerup property.
Photo: Evan Collis

The 350mm ripping treatment only just broke even between 2016 and 2018, giving back a total of $1/ha.

"Clearly this was not deep enough to penetrate and break up the whole depth of the hardpan compaction layer to allow root penetration deeper into the subsoil," Mr Lemon says.

Two-year window to recoup costs

Mr Lemon says based on these results and on the experience of other growers across the south coastal region, the cost of any deep ripping must be recouped in the first two seasons to make it a worthwhile investment.

"This means growers shouldn't rely on long-term results to justify the initial soil amelioration investment," he says.

According to Josh, frosts and waterlogging in 2017 would have contributed to the poor canola yield results in 2017.

The soil had also largely compacted by 2018, which contributed to the short-term results.

Mr Lemon says sandy soils re-compact naturally through wetting and drying cycles and, after the waterlogging event in 2017, the soil would have compacted as it dried out.

"As the water dries out from the soil, it pulls the sand particles back together again, creating natural compaction," he says.

"Perhaps this raises other issues for growers in this region, in regard to drainage opportunities, to better protect any investment in soil amelioration."

Grower group Stirlings to Coast Farmers is managing further GRDC-invested trials in the region, including on the Goads' property, and investigating the responses from a range of soil amelioration treatments.

Scott and Lisa Thompson

Moving to a controlled-traffic farming system can be an affordable change if done over time

SNAPSHOT

Growers: Scott and Lisa Thompson

Location: Broomehill, Western Australia

Farm name: 'Nardlah Grazing Company'

Size: 4000 hectares

Enterprise: 80 per cent cropping and 20 per cent Merino sheep

Crops grown: Barley, canola, wheat and lentils or lupins

Average annual rainfall: 405 millimetres

Scott Thompson, who farms in the higher-rainfall zone of Western Australia's Great Southern region, has shown that moving to controlled traffic does not need to happen overnight. Photo: Evan Collis

Broomehill , Western Australian growers Scott and Lisa Thompson took a decade to move their whole farming operation to a CTF system. Scott first toyed with the idea back in 2001 and it was not until seeding in 2012 that he had all his machinery matched on permanent wheel tracks.

It may have been a long time in the planning, but Scott believes the steady strategy of gradually turning over his machinery to fit his 12m CTF system has been worth the wait, with the benefits now clear on his 4000ha property.

For growers in the higher-rainfall zones – Scott's annual average rainfall is 405mm – moving to a CTF system may appear to be a massive hurdle, especially with the added challenge of a mixed livestock and cropping rotation.

However, Scott says that making it a measured move with a long-term aim to line up all machinery on the same tracks was not daunting, and the strategy fits his business and management style.

Scott began his progression into CTF by matching machinery purchases with his 36m self-propelled sprayer. All machinery is now based on a 3:1 principle, in multiples of 12m, with 25cm row spacings on the seeder bar.

Scott admits he did not have clear goals at the start of the process, but says the benefits and opportunities have now become clear, including improved trafficability in wet paddocks, greater fuel efficiencies, better stubble management and improved moisture retention in the crop rows during the growing season.

Ultimately, though, a steady increase in crop yields since 2012 has been the clear validation for his decision to move to CTF.

"While the CTF system might not be the only contributor to these yield increases, we have seen improvements in the order of eight to 10 per cent over the past five years, so something has certainly changed since we implemented this system," Scott says.

"Having a controlled-traffic farming strategy has also allowed me to improve my management, and every year I'm learning to do things a little better."

One of the most significant opportunities to come from the implementation of CTF on the Thompsons' property has been their ability to manage weed seeds during harvest.

"I spread straw over the paddock and I put chaff on the tracks using a chaff deck," Scott says.

He says weeds germinate early in the season on the wheel tracks and he can usually get a good 'knock' before seeding.

"There is a portion of seeds that don't germinate at all, because they have been through a mulching process. Of what's left, there are higher numbers on the tracks, but not too many to worry about."

Scott says he has considered a shielded sprayer, which may give him added weed control on the track lines.

"That's something that I will look at in coming years as I see how the wheel tracks handle the weed burden," he says.

"Having a controlled-traffic farming strategy has also allowed me to improve my management, and every year I'm learning to do things a little better."

GRDC

Inter-row seeding

Scott is now inter-row seeding every second year.

“By doing this, my theory is that there will be increased trash flow and, because I’ll have the two furrows, it will allow for more residue,” he says.

“This will increase trash flow at seeding and in the long term I would expect to increase residue cover. I’m hoping to maintain moisture in both furrows.”

He also believes there is a biological advantage to the system: “We don’t seem to have enough science out there to measure what is happening below the surface, and perhaps we don’t have enough respect for what is going on underneath. But I think this system, and the increased residue, is the start of trying to protect the health of the soil and I think I’ll see the benefits of that over time.”

Scott began implementing CTF in a small number of paddocks, and over the past few years has applied the wheel tracks to paddocks as they come out of pasture.

But Scott is the first to admit the new system comes with its challenges, particularly with sheep being a critical part of the business structure.

While he has downsized his flock dramatically in the past three years, from 12,500 Merinos to just 4000 this season, sheep will continue to be part of the rotation, at least for the short to medium term.

“Going forward, the sheep are really just going to be a weed-control tool within a long-term cropping rotation. It’s difficult to stick to CTF with sheep walking all over the lines, and having to drag the sheep feeder across the paddocks,” Scott says. “Over summer, while we graze most paddocks, there is about 10 per cent I don’t graze. By keeping sheep out of those paddocks the weed seeds remain on the surface. I don’t want the sheep to cultivate those seeds into the soil. They also put tracks through the chaff, and I have noticed water infiltration is much poorer in the following season after too much grazing.”

Paddock logistics

The change to a CTF system was also a mental shift for Scott's workers and contractors.

“I have to use contractors who fit into my system, particularly spraying and harvesting contractors,” Scott says. “We have to enter and exit a paddock in the one spot, and put field bins in strategic places during harvest. It takes a level of discipline, and for the first couple of years it was difficult. It was a whole new paradigm that we all had to get used to.”

Tackling the myth

WA DPIRD officer Bindi Isbister, who works with growers considering a CTF system, says there is a myth that this move can be too expensive.

Ms Isbister says results from a 2016 survey of more than 100 growers, consultants and agronomists looking at soil-compaction management strategies for a WA DPIRD-managed, GRDC-invested soil-compaction project showed only 22 per cent of growers were using CTF – although this was up from 17 per cent recorded in a 2012 survey.

“Growers, agronomists and consultants are saying that incompatible machinery and financial limitations still remain key limitations to the adoption of soil-compaction management, particularly the introduction of CTF,” Ms Isbister says.

“But Scott and Lisa’s strategic approach has demonstrated that, with proper planning, those two limitations can be overcome. Apart from the purchase of some guidance equipment, Scott hasn’t found the outlay any more significant than his normal machinery turnover program.”

Scott believes the opportunities presented by CTF have far outweighed the challenges.

“It’s taken me 10 years to accumulate all that gear for the CTF system, and most growers would turn over their gear in 10 years, so there really isn’t a huge difference in the financial outlay,” he says. “There is also plenty of second-hand machinery out there that will do the job – you don’t have to purchase new.”

Scott says his only regret today is not establishing the wheel tracks in 2001 when he was first thinking about it.

Ben and Fiona Hobley

Understanding soils underpins return on investment from fixing constraints

SNAPSHOT

Growers: Ben and Fiona Hobley; Jarrad and Ellaine Hobley; Neil and Chris Hobley

Location: Nyabing, Western Australia

Business name: Compass Agriculture

Size: 8300 hectares (including 7000ha crop, 1300ha pastures and livestock)

Average rainfall: 350 millimetres (annual); 180 to 220mm (2019 growing season)

Crops grown: Wheat, barley, canola, oats and lupins

Soil types: Duplex sand over clay, gravels and loams

Soil pH: 4.5 to 6.0

Nyabing grower Ben Hobley has been running paddock-scale, deep ripping trials to address common soil constraints of acidity, water repellence and compaction.
Photo: Evan Collis

Nyabing grower Ben Hobley is dipping his toes into the science of soil amelioration in an attempt to solve the multiple constraints of compaction, soil acidity and water repellency on his many different soil types.

Deep ripping, delving and spading are all being trialled and tested on his property in WA's southern wheatbelt to better understand which strategy will provide the best yield responses across his wheat, barley, canola, oats and lupin crops.

To specifically target soil compaction and acidity, Ben, his brother Jarrad and his father Neil have been running paddock-scale deep ripping trials.

While it is still early days, the trial data is showing promise in terms of yield responses and a positive return on investment.

Making the most of inputs

Lime has been applied for many years across the Hobley's property, with rates increasing to two to four tonnes per hectare over the past four years.

Until now, lime has only been applied to the topsoil. But Ben is hoping to see significant improvements to his subsoil pH after pushing the lime down through the soil profile in the amelioration treatments.

In 2017, Ben deep-ripped paddock strips to a depth of 400mm in two different locations and across varying soil types – with parallel control strips to compare the data.

The treatments were planted to wheat in 2017, with yield increases across both separate trials averaging 199kg/ha above the control.

In 2018, the treatments were planted to barley, with even greater yield increases – an average of 346kg/ha – compared to the controls.

Ben was sufficiently encouraged by these two-year responses (see Table 14 for gross margins) to conduct more trials, this time using a very deep ripping machine to rip to depths of 700mm in some places.

"We are waiting to see how these new trial strips respond this season as to whether we will look at investing in deep ripping in a bigger way across the farm," Ben says.

"Being able to deep rip is seasonally dependent and we can't do much if we have a very dry start to the year."

Reaping returns

To protect any future investment in deep ripping, the Hobleys run a 12m CTF system and while Ben admits it is not yet perfect – with dual wheels still on the harvesters and an 18m seeder bar – it will go a long way towards reducing re-compaction issues.

Data from Ben's trial work has been analysed by former agVivo consultant Joel Andrew as part of a GRDC-invested project considering the economic return on investment from deep ripping.

According to Mr Andrew, the economic analysis is showing deep ripping is a profitable strategy for the Hobleys.

"There was an average net benefit of $106/ha across the two years, from the deep ripping treatment in this paddock over the control, which is economically significant and makes the deep ripping practice worth the effort, especially if the yield benefits continue over time," Mr Andrew says.

But he says the real story will be told after several years of yield data are collected.

Soil benefits

Mr Andrew also measured soil strength throughout the trial period.

He says crop plant root growth starts being inhibited at soil strengths of 2500kpa and above, and these levels were reached consistently in the control (non-deep-ripped) treatments at depths of between 150 and 300mm.

"But soil strengths increased to levels of 4500 to 5000kpa at [a depth of] around 500mm, which suggested there is a compaction layer at this depth," he says.

"Results from Ben's 2019 trial work, where he has ripped down to 700mm, will tell us the true story of how much this compaction layer is restricting plant root growth and, ultimately, yield."

Conversely, soil strengths in the deep-ripped treatments were maintained below 2500kpa at depths of up to 400mm, which Mr Andrew says can almost certainly be attributed to the deep ripping process.

Ben believes the deep ripping treatments were visually more robust than the control in this season and he expects there will be another positive yield response when the data is analysed, meaning an even bigger return on investment.

"The deep-ripped strips certainly looked better all throughout the 2019 season and my gut feel is that we will be looking at deep ripping in a much bigger way in future years," he says.

Delving and spading tactics

The Hobleys also trialled 30ha of delving and spading in the 2019 season to see whether this treatment would alleviate soil water repellency.

While yield results from this trial are not yet finalised, Ben says the crops looked better than the unspaded and undelved areas, particularly after such a dry end to the season.

"We picked up some rain at the very end of September and the crop in this delved and spaded part of the paddock seemed to hang on much longer than the rest of the paddock," he says.

"There was an average net benefit of $106/ha across the two years, from the deep ripping treatment in this paddock over the control, which is economically significant and makes the deep ripping practice worth the effort, especially if the yield benefits continue over time."

"This is another strategy that we will now consider to combat water repellency, given that these crops looked so much better than the control – particularly at the end of the season."

Grower learning

As president of the Nyabing Farm Improvement Group, Ben is keen to see more amelioration research trialled in his area, with growers in this southern wheatbelt region dealing with multiple soil types across their properties.

"There isn't going to be a one-size-fits-all approach to our constraints in this part of the wheatbelt," he says.

"But we are always on the hunt for flexible strategies that can be applied to such a diverse range of constraints and soils to increase yields."

Ben has recently carried out a ground-based radiometric survey to help identify soil types that could respond to various amelioration methods.

"We have always known we have many different soil types, but we are now objectively trying to define them within certain paddocks, and with this survey information we can match anything we do in the future – be that liming or deep ripping or other soil amelioration treatments – to certain soil types," he says.

MORE INFORMATION

Philip Barrett-Lennard, agVivo, pbl@agvivo.com.au

Table 14: The annual gross margin for each treatment and cumulated return over the two years examined.

Treatment	Treatment cost ($/ha)	Amortised treatment cost over two years ($/ha/yr)	Net benefit from ripping 2017 ($/ha) wheat at $300/t	Net benefit from ripping 2018 ($/ha) barley at $250/t	Return on investment over two years ($/ha)
Control	-	-	0	0	0
Deep rip north	40	20	54	56	69
Deep rip south	40	20	65	117	143
Average	-	-	60	87	106

Source: agVivo/DPIRD

Ty Fulwood

Overcoming soil constraints is key to profitability

SNAPSHOT

Growers: Ray, Ty and Em Fulwood

Location: Mt Noddy, north-east of Northam, Western Australia

Farm size: 3400 hectares

Enterprise: 100 per cent continuous cropping

Growing season rainfall: 360 millimetres

Cropping: Wheat, canola, barley, lupins and oats

Soil types: Sand and loam over gravel, yellow sands

Ty Fulwood, digging into the Helirippped treatment, shows the significant change in soil structure. Photo: Jo Fulwood

Overcoming the two main constraints of non-wetting sands and soil compaction is critical to improved long-term profitability, according to central wheatbelt growers Ty, Em and Ray Fulwood.

Like many farm businesses in the wheatbelt, water repellent soils combined with compaction have been very obviously impacting on plant growth and ultimately crop yield, so the business has invested in numerous different strategies over recent years to address this problem.

Now, trials on their Mt Noddy property, invested in by GRDC and run by DPIRD WA research officer Dr Stephen Davies, are investigating 13 different strategic tillage treatments to ascertain the most effective way to relieve these dual constraints.

With an estimated eight million hectares of WA's grain growing soils considered water repellent to some degree, overcoming this massive soil constraint could see major profitability improvements across the grain industry, and results from these trials could prove invaluable for growers right across the grain growing regions.

While the trials are only relatively new, outcomes are showing clear yield responses, with the largest yield response occurring from very deep ripping with topsoil inclusion plates, followed by spading.

According to Dr Davies, this three-way treatment resulted in a 1t/ha yield increase.

He says very deep ripping was the most effective way to overcome soil compaction, but it had been the addition of topsoil inclusion plates plus the rotary spading that had been critical to the reduction in the water repellence of the soils.

"We know that 75 per cent of wheatbelt soils are water repellent to some degree. In fact, up to three million hectares are considered severely water repellent," he says.

"So, if you are attempting to overcome compaction constraints, it would often be beneficial to include a strategy to reduce soil water repellency at the same time," he says.

Of the 13 different treatments, very deep ripping (using a Heliripper), both on its own and using a combination of topsoil inclusion plates and/or spading, saw yield responses at 800kg/ha or above.

While deep ripping (to 400mm) did see a response, it was not as large as the very deep ripping treatment.

According to Dr Davies, while the trend in recent years for many growers has been to mouldboard plough, the trials showed plant establishment issues associated with this treatment.

"The plots with mouldboard ploughing had the worst crop establishment, because it was difficult to form an even seedbed on the plot scale and the seeder really struggled over this area," he says.

"So ultimately yields weren't as good – showing an increase of 200kg, but that was because of the seeding problem.

"Regardless of this, the plants that grew there were obviously healthier, and it should have yielded a lot more, so results from the coming seasons on those plots will be interesting."

Dr Davies says deep ripping with a one-way plough showed similar results.

"That plot also had plant establishment problems so the end yield result wasn't quite what we had anticipated," he says.

Dr Davies says soil compaction is becoming more of an obvious issue right across the wheatbelt.

"Over time, the soil density increases to such an extent that the root will get thicker to slowly push through the soil, or roots must find a soil fracture, or a weaker area of soil to grow through. This then reduces the rate of root growth and constrains the overall volume of soil that plant root system can ultimately explore.

"Compaction doesn't generally completely stop root growth, but it does slow it down, impacting on plant health and therefore yield."

Dr Davies says while very deep ripping appears to be winning in the yield results, particularly in terms of reducing compaction problems, the trails have also illustrated the importance of the combination of treatments in improving overall soil quality.

In fact, according to Ty, deep ripping non-wetting soils to solve compaction issues could serve to exacerbate the repellency problem.

"What we have found, using different strategies over recent years, is that non-wetting soils should not be ripped without spading. In fact, it seems to make the water repellency worse," Ty says.

Ty has now invested in a Heliripper, which deep rips the soil down to 800mm. He has added inclusion plates to the machine and has a rotary spader to use in those areas where the soil is water repellent.

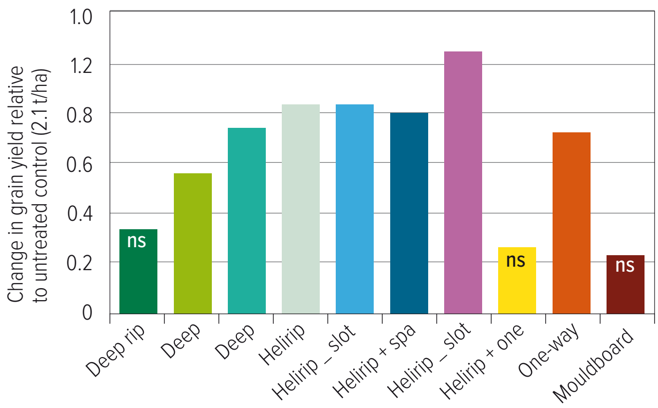
However, the technique is not without its challenges and ripping to 800mm is unchartered territory.

"It's very slow going. We have three or four different soil types in every paddock, and we can only take the Helripper into areas where we have done something to soften the top soil in the past, to preserve the longevity of the machine," Ty says.

"Otherwise we are constantly breaking parts on the machine."

Ty says seeding the paddocks after they have been deep-ripped and spaded also becomes a challenge, particularly in wet years.

Figure 1: Tillage impacts on grain yield response.

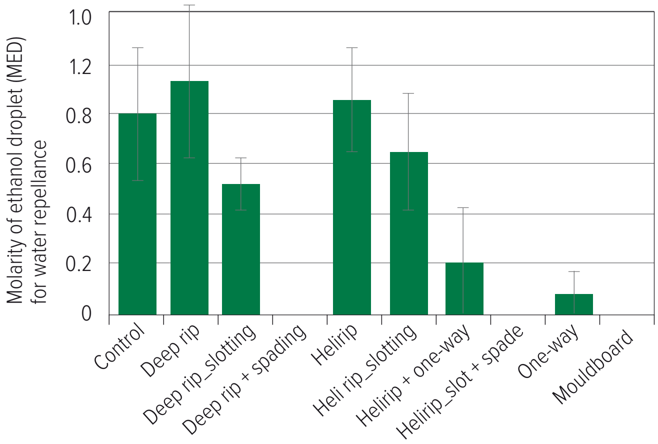


ns = yield not significantly higher than untreated control yield, which was 2.1t/ha.
Source: Dr Stephen Davies, DPIRD

"Over time, the soil density increases to such an extent that the root will get thicker to slowly push through the soil, or roots must find a soil fracture, or a weaker area of soil to grow through. This then reduces the rate of root growth and constrains the overall volume of soil that plant root system can ultimately explore."

Mt Noddy grower Ty Fulwood (left), with DPIRD WA research officer Dr Stephen Davies, inspects the 2017 wheat establishment on the Helipped (with inclusion plates) and spaded trial plot. Photo: Jo Fulwood

Figure 2: Tillage impacts on water repellence.



Source: Dr Stephen Davies, DPIRD

"I don't think our outlay for this deep ripper has been particularly large. But just as an estimate, 80 to 90 per cent of the time, the work we have done has paid for itself in the first year. I think other growers would find this too."

"It's pretty hard to access country that has been Helirripped – it's very soft, and there are a lot of bogging issues," he says.

But regardless of the hurdles, Ty is convinced the investment has been worth it for his business.

"I don't think our outlay for this deep ripper has been particularly large. But just as an estimate, 80 to 90 per cent of the time, the work we have done has paid for itself in the first year. I think other growers would find this too."

The proof really is in the pudding.

Tissue testing of on-farm test strips with the Heliripper showed obvious improvements to plant health.

"The testing showed the plant had greater access to nutrition, was more than double the plant weight, had more than double the nitrogen recovery, and close to double the potassium recovery, when compared with the control," Ty says.

"If the plants can get their roots down to the deeper gravel-clay subsoil, where all these applied nutrients have likely accumulated over the years, there may be a real opportunity to wind back fertiliser rates.

"I anticipate we will be able to do that, and with the inclusion plates, we may look to reduce liming rates as well."

Heliripper in action on Ty Fulwood's property.

Photo: Jo Fulwood

DPIRD WA research officer Dr Stephen Davies tests the soil strength to depth in a deep-ripped plot using a cone penetrometer.

Photo: Jo Fulwood

Rob Dempster

Tackling the yellow acidic sandplain challenge

SNAPSHOT

Growers: Rob, Dan and Vern Dempster

Location: Goomalling, Western Australia

Farm name: 'Adair Farm'

Farm Size: 4000 hectare arable

Enterprise: 75 per cent cropping and 25 per cent sheep

Crops grown: Barley, wheat, oats, lupins and canola

Average annual rainfall: 375 millimetres

Vern Dempster, Tim Boyes (agVivo) and Rob Dempster stand in the one-way plough treatment – one of 13 – at the soil amelioration trial on Rob's Goomalling property. Photo: Jo Fulwood

Rob Dempster has made numerous attempts to fix the three major constraints of non-wetting soils, compaction and acidity on his two Goomalling farms, but he admits he is yet to find a silver bullet.

Rob, who farms with his brother Dan and father Vern, hopes that the trials on his property will provide him with a cost–benefit analysis of various amelioration options targeting these constraints.

The Dempster's first south Goomalling property was purchased by Rob and Vern in 2011, and has areas of deep yellow sandplain typical of the area. A second land parcel was purchased in 2015, comprising similar patches of sand.

Rob knows these soils can be unlocked to the point where he believes they could actually be real assets in the dry seasons.

Early observations of the deep ripping trial implemented on the Dempster's farm, with GRDC investment, are showing interesting results, given the exceptionally dry start to the season that has highlighted the problem of water repellency.

Treatments have included deep ripping, a modified one-way plough, mouldboard ploughing, very deep ripping (Heliripping), spading, delving and combinations of these methods.

Results from these trials will be valuable to any grower with deep yellow non-wetting acidic soils.

The trials are a replication of research currently in its second year on the property of Ty, Em and Ray Fulwood at Mt Noddy, where 13 different treatments are being applied to Ty's non-wetting and compacted soils.

While the soil constraints are the same in both sets of trials, the major difference is the soil type.

Rob and Dan also farm at Southern Brook and North Meckering, and like many farms across the wheatbelt, the soils on these farms suffer from the dual soil constraints of moisture repellency and compaction.

The Dempsters clayed significant areas of the North Meckering farm back in the late 1990s, and have seen positive results from this strategy.

But with the soil type on their Goomalling farm being very different, they have experimented with various options to attack each constraint.

Over the last six years, they have used a rotary hoe, a mouldboard plough and have also deep-ripped. These treatments all have positive and negative aspects that need to be considered.

Rob believes the deep ripping he attempted on 300ha immediately after purchasing the second Goomalling farm in early 2015, while solving the hardpan compaction problem, exacerbated the non-wetting constraint.

"We purchased a deep ripper in 2015 and we ripped 300ha prior to seeding and ended up with a negative response from that treatment, perhaps because we deep-ripped when the soil was dry," Rob says.

"After that, we undertook extensive soil testing to depth and realised that we have a fairly bad acidity problem on that farm that we need to address, in addition to the non-wetting problem.

"So, I'm looking at the various options that are in the trial to help me make the decision as to which tool is going to best suit our situation, not just in terms of reducing the impact of the constraints on crop yield, but also in terms of cost and time effectiveness."

Rob says the dry start to the season this year has given them the additional problem of poor canola germination in the mouldboarded paddocks as a result of a clay sealant covering the surface.

At this early stage, Rob says he is favouring the efficiency and cost effectiveness of the one-way modified disc plough, meaning some organic matter remains close to the soil surface, reducing the risk of clay sealing commonly experienced after mouldboard ploughing.

While this treatment may not be the single silver bullet that solves every constraint, it could be the most suitable strategy for the Dempsters's overall business profitability.

Rob has used the concept designed by the Plozza brothers of South Eneabba to modify an old Chamberlain plough purchased by his father back in the 1970s.

"I spoke to Ben and Sean Plozza in 2014 and have always been intrigued by this modified plough concept," he says.

"I'm hoping it will address the non-wetting and the subsoil acidity, while at the same time being a relatively cheap machinery investment."

He says a major bonus will be the faster work rate of the modified plough when compared with the mouldboard plough or the spader.

It will also allow the incorporation of lime to depth.

Whether or not it will solve the compaction problem is yet to be determined.

Farm consultant Tim Boyes, who is managing the trials on behalf of consultancy group agVivo with GRDC investment, says the trials are not just about finding the ultimate solution to the three constraints, but also about making the economics work, and ensuring a profitable outcome for Rob, Vern and Dan's business in the long term.

He says the project will analyse all treatments, their effectiveness to attack those three constraints and also their gross margins.

"More recent research has highlighted each of the more commonly adopted amelioration strategies can positively impact in some way on those constraints," Mr Boyes says.

"But this is about looking at the economic outcomes and what is the most cost-effective treatment on this soil type."

He says Rob's Goomalling property was chosen for the trial because the soil type is very representative of some soil types across large parts of the central wheatbelt, in particular the Goomalling–Meckering Sandplain.

My Boyes says molarity of ethanol droplet (MED) testing on the trial plots after the completion of the 13 treatments showed an early positive response on most of the trial plots, particularly the very

Rob Dempster in the mouldboard ploughed and Heliripped (very deep ripped) treatment.

Photo: Jo Fulwood

deep ripping, the delving and spading, the mouldboard ploughing and the one-way ploughing.

The trial site received a 7mm rain event after the treatments were implemented, which showed encouraging visual results.

"After a rain event, it's easy to see what is happening in each trial plot with the different treatments on the non-wetting soils," he says.

However, the impact of the different treatments when it comes to reducing acidity and breaking through the hardpan compacted layer may only be determined with yield results, and be potentially better known over the long-term outcomes of the trial.

While the trend in the past decade has been to mouldboard non-wetting soils and/or rip and spade, Mr Boyes believes it is also important to consider other strategies.

Like Rob, at this early stage in the trial process, he believes there is value in considering a one-way modified plough.

"The Plozza plough appears to remove that non-wetting constraint, and it will be interesting to compare its effectiveness with all of the other treatments over the long term," Mr Boyes says.

"It's easy to modify some of the older one-way ploughs and cheap to use, and perhaps a little bit more forgiving to implement than a mouldboard plough, which takes a lot of skill to set up and operate correctly.

"Some non-wetting soils react very negatively to mouldboard ploughing and it can be difficult to know where you will get negative outcomes, particularly when you are inverting the entire soil profile."

"Some non-wetting soils react very negatively to mouldboard ploughing and it can be difficult to know where you will get negative outcomes, particularly when you are inverting the entire soil profile."

"Dry seasons have shown us that you can create more problems if the wrong amelioration strategy is employed."

In stark comparison to the soil ameliorated plots, the control soil shows the non-wetting layer lying across the surface. Photo: Jo Fulwood

The mouldboard ploughed plot after a July rain. Photo: Jo Fulwood

Tim Cusack

Understanding soils is key to economic return on amelioration investments

SNAPSHOT

Growers: Tim and Holly Cusack, Brian and Joan Cusack

Location: Mount Walker, Western Australia

Farm size: 7200 hectares

Enterprise: Continuous cropping, including 1400ha fallow

Crops grown: Wheat, canola, barley and field peas

Average annual rainfall: 300 to 350 millimetres

Soil types: Sand over gravel, sand over clay, deep yellow sands, plus some medium/heavy country

Soil pH: 4.2 (subsoils) to 9.0 (heavy country)

Tim Cusack, left, and consultant Joel Andrew, formerly of agVivo, inspect a deep ripper at Tim's Narembeen, WA property.

Photo: Evan Collis

Outside of land and machinery, investing in soil health can be a major spend in any grain growing business.

With the now well-known benefits of liming to improve acidic soils, plus soil amelioration to alleviate water repellency and compaction, more growers are investing in lime and strategic tillage to ultimately improve crop yields.

But while yield responses can often be significant after tillage, particularly in the first year, does the economic data stack up as well?

Economic analysis

Former agVivo consultant Joel Andrew is conducting a GRDC-invested project that is considering the economic impact of soil amelioration, with and without additional lime, rather than just yield outcomes. The project is aiming for a better understanding of whether such a large investment in soil amelioration will pay dividends in the longer term.

"Soil amelioration, such as deep ripping and spading, is a slow, expensive process that does not suit all soil types or situations," Mr Andrew says.

"Since many growers are seeing large yield responses, we need to better understand the economic impacts on the business, not just the yield responses."

Mr Andrew says the data from the project is demonstrating the need to understand which soil amelioration strategy is the right fit for individual situations – which means understanding the soil type, depth of compaction, the paddock liming history, the topsoil and subsoil pH, and the environmental impacts of each different strategy.

As one part of this wide-reaching project, Mr Andrew has analysed data from a trial on the eastern wheatbelt property of Tim and Holly Cusack, where the financial returns from 12 different treatments were compared across two years of yield data.

The Cusacks have been liming their property intensively over the past 20 years, applying between four and sixt/ha of lime to their soil.

As a result of this liming program, the topsoil pH in the trial (down to 100mm) was between 6.0 and 6.5, while the subsoil (down to 500mm) was tested at pH levels between 3.8 and 4.2.

On-farm work

Tim and Holly, who farm with Tim's parents Brian and Joan Cusack, have only recently begun their journey into large-scale soil amelioration, with a number of dry starts to the season in the past few years and a lack of subsoil moisture holding up their deep ripping program.

"We need to have a bit of moisture in the profile to allow the deep ripper to get down to depths of around 550mm," Tim says.

"But we have had a run of very late starts to the season, which has meant we haven't been able to do as much ripping as we would have liked.

"But the plan is to keep ripping all the sandy soils on the property over the next five years."

Tim believes the dual constraints of compaction at depth and this subsoil acidity are restricting root growth which, in turn, restricts plants' ability to access moisture, particularly at the end of the season.

"This means not only deep ripping to allow a pathway for plant roots, but also using inclusion plates to incorporate the lime that we have applied to the surface over many years."

GRDC

Table 15: The cost of each treatment as applied in this trial.

Treatment	Treatment cost ($/ha)		
	Lime	Tillage	Total
Control	0	0	0
3 t/ha lime	188.6	0.0	188.6
3 t/ha lime + disc	188.6	11.0	199.6
3 t/ha lime + rip	188.6	38.5	227.1
3 t/ha lime + rip + spade	188.6	113.7	302.2
6 t/ha lime	377.1	0.0	377.1
6 t/ha lime + disc	377.1	11.0	388.1
6 t/ha lime + rip	377.1	38.5	415.6
6 t/ha lime + rip + spade	377.1	113.7	490.8
Disc only	0.0	11.0	11.0
Rip only	0.0	38.5	38.5
Rip + spade only	0.0	113.7	113.7

Source: agVivo/DPIRD

"We don't think there is much point in creating these root pathways if the roots are still constrained by acidity at depth."

The Cusacks have purchased a deep ripping machine to begin a long-term ripping program on the lighter soil types across their property.

"In some on-farm trials we undertook ourselves a few years ago, we saw an initial yield improvement of around one tonne per hectare in the canola in just the first year," Tim says.

He also notes that with average returns of $600/t, the investment has paid for itself in just one year.

Subsequent yield improvements have also been encouraging and Tim says he can still see positive yield benefits five years down the track on these deep-ripped trial plots.

The research

For former agVivo consultant Joel Andrew, the purpose of his economic analysis project is to give growers greater financial confidence in their investment decisions and to better understand the real cost of investing in soil amelioration to a grain business.

Undertaking any type of soil amelioration is costly – not only in regard to the hire or purchase of machinery, but also because of fuel costs and time.

"Plus, there is also the unknown business cost of any strategy that has a negative impact on yields," Mr Andrew says.

"In this trial, we set out to find which lime and amelioration combination would provide the best return on investment over a two-to-three-year period, and so we really pushed up the lime rates to do this."

What Mr Andrew discovered in analysing this data is that a number of treatments in this trial actually achieved a negative return – meaning that not all amelioration or additional liming will pay dividends.

The 12 treatments included:

- a control (with a liming history of at least 4t/ha);
- 3t/ha lime without incorporation;
- 3t/ha lime with disc incorporation;
- 3t/ha lime with deep ripping;
- 3t/ha lime with deep ripping plus spading;
- 6t/ha lime;
- 6t/ha lime with disc incorporation;
- 6t/ha lime with deep ripping;
- 6t/ha lime with deep ripping plus spading;
- disc only;
- deep ripping only; and
- deep ripping and spading only.

Costs of implementing these treatments can be found in Table 15.

The results

The treatments were applied in 2016, with canola planted in 2017, followed by wheat in 2018.

A dry start to the season in 2017 meant patchy canola establishment, particularly on the spaded plots, where the uneven

Table 16: Economic return of the treatments for the 2017 and 2018 season.

Treatment	Treatment cost ($/ha)	Amortised treatment cost over two years ($/ha/yr)	Benefit from ripping 2017 ($/ha) canola at $500/t	Benefit from ripping 2018 ($/ha) wheat at $350/t	Net return minus costs of investment over two years ($/ha)
Control	0	0	0	0	0
3 t/ha lime	189	94	25	-92	-256
3 t/ha lime + disc	200	100	100	-29	-129
3 t/ha lime + rip	227	114	325	212	310
3 t/ha lime + rip + spade	302	151	-175	232	-245
6 t/ha lime	377	189	25	-30	-382
6 t/ha lime + disc	388	194	100	-82	-370
6 t/ha lime + rip	416	208	375	483	442
6 t/ha lime + rip + spade	491	245	-150	136	-505
Disc only	11	6	100	-25	64
Rip only	39	19	275	418	655
Rip + spade only	114	57	-150	337	73

Source: agVivo/DPIRD

and soft seedbed made accurate seed placement difficult.

Despite the dry start in 2017, Mr Andrew says all the canola in the deep-ripped treatments returned the highest yield increases when compared with the control.

In 2018, with the trial planted to wheat, the ripped-only treatment, the spaded-only treatment and the ripped plus lime treatment showed the highest yield responses.

“What we found after analysing all the results was that the biggest net return (minus all costs) came from the ripped-only treatment, and this return was significantly higher than all other treatments,” Mr Andrew says.

“While we could have assumed that mixing the extra lime through to the subsoil via amelioration would immediately provide increased yields and the largest return on investment, this wasn't necessarily the case.”

The largest loss came from the treatment that was deep-ripped, spaded and had 6t/ha of applied lime (Table 16).

Economic returns of different amelioration treatments at Narembeen, WA

Mr Andrew says while this was not entirely surprising, given the very high cost of the treatment, the impact of poor crop establishment in the first year had meant the financial loss was much bigger than anticipated.

“We knew this particular treatment was excessive in terms of lime application and amelioration, but we wanted to push the boundaries to see what was possible, to see if there would be any financial upside – and clearly there wasn’t that upside in making this excessive investment,” Mr Andrew says.

Another interesting outcome was the lack of any yield benefit when compared to the control, from either the canola in 2017 or the wheat in 2018, in the treatment with 3t/ha or 6t/ha of applied time with no tillage.

“Again, this demonstrates that the topsoil had been adequately limed already and there has not been enough time for it to move through to the subsoil.

“But it also shows that without any incorporation, this additional lime had no economic benefit in a short timeframe but can, in fact, erode business profits.”

What does this mean for growers?

Mr Andrew says growers can interpret these results in a number of ways, but the most obvious message is that lime previously applied on to the surface over a number of years can provide immediate benefits when incorporated into the subsoil.

“The Cusacks have been liming for a long time and, while their topsoil pH had improved, their subsoil levels didn’t improve until this lime was incorporated and the deep ripping removed soil compaction as a constraint,” he says.

“The ripped-only treatments were the best return on investment, but I doubt we would have seen this result if there had been no previous liming history on this paddock.

“Tim and Brian have been liming for many years at relatively high rates, so that cost has been accounted for, and now isn’t a huge outlay for their business.”

Secondly, Mr Andrew says, given the expense of soil amelioration, growers could find themselves unnecessarily spending on treatments that may not provide an economically viable result.

Western Australian grower Tim Cusack, left, and consultant Joel Andrew, formerly of agVivo, and a deep ripper at Tim's Narembeen property.

Photo: Evan Collis

Cost of soil amelioration

"In the deep ripping plus spading plus the application of 6t/ha of lime treatment, we saw the biggest loss of $505/ha, so this was not just an over-capitalisation on lime spending, but also on the two different amelioration strategies," Mr Andrews says.

"Lastly, if there is no liming history, applying high rates of lime at the same time as incorporation may be the only way to achieve yield responses but, economically, it's likely to take longer than two years to see a return on investment."

Tim agrees with the research findings that are showing the importance of incorporating lime that is not dissolved.

While his liming program may be slowing down, his amelioration program will go full-steam ahead in coming years.

"We believe in the value of lime to the business, so we have invested heavily in lime over a long time and we are almost at the stage now where we can scale this investment back, which will allow us to invest more into deep ripping," he says.

"Deep ripping allows us to create these root pathways and the inclusion plates push the lime that we have already applied down to depth."

MORE INFORMATION

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"The Cusacks have been liming for a long time and, while their topsoil pH had improved, their subsoil levels didn't improve until this lime was incorporated and the deep ripping removed soil compaction as a constraint."

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