

DEEP RIPPING FACT SHEET

Correcting layers of high soil strength with deep tillage

Deep tillage can ameliorate layers of high soil strength and allow roots to access subsoil water and nutrients. Major crop yield responses to deep ripping lasting three years or more have been recorded on sandy soils in the northern region.

KEY POINTS

- The purpose of deep ripping is to ameliorate poorly structured layers of soil with high strength and/or poor aeration, which restrict root growth and uptake of subsoil water and nutrients
- Yield responses tend to be highest on deep sandy soils and less on heavier-textured soils
- Layers of high soil strength can occur in conjunction with other constraints (for example, acidity, sodicity) and yield responses from deep ripping will be limited if these are not addressed. Deep ripping, on its own, provides little benefit, or can be detrimental, on soils with sodic or toxic layers in the subsoil
- Investigation of the soil profile is essential to identify the type, severity and depth of constraints affecting crop root growth prior to ripping
- Precision agriculture (PA) tools can be used to establish the spatial distribution of soil constraints and establish zones for deep ripping
- Deep ripping can reduce standing stubble and increase the risk of erosion, especially on sandy soils
- Rapid crop establishment after deep ripping is critical to protect the soil from erosion and to stabilise the soil
- Deep-ripped soils are readily re-compacted by machinery traffic. Adopting controlled-traffic farming systems minimises re-compaction and reduces or eliminates the need to repeat ripping

Photo: Evan Collins



Some growers use deep ripping to ameliorate soil constraints that otherwise restrict the uptake of moisture.

Deep ripping

Deep ripping with tyne implements is primarily aimed at ameliorating poorly structured subsoil layers through fracturing and loosening. These layers are formed by compaction from machinery traffic and natural cementation and consolidation processes. Operations that are sometimes combined with deep ripping include topsoil inclusion, deep placement of ameliorants and fertilisers behind tynes, and delving to lift subsoil clay to the surface to ameliorate water repellence in water-repellent sands (Table 1).

High strength and/or poor aeration caused by compaction

Layers of compacted soil are caused by tracking of machinery, especially when soils are wet, and can develop through naturally occurring processes over time.

Compacted layers have comparatively higher soil strength when dry and poorer aeration when moist, which can lead to waterlogging and perched water tables when excess water is present. This restricts root growth, limits access to water and nutrients, reduces the capacity of soil to store water, and can cause loss of water by evaporation and run-off due to slow water infiltration through the soil profile.

Compaction can occur in all soils and is more likely to occur when time-sensitive operations, such as harvest, are conducted on wet soils. This can be a particular problem in irrigated fields and in summer rainfall areas.

Research has shown that after deep ripping, up to 80 per cent of compaction occurs in the first pass of machinery. In dryland cropping systems, 40 per cent of a paddock can be covered by machinery tracks in one year if traffic

Table 1: Summary of deep ripping approaches, soil constraints addressed, working depth, incorporation characteristics and approximate cost.

| Strategic tillage method | Most suitable soil types | Principal constraints addressed | Implement working depth (cm) | Implement impact on incorporation of topsoil and soil amendments | Estimated cost (\$/ha) ^A |
|---|--|--|------------------------------|---|-------------------------------------|
| Deep ripping | Deep sands, loamy sands, deep sandy duplex | Compaction, hardpans | 30 to 70 | Minimal incorporation. Backfill to 15cm | \$40 to \$90 |
| Deep ripping with topsoil inclusion | Deep sands, loamy sands, deep sandy duplex | Compaction, hardpans, subsoil acidity, subsoil infertility | 30 to 70 | Topsoil slots from surface typically to depths of 35 to 40cm, but ripping depths can extend to 70cm. Can partially incorporate surface-spread amendments (for example, lime, nutrients, organic matter) | \$55 to \$95 |
| Amendment placement in subsoil using ripper | Duplex soil, clay soil, loam | Compaction, hardpans, subsoil acidity, subsoil fertility | 30 to 60 | Direct deep placement of amendments (for example, organic matter, lime, gypsum, nutrients) in bands at depths up to 70cm | \$300 to \$1400 ^C |
| Subsoil clay delving and incorporation | Duplex soil ^B | Water repellence, compaction, fertility of A-horizon | 60 to 120 | Backfill likely due to wide delving tyres and high disturbance. Subsequent clay incorporation will mix soils and surface-applied amendments to 15 to 45cm | \$300 to \$450 |

^A Cost estimates based on contractor rates and quoted costs from growers who have adopted practice.

^B Optimum depth range of sand over clay for delving is 20 to 60cm.

^C A large component of this cost is sourcing and applying amendments.

Source: Adapted from Davies et al., 2019

Figure 1: Yield responses from deep ripping are more consistent and persist for longer on deep sandy soils.

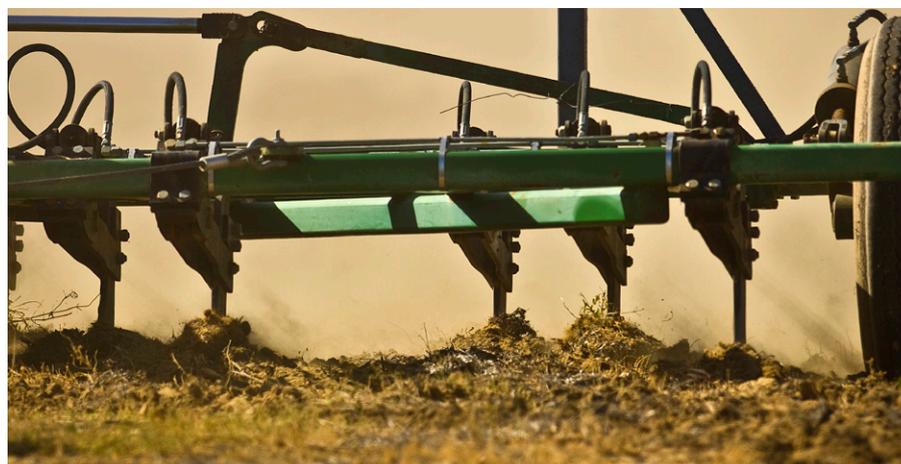


Photo: GRDC

is not restricted to defined tracks. This situation is exacerbated on paddocks sown to cotton, where cotton harvesters can track 66 per cent of paddocks.

As machinery is becoming larger and heavier, the higher axle loads are increasing the depth of the hardpan in the soil profile. Grain and cotton harvesters, for example, can cause significant compaction down to 80cm.

Livestock cause compaction, but this is typically in the topsoil and can be ameliorated with shallow cultivation, including with seeding equipment. Livestock do not cause compaction deep in the profile.

Responses to deep ripping

Responses to deep ripping vary according to soil type (Table 2) and tend to be more consistent on deep, coarse-textured (sandy) soils. On fine-textured (clay-rich) soils, including duplex soils with hostile clay or sodic subsoils, non-duplex soil with chemical constraints in the subsoil, and cracking clays (vertosols), yield responses are often small or negative, and may not last beyond one season.

Responses vary according to seasonal conditions, with smaller responses in years where there is no subsoil moisture

to exploit, or in years when frequent rainfall events keep the topsoil moist and the crop is not reliant on subsoil moisture. On grey vertosols, responses last for many years, provided machinery traffic is managed. On other soils, for example, deep sands, responses decline in successive years as soil strength increases through natural processes.

It is common for plant productivity to be limited by other soil constraints, in addition to high soil strength (when soil is dry) and poor aeration (when soil is moist) in soil that is compacted (Table 2).

The occurrence and combination of constraints varies across soil types and regions. For example, finer-textured and duplex soils may be constrained by sodic subsoils and other chemical constraints such as high acidity, aluminium, boron and salinity, while sandy soils may also be constrained by water repellence, acidity and subsoil nutrient deficiencies.

The full yield response and return on investment in deep ripping will not be realised unless these other constraints to production are ameliorated. Ameliorating other constraints, such as soil acidity, may provide a greater return than deep ripping and be a higher priority. In some cases, it may not be economically viable or possible to ameliorate the constraints, making returns on deep ripping unlikely. More information

Table 2: Summary of deep ripping responses of wheat crops across soil types and their associated constraints.

| RELIABLE RESPONSES | | VARIABLE RESPONSES | | | | FEW RESPONSES | |
|---|--|---|--|--|---|---------------------------------|--|
| SOIL TYPE | DEEP SANDS | NEUTRAL-ALKALINE SANDS | DUPLEX-DEEP (A HORIZON >30cm DEEP) | DUPLEX-SHALLOW | SODIC CLAY | RED AND LOAMY EARTHS | BLACK EARTHS |
| AUSTRALIAN SOIL CLASSIFICATION | TENOSOL | TENOSOL | SODOSOL | SODOSOL | GREY VERTOSOL | RED KANDOSOL AND CHROMOSOL | BLACK VERTOSOL |
| CULTIVATED ZONE 0cm 10cm | Water repellence | Water repellence | Water repellence | Waterlogging | Waterlogging | | Self-mulching |
| UNCULTIVATED SUB-SURFACE ¹ | | | High soil strength | | | | |
| SUBSOIL PROBLEMS THAT MAY BE ASSOCIATED WITH COMPACTION | 25cm Acid layer (15 to 30cm) | High soil strength (10 to 70cm) | Waterlogging | Waterlogging | Waterlogging | Acid layer | Salinity (Cl ⁻) |
| | 70cm High soil strength (10 to 70cm) | | Sodic clay Anaerobic High density Poor structure Salinity | Sodic clay Anaerobic High density Poor structure Boron | Sodic clay Anaerobic High density Poor structure | High density Well structured | |
| | 100cm High density Porous | Low nutrient availability | | | | | |
| | 200cm Low water, N and K holding N and K leaching | Salinity Boron | Boron | | Salinity Boron High alkalinity | | |
| MEAN WHEAT YIELD RESPONSE RANGE IN YEAR OF RIPPING | WA 13 to 125% ² | VIC/SA 30 to 80% | WA 14 to 60% ² NSW 0 to 20% | 4% | NSW 0 to 33% WA 47% VIC -10 to 10% | Few | Few |
| BEST BET MANAGEMENT | Rip Deep mix/invert Soil wetters Near/edge row sowing Incorporate/deep place lime CTF | Rip Deep mix/invert Soil wetters Near/edge row sowing CTF | Rip Deep mix/invert Soil wetters Near/edge row sowing Incorporate/deep place lime CTF | Do not rip CTF | If dispersive, apply gypsum or gypsum-lime blend Rip if subsoil compacted and dry CTF | Few responses CTF | Few responses Self repairing CTF |

¹ Caused by machinery and/or naturally occurring

² Higher yield responses tend to be from deeper ripping

Source: Adapted from table compiled by J Kirkegaard with input from Dr S Davies, DPIRD; Dr L Macdonald, CSIRO; Prof R Armstrong, DJPR; Dr David McKenzie, SOILmgt.

on soil type and yield response to deep ripping can be found in 'Useful resources' at the end of this fact sheet.

In systems where traffic is not managed, soils are quickly re-compacted by machinery. Controlled-traffic farming (CTF) systems that restrict machinery to the same tracks – that is, a single wheel per axle side – and match track width for all machinery, restrict compaction to the tracks and reduce or eliminate re-compaction caused by machinery. This reduces or eliminates the need for frequent ripping to overcome re-compaction. Frequent ripping is undesirable on clay soils as it can cause a decline in soil condition through loss of soil carbon and organic matter.

Implementing a CTF system is considered best practice to minimise re-compaction and reduce the need to repeat ripping, and results in a higher return on the investment in deep ripping.

More information about CTF systems can be found [here](#).

Identifying compacted subsoils

Areas of poor crop growth and premature ripening are indicators that soil constraints are restricting root growth and the crop has restricted access to subsoil moisture and nutrients.

The occasional vigorous plant which has exploited a crack in the hard subsoil layer, or more vigorous growth over old cable or pipelines, could be indicators that compaction is the main constraint. Waterlogging and perched water tables in heavy-textured soils often result from poor infiltration due to compaction and poor aeration in the subsoil.

However, these symptoms are not specific, and investigation of the subsoil is required to confirm which constraints are present and the depth at which they occur.

The following techniques can be used to investigate further.

Soil pits

Soil pits dug with a spade or backhoe allow a visual assessment of root growth, moisture levels and physical constraints down the soil profile. Ideally, soil pits should be dug at right angles to the direction of machinery travel, and include a machinery track and non-trafficked soil.

A lack of roots below a certain depth and/or horizontal growth of roots may indicate compaction but can also be an indicator of other constraints, such as soil pH extremes, sodicity, and toxic levels of aluminium, boron and salinity. Unused soil moisture at depth at the end of the season also indicates root growth and function is being impaired.

It is important to determine the depth to the bottom of the compaction layer as this informs the depth of ripping required (Figure 2). When struck with a trowel or screwdriver, this layer feels more dense and stronger than the soil above and below it. On some sands, compaction starts

at 20 to 25cm and continues to depth, rather than being in a defined layer. In clay soils compacted layers often have a distinct upper and lower boundary with large clods that may have a platy (horizontal) shape and a massive appearance.

In poorly structured cracking clays, clod faces are dull rather than shiny. The soil may feel puggy when wet and wet clods will stretch and tear apart like raw pastry rather than breaking apart. When dry, the clods are not friable, but break where force is applied rather than parting along natural fracture faces.

Visual assessment experts can determine the full depth of compaction in clay subsoils, but novices may struggle with the evaluation. A valuable alternative method is to measure bulk density throughout the root zone using thin-walled sampling rings (75mm diameter, 50mm long).

If the soil is dispersive, small clods placed in distilled water or rainwater will disperse without the need to shake them, and the water will turn cloudy within an hour. Field pH kits allow rapid assessment of pH extremes in topsoil, subsurface and subsoil.

Chemical analysis

Chemical analysis of the soil by a laboratory is required to confirm constraints such as soil pH extremes, sodicity, subsoil nutrient deficiencies and toxic levels of aluminium, boron and salinity. This requires careful sampling and analysis of soils to depth.

Push probes

Push probes are made of steel rod (typically 8 to 10mm diameter) with a

pointed end, and are pushed into the soil by hand. Layers with high soil strength can be detected from the changing force needed to push the rod into the soil. Push probes indicate how deep and thick the layer of high soil strength is. Penetration force is strongly influenced by soil moisture and this should be taken into consideration when making assessments. A zone of increased resistance may indicate a layer of dry soil, or could indicate a layer of gravel or rocks. Ideally, assessments of soil strength should be done in conjunction with a measurement of soil moisture.

Push probes do not reliably identify changes in soil strength in clay soils. In wet clay soils, increases in the penetration force are likely to be due to a wet clay plug developing at the point of the probe, rather than being due to any changes in soil strength.

Digital cone penetrometers

Digital cone penetrometers work in a similar way to push probes, but provide a quantitative measure of soil strength. A sensor measures the resistance or soil strength as it is pushed into the soil. For cereals, root growth is restricted when penetration resistance in moist soil is above 1.5 megapascals (MPa), and severely restricted above 2.5MPa. As with push probes, penetration resistance is strongly influenced by soil moisture, gravel layers and rocks. Changes to penetration force in soil profiles with layers of wet and dry soil can be confused with changes in soil strength. Ideally, measurements should be taken when the whole soil profile is moist, or in conjunction with a measurement of soil

Figure 3: Push probes and cone penetrometers can be used to identify layers of high soil strength and to assess subsoil fracturing and loosening after ripping.



Photo: Evan Collis

moisture. A comparison with readings from other areas in the paddock and a known non-compacted area on similar soil types is useful. Cone penetrometers have the same limitations as push probes and are not a reliable tool for identifying changes in soil strength in clay soils.

Test strips

Deep ripping strips across varying soil types and at varying depths can provide a useful indication of likely yield responses and help to assess how deep the soil will need to be ripped. Deep

Figure 2: (a) A distinct compacted layer in a sandy loam. Note fractures in hardpan through which roots preferentially grow. (b) Massive unstructured soil between three rip lines, compared with the aggregated soil on the deep ripping breakout.



Photo: Dr Stephen Davies, DPIRD



Photo: Dr David McKenzie, SOILmgt

ripping test strips on previously ripped soil, or leaving an unripped strip within a paddock that has been ripped, can also provide a measure of the decline in response from ripping, and if and when re-ripping will be economically viable.

More information on identifying high soil strength and subsoil compaction can be found [here](#) and in 'Useful resources' at the end of this fact sheet.

Where to deep rip

Understanding the soil physical and chemical characteristics is essential to maximise returns from deep ripping, and avoid damaging soil structure or bringing a hostile subsoil to the surface.

While precision agriculture tools such as yield maps, electromagnetic imaging surveys, satellite or drone biomass imagery, and gamma radiation surveys do not identify compaction, they can be used to identify variation in soil types which may be correlated to areas of poor production. These can be used to guide assessment of the soil and, if compaction is identified as the main constraint, define the zones where deep ripping will be beneficial.

Planning deep ripping

Timing in crop sequence

Deep ripping opens up the soil leading to loss of soil water, which can reduce planting opportunities and yields in areas where crops are reliant on stored water. Deep ripping early in the fallow phase provides more opportunity for this moisture to be replenished. Also, soils are generally drier early in the fallow phase, which reduces the risk of smearing when deep ripping clay soils. Deep ripping reduces the amount of standing stubble and can leave soil more exposed to erosion. The erosion risk can be reduced by ripping when stubble loads are high and by planting crops which cover and stabilise the soil quickly. It is common for deep ripping to be deferred on sandy soils if there is inadequate stubble cover and the erosion risk is too high.

Depth of ripping

Soils must be deep ripped to below the compaction layer to provide adequate fracturing and loosening of the subsoil. Ripping too shallow will

not break up the compaction layer and the operation will have to be repeated. Ripping deeper than needed increases costs by increasing draft force, tractor power requirements and fuel usage, as well as increasing wear and tear and reducing operating speeds, for limited additional yield benefit.

Soil moisture

Soil moisture throughout the profile is a critical aspect of successful deep ripping as it influences the draft force required and how effectively the soil is fractured and loosened. Deep ripping in dry soil requires greater draft forces, increases fuel consumption and wear and tear, and can slow operating speed, all of which increase costs. Tynes may have difficulty penetrating to the required depth, resulting in suboptimal fracturing and loosening. Deep ripping when soil is too dry can also leave a rough surface with large clods, which are difficult to break down, creating problems with paddock preparation for sowing.

Deep ripping when the soil is too wet causes smearing of clay soils (Figure 4), which increases the severity of dispersion in soil with poor structural stability. It also causes localised compaction around the tyne foot, which impedes water and air movement and root growth in both dispersive and non-dispersive soils. Tynes are at risk of working too deep in wet soils, thereby increasing power requirements, and may not create enough fracturing and loosening to overcome the compaction.

Soil moisture should be below the plastic limit, which is loosely defined as the water content where soil behaves like plasticine. A simple test is to roll a ball of soil between your hands. If a long sausage (>10cm) forms without breaking easily, the soil is too moist for deep ripping.

Deep ripping in optimal moisture conditions presents logistical challenges as the window can be narrow, and often coincides with other time-critical operations. Options to extend the window for ripping are limited on heavier-textured soils, but on sandy soils growers are extending the window by deep ripping in drier-than-optimal conditions and balancing the potentially higher operating costs and rough seedbed finish against expected returns.

Figure 4: Deep ripping when soil is too wet causes smearing of clay soils.



Photo: Dr Andrew Biggs, Department of Natural Resources, Mines and Energy, Queensland

Machinery

A range of commercial deep rippers and machines built on-farm with varying tyne designs and configurations are used for deep ripping. Many are designed for use in CTF systems with tyne spacings to accommodate permanent tracks. Tyne design, layout and spacing influence draft force requirements, the degree of fracturing and loosening of the subsoil, topsoil disturbance and mixing, and the condition of the soil surface after ripping. The optimum set-up will vary according to individual situations, however the key considerations are that the compaction layer is effectively fractured and loosened, and that the soil surface can be levelled for sowing. More information on tyne design and operation can be found in 'Useful resources'. A research report by the Kondinin Group on deep rippers can be found [here](#).

Inclusion plates

Inclusion plates are fitted to the rear of ripper tynes (Figure 5). They work below the soil surface and are designed to allow topsoil from above the top edge of the plate to fall into the slot behind the tyne and be buried at depth.

Yield responses have been observed in dry, free-flowing soils which have low nutrient levels in the subsoil and/or are constrained by a layer of acidity in the subsoil. Placing topsoil containing organic matter and nutrients at depth provides the crop with access to nutrients which can be taken up from moist subsoil.

Figure 5: Topsoil inclusion plates fitted to deep ripping tynes on a Yeoman's Keyline plough tynes.



Photo: Brett Masters, Department of Primary Industries and Regions, South Australia

Placing soil ameliorated with lime in the subsoil can provide pathways for roots to grow through acid layers and access soil water and nutrients from the subsoil.

Inclusion plates are less effective at placing topsoil at depth when the topsoil is moist and where there are high stubble loads. Inclusion plates create deeper furrows which can be difficult to level off, can smear clay soils and can cause compaction between ripping lines in sandy soils if operating in soil not loosened by the tyne. Deep ripping with inclusion plates requires more draft force, resulting in increased fuel use and cost.

Research has identified improvements to the design of inclusion plates which increase the efficiency of operation and the quantity and depth of topsoil burial. The yield responses from these improvements are yet to be quantified. More information on this work can be found [here](#).

Where the main constraint to root

growth is high soil strength, deep ripping alone provides a better return on investment than deep ripping with inclusion plates.

Amendments

Research into the deep placement of amendments such as lime, gypsum and nutrient-rich organic matter in the subsoil is in progress. Responses to deep amendments depend on the characteristics and constraints in both the topsoil and the subsoil.

For example, deep placement of lime has resulted in yield increases by reducing subsoil acidity within the ripping line.

Deep placement of nutrient-enriched organic matter (for example, chicken litter) has provided inconsistent results in medium and low-rainfall zones, where similar responses are often measured when it is applied to the topsoil at lower cost. Yield increases initially appear to be

mainly due to supply of nutrients, but the long-term effect is unknown at this stage.

In the higher-rainfall zones, placing nutrient-rich organic matter into dispersive subsoils encourages root growth into this layer, resulting in improvements to subsoil structure. Yield responses are related to access to more plant-available water and have been greatest when the crop is relying on subsoil moisture to fill grain during dry springs. Research is continuing into the processes that lead to these yield improvements, alternative sources of organic matter and quantifying the benefits.

Adding amendments to the subsoil on a commercial scale presents logistical challenges with supply and application of large quantities of material, and most equipment has been developed on-farm or for trial purposes. More information can be found in 'Useful resources' and [here](#).

Weeds

Soil disturbance during deep ripping buries weed seed, causing increased emergence from varying depths in the soil. This can lead to variable control with pre-emergent herbicides where weeds emerge from below the herbicide band. To manage this, consideration should be given to using robust pre-emergent and post-emergent herbicide packages, and to planting crop types and varieties which allow effective control strategies to be used in-crop. Using 'imi' herbicides in imi-tolerant crops is one strategy that has been used successfully. Reducing weed seedbanks in the seasons leading up to deep ripping can also assist.

Figure 6: Rollers range from (a) flat steel rollers to (b) rollers mounted on deep ripping machines. Note the reduction in standing stubble following ripping and rolling in Figure 6b.



Photo: DPIRD

Photo: Brad Bennett, AGRIVision Consultants

Monitor results

Check results before committing to large areas. The degree of loosening and fracturing in the subsoil can be assessed by digging pits and making a visual assessment, and by comparing soil strength within and between the rip lines to that of unripped soil. Also, assess the condition of the soil surface after deep ripping. An uneven soil surface caused by deep furrows and large clods can be difficult to level and may affect crop establishment.

After deep ripping

Deep ripping typically leaves soil uneven and very soft, and can leave large clods on the surface, all of which present challenges for trafficability of seeding equipment and crop establishment. Issues with trafficability are exacerbated if deep ripping is combined with amelioration techniques like spading and deep ploughing.

Leaving the surface as flat as possible by filling in furrows and breaking up clods, and consolidating the surface of sandy soils, improves the accuracy of seed placement and crop establishment.

Rolling

Rolling sandy soils after deep ripping is common practice to consolidate and level the topsoil and to break up clods, which improves trafficability, seed placement and crop establishment. Rolling can increase erosion risk by flattening the soil surface and reducing the amount of standing stubble.

Deferring rolling until just prior to seeding reduces the risk of erosion by retaining stubble cover for as long as possible, and minimises the period of time the soil is exposed to erosion events. Rollers that leave the surface slightly ridged or indented also reduce the risk of erosion compared with rollers that leave the surface flat.

A range of rollers of varying designs are being used commercially (Figure 6). The ideal roller for individual situations will depend on soil type, the degree of topsoil consolidation and levelling required, the size and number of clods, erosion risk and the surface finish required for crop establishment.

More information on roller types and suitability for various situations can be found [here](#).

Pre-emergent herbicides

Deep ripping combined with soil mixing techniques – that is, spading and ploughing – can lower organic matter content of topsoil, resulting in increased risk of crop damage. Bringing clay to the soil surface can either increase or decrease herbicide activity, depending on the herbicide and the properties of the soil.

Where soil is deep-ripped without topsoil mixing, the main issues are furrow collapse after seeding into soft soil, soil throw or the backfilling of furrows caused by erosion, which may concentrate soil-applied herbicide over the drill row and lead to crop damage. Applying herbicides to cloddy soil surfaces reduces the efficacy of some products and can concentrate the herbicide via preferential pathways of water infiltration.

Practices which reduce the risk of crop damage include rolling to consolidate the soil surface before herbicide application, retaining enough stubble cover to reduce erosion risk, forming stable furrows, accurate seed placement, reducing herbicide rates within the ranges stated on label recommendations, using herbicides which are safer on the crop and, where possible, avoiding pre-emergent herbicides in favour of post-emergent weed control.

Crop establishment

The main issue with seeding after deep ripping is poor crop establishment due to inaccurate seed placement. This is caused by poor flotation of seeding equipment, an uneven soil surface and movement of soil into drill row furrows via excessive soil throw, furrow collapse and backfilling of furrows during erosion events.

Growers have found it useful to do a 'dry' test run with the seeder to assess seed placement and soil movement, which can also guide the use of pre-emergent herbicides. Other techniques to improve crop establishment include:

- ground-following seeding equipment, where the seeding depth of each row is controlled by a press wheel;
- seeding systems that place seed into the furrow wall instead of the bottom of the furrow;
- seeding points that work to a shallow depth and deliver seed to the bottom

of the furrow – worn or cut-off knife points have been used successfully;

- flexible, trailing seeding boots which maintain a shallow sowing depth on very soft soils;
- reducing pressure on tynes and press wheels;
- fitting wider press wheels to reduce bar sinkage and bulldozing of soil where bar weight is partially carried on the press wheels;
- fitting press wheels which produce shallow furrows with stable side walls;
- improving flotation by setting up lightweight, smaller seeding bars, half-filling air carts, lowering tyre pressures, increasing tyre width and locking castor wheels;
- deep ripping at an angle to the direction of working and seeding;
- seeding early and into moisture to promote rapid emergence and early growth to stabilise soil;
- selecting crop types and varieties which have long coleoptiles, emerge quickly, have vigorous early growth and cover the ground quickly;
- increase sowing rates to compensate for reduced emergence;
- top-dressing some seed prior to sowing at an angle to the rip line to compensate for poor seed placement by the seeder; and
- CTF systems – avoid ripping wheel tracks. Flotation can still be an issue for wheels that do not run on the permanent tracks, which creates uneven seeding depth across the width of the bar unless the depth of each row is controlled by a press wheel. Bogging can be an issue for machinery that falls off the firm wheel tracks into wet soft soils, particularly when travelling at faster speeds for spraying. Options to manage this include leaving wider, unripped wheel tracks, using wider tyres, or running a shallow ripping tyne in line with the main wheel tracks to form a shallow channel that the sprayer can track in.

More information on establishing crops after deep ripping can be found [here](#).

Crop nutrition

Fertiliser programs will need to be adjusted to supply enough nutrients to match the higher production levels if the full benefits of deep ripping responsive soils are to be realised. Tactical, in-season application of some nutrients, for example, nitrogen, can help to improve yield potential in favourable seasons while avoiding over-fertilising in dry seasons. In some cases, the first crop post-ripping has access to leached nutrients that previous crops have not been able to access, plus additional mineralised nutrient, so nutrition may be able to be reduced for that season.

Traffic management

Traffic after deep ripping causes enough compaction to restrict root growth and can severely re-compact wet soils. In some instances, it can undo any benefits of ripping within a single pass. Restricting

machinery traffic to defined tracks in CTF systems minimises re-compaction, maximises the yield benefits from deep ripping and eliminates the need to repeat ripping except where soils develop high strength through natural processes.

MORE INFORMATION

Identifying compaction

<http://soilquality.org.au/factsheets/subsurface-compaction>

Kondinin Research Report – Deep ripping

<https://www.farmingahead.com.au/issues/special-report/1392168/farming-ahead-research-report-deep-ripping-august-2020>

Rolling

<https://groundcover.grdc.com.au/agronomy/soil-and-nutrition/solutions-roll-in-for-managing-soil-surfaces-after-deep-ripping>

Crop establishment

<https://www.agric.wa.gov.au/soil-compaction/seeding-deep-ripped-or-renovated-soils>

Inclusion plates

<https://groundcover.grdc.com.au/agronomy/soil-and-nutrition/advice-to-match-design-of-inclusion-plates-to-soil-type-for-optimum-effect>

Soil amendments

<https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2020/02/deep-ripping-where-it-will-work-and-where-it-wont>

Ranking Options for Soil Amelioration

<https://groundcover.grdc.com.au/agronomy/soil-and-nutrition/rosa-supports-soil-constraint-management-decisions>

Soil sampling guidelines

<https://fertilizer.org.au/Fertcare/Nutrients-And-Fertilizer-Information/Soil-Sampling>

Controlled-traffic farming

https://www.nacc.com.au/wp-content/uploads/2015/05/NACC_Controlled_Traffic_Farming_Technical_Manual.pdf

ACKNOWLEDGEMENTS

Dr David McKenzie, Soil Management Designs (SOILmgt)

Dr Stirling Robertson, University of Southern Queensland

Mark Crawford, Department of Natural Resources, Mines and Energy, Queensland

Dr Lynne MacDonald, CSIRO

Dr Stephen Davies, Department of Primary Industries and Regional Development, WA

Wayne Parker, Department of Primary Industries and Regional Development, WA

Professor Roger Armstrong, Agriculture Victoria, Department of Jobs, Precincts and Regions

Dr Chris Saunders, Agricultural Machinery Research and Design Centre, University of South Australia STEM

USEFUL RESOURCES

Responses to deep ripping and deep placement of soil amendments

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