# RIPPING TECHNOLOGY FACT SHEET

NATIONAL
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# Technology considerations for cost-effective subsoil loosening

## KEY POINTS

- Deep ripping tyne technologies vary in their ability to loosen, mix, delve and rearrange clods within the profile
- Key strategies to minimise costs include:
  - rip no deeper than necessary;
  - operate above the tyne critical depth;
  - optimise timing (soil moisture); and
  - use winged tynes at an optimised spacing when operating deep.
- Opportunities exist for optimising multi-depth tyne layouts and spacings for maximum loosening efficiency and reduction of total draught


**Photo 1: High disturbance ripper using narrow-spaced delving tynes to bring up soil from deeper layers combined with levelling spike rollers to provide a levelled finish.**

## Introduction

The extent and longevity of soil and crop responses to deep ripping are often site-specific and sometimes timing-specific. These aspects are increasingly well documented (see Useful Resources section), whereas there is less information available on optimising the performance of the deep ripping operation itself. This factsheet reviews key principles of efficient deep ripper technologies.

## Deep ripper performance

When assessing the physical performance of deep ripping (or subsoiling) machinery, key considerations of soil–machine interactions are:

**1 How much draught is required?** Soil strength, depth and speed of the ripping operations significantly influence the implement draught and tractor power requirements. The ripper tyne design and layout on the bar can also affect draught.

**2 How complete is the soil disturbance?** After deep ripping, the loosened soil profile typically narrows down at depth, leaving unripped soil zones between tynes. Tyne design, spacing and layout can affect this outcome, quantified by the proportion of the soil profile loosened.

**3 How energy efficient is the operation?** Efficient loosening is expressed as the amount of pull required (for example, draught force, kilonewton; kN) per unit of furrow loosened area (for example, metre squared; $m^2$). Optimising this specific resistance ratio ($kN/m^2$) is critical to maximising efficiency.

**4 What is the quality of soil disturbance?** The quality of the soil disturbance is assessed against other objectives complementary to soil loosening, such as seeder-ready finish (for example, clod size distribution, surface finish roughness), profile re-consolidation risks (soil clod rearrangement, which influences ease of recompaction), and impact on other soil constraints (for example, quantity of clay delved to the surface, efficacy of sublayer mixing or efficacy of surface amendment inclusion).

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The above performance parameters are important for reducing costs and improving the efficiency of deep ripping; however, their agronomic impacts on both the extent and longevity of crop (biomass) response are not well documented.

## Tyne technology

The soil engaging components of a deep ripping tyne consist of a shank (or leg) associated with a primary loosening point (or foot), with or without wings, generating the bulk of draught requirements. The foot component is designed to loosen the soil profile from depth, while specific point design and leg attachments can also delve the subsoil (that is, lift soil from deeper layers up along the front of the tyne) or include topsoil at depth (that is, falling in behind the tyne) resulting in some mixing within the profile. Deep ripper tyne designs may be categorised as follows (Figure 1):

**A and B: Conventional narrow shank (A, straight; B, parabolic)**. The leg portion splits the loosened soil upheaved by the point and has a small draught component mitigated by its rake angle being lowest for parabolic designs.

**C: Curved or bentleg slanted narrow shank with offset point.** This design can achieve uniform surface disturbance where the slanted shank bypasses the bulk of loosened soil upheave, minimising its draught component. Such asymmetrical tynes can be arranged in various layouts across the bar, both side-to-side and front-to-back (Photo 3).

**D: Wide continuous face shank.** These are used for combined profile loosening with delving/mixing of sublayers. The face plate is typically set near a 45° rake angle, extends up to the soil surface (Photo 1) and is a significant component contributing to draught. Its action causes soil from deeper layers to flow upwards in a delving process, released both within the profile and onto the surface.

**E: Winged narrow shank.** In this design, wings are added to straight/parabolic shanks or integrated into their primary loosening points (Photo 2). While the primary point facilitates penetration into hard soils, at full depth the wing portion adds to the downward pull and broadens the bottom of the loosened profile to greatly increase total loosening.

## Critical depth

Efficient soil loosening with a narrow shank ripper tyne requires a point set at a low angle of approach and of sufficient width and lift height to achieve loosening of the whole profile from full ripping depth. There is a critical depth beyond which this loosening capacity is lost, whereby the loosened area is drastically reduced, combined with a high draught arising from soil compaction and smearing developing at depth. Deeper critical depths can be achieved by greater lift height and wider points (Figure 2).

**Figure 1: Types of ripper tynes: conventional with straight (A) and parabolic (B) narrow shank, curved slanted narrow shank (C), wide continuous face delving shank (D) and winged narrow shank (E).**

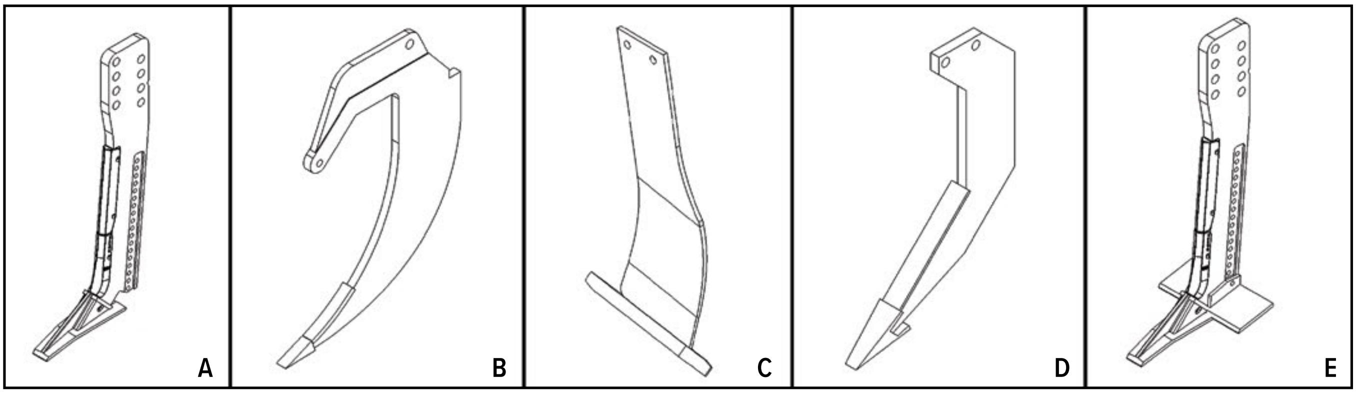
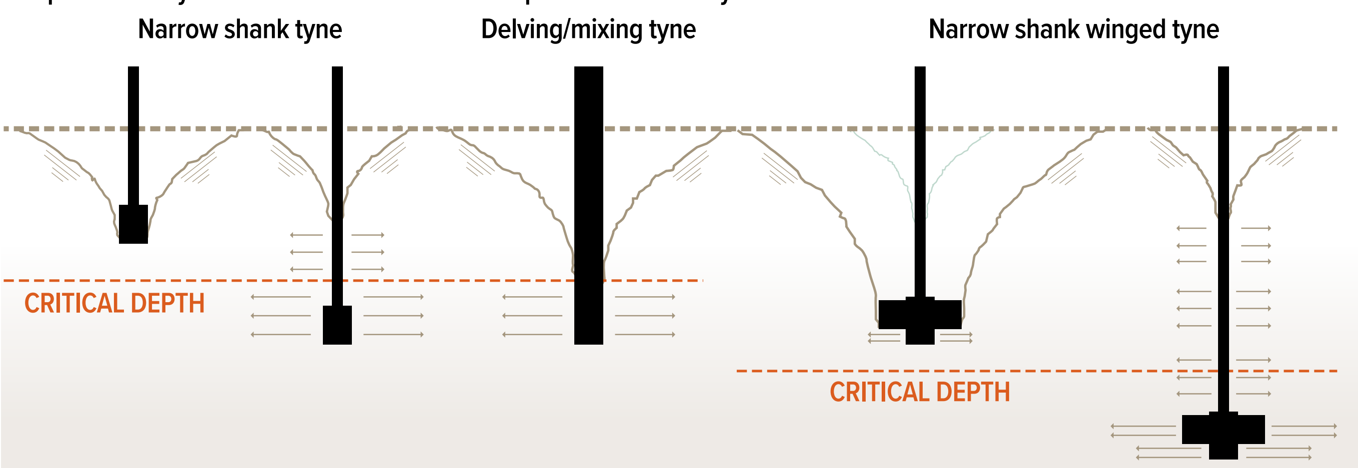



**Figure 2: Impact of tyne design on soil disturbance patterns and critical depth. Loosened soil boundary is represented by the brown line and lateral compaction stresses by arrows.**



For cost-effective loosening, it is therefore pivotal that rippers be operated above their critical depth, by selecting suitable tyne designs and layouts for the targeted depth and soil context, and by avoiding soft and wet soil conditions at depth. Winged tynes have significantly deeper critical depth thresholds than tynes without wings (Figure 2).

In heavy textured soils, moisture should be on the dry side of the lower 'plastic limit' (the soil moisture beyond which the soil changes from a semi-solid and friable consistency to a plastic one) for maximum effectiveness. While the impact of high soil moisture is less critical in deep sandy profiles, ripping during overly dry conditions significantly increases clod size and surface roughness, power requirement and machinery wear, which translate into higher costs of operation, including a greater need for follow-up tillage operations.

## Operating depth

Research shows the draught force in a compact soil is typically proportional to the square of operating depth, so operating 50 per cent deeper is expected to more than double (= x 2.25) the draught requirement. This effect can be seen in Table 1 when operating 50 per cent deeper (for example, from 400 millimetres [mm] to 600mm) increased the loosened area by 69 per cent but at the cost of a 2.7-fold increase in draught, therefore augmenting the specific resistance by 60 per cent, which indicates a much less efficient loosening process.

## Adding wings

Adding wings is one of the best ways of increasing the energy efficiency of subsoiling, especially when operating at greater depth. Key design features of wings include width, sweep and rake angles of approach, total lift height and front-edge distances above and behind the ripper point tip. The data in Table 1 show that 300mm wide and 43mm lift wings fitted at 145mm above tip increased tyne draught by 41 per cent and 24 per cent at 400mm and 600mm ripping depth, respectively, while augmenting the loosened cross-sectional area by 49 and 53 per cent, respectively. This leads to a more efficient loosening process as shown by a corresponding decrease in the specific resistance by up to 19 per cent. Benefits reported in literature (Spoor and Godwin, 1978) range between a 30 and 60 per cent reduction in specific resistance from adding wings, being greatest in cases where the wingless tyne was operated below critical depth. Optimum design and positioning of wings on the shank also affects the benefits. The optimum wing lift height is the minimum necessary to remain above critical depth, while greater lift height accentuates the extent of clod rearrangement. Wing width can be increased within practicality to maximise the loosening at depth.

## Operating speed

Faster operating speed increases the ripper tyne draught force to a smaller extent, which is a function of the volume of soil moved and its rate of displacement during loosening. As the drawbar power varies in proportion to both the speed increase and any associated draught increase, tractor power is therefore consumed rapidly by a higher speed of operation. For instance, in Table 1, increasing speed from 4 to 7 kilometres per hour (km/h) at 600mm depth raised the drawbar power 2.3-fold (from 10.2 to 23.5 kilowatt [kW] per tyne).

## Tyne interactions

When two ripping tynes within a leading/trailing tool bar layout are spaced close enough to interact, some extra soil volume between them is loosened at depth (Figure 3). This lowers the draught of the trailing tyne and reduces the overall specific resistance. As the spacing narrows further, the area

**TABLE 1: Example impacts of operational settings on the performance of a narrow shank ripper tyne (type A in Figure 1) in a deep red sand at Caliph, SA Mallee, 2019 (dry bulk density ranging 1.47-1.53 grams per cubed centimetre [g/cm3] in the 200-600mm depth range).**

| Factors relative to baselines | Single tyne draught, kN (relative) | Loosened area, $m^2$ (relative) | Specific resistance, $kN/m^2$ (relative) | Drawbar power, kW | Notes |
|---|---|---|---|---|---|
| **Baseline 1: Single tyne 400mm depth, 4.0km/h** | **3.4 (ref=1.0)** | **0.099 (ref=1.0)** | **34.5 (ref=1.0)** | **3.8** | **No wings** |
| **Impact of adding wings** | 4.8 (x1.4) | 0.147 (x1.5) | 32.7 (x1.0) | 5.3 | 300mm wide, 43mm lift height, 145mm above tip |
| **Impact of deeper depth (600mm)** | 9.2 (x2.7) | 0.167 (x1.7) | 55.1 (x1.6) | 10.2 | No wings |
| **Combined impact of deeper depth + adding wings** | 11.4 (x3.0) | 0.255 (x2.6) | 44.7 (x1.3) | 12.7 | 300mm wide, 43mm lift height, 145mm above tip |
| **Baseline 2: Single tyne 600mm depth, 4.0km/h** | **9.2 (ref=1.0)** | **0.167 (ref=1.0)** | **55.1 (ref=1.0)** | **10.2** | **No wings** |
| **Impact of adding wings** | 11.4 (x1.2) | 0.255 (x1.5) | 44.7 (x0.8) | 12.7 | 300mm wide, 43mm lift height, 145mm above tip |
| **Impact of faster speed (7km/h)** | 12.1 (x1.3) | No data | -- | 23.5 | No wings |

Notes: Drawbar power (kW) = draught (kN) x speed (m/s); 1kN = 100kgf (kilogram-force); 1m/s = 3.6km/h. The effects of multi-tyne interaction were not quantified.

loosened eventually peaks, then reduces quickly, which leads to a rise in specific resistance. Beyond the optimum, the total draught per unit width of ripper increases through an 'overcrowded' tyne layout. Optimising tyne spacing is therefore key to minimising total draught requirement and maximising loosening efficiency. Requirements for greater clod re-arrangement, layer mixing/delving and topsoil inclusion may, however, justify the use of less energy efficient, narrower spacings.

**Shallow leading tyne (SLT)** layouts allow for a two-stage soil loosening process, reducing the draught load of the deeper tyne and increasing its critical depth threshold. SLT layouts therefore favour a longer window of ripping into wetter conditions and can significantly reduce clod size. The shallow tynes can be set to operate directly in-line or in between the main rip lines.

In-line SLT layouts are commercially available in Australia following local research (Hamza et al. 2013), while older literature (Spoor and Godwin 1978, Godwin et al. 1984) suggests that offset SLT layouts may have the greatest potential to improve soil loosening efficiency, which would allow increased tyne spacing, minimising ripper total draught. Ongoing research is underway to shed light on the above.

Tyne layouts in a 'V' formation provide a more continuous lift across the machine and leave a more level surface finish, while some manufacturers claim reduced draught benefits.

**Figure 3: Impact of tyne spacing on soil disturbance pattern. Note: the undisturbed dome or ridge between rip lines represents a loosening gap relative to the targeted area of *spacing x depth* while the optimum tyne spacing is also affected by ripping depth.**

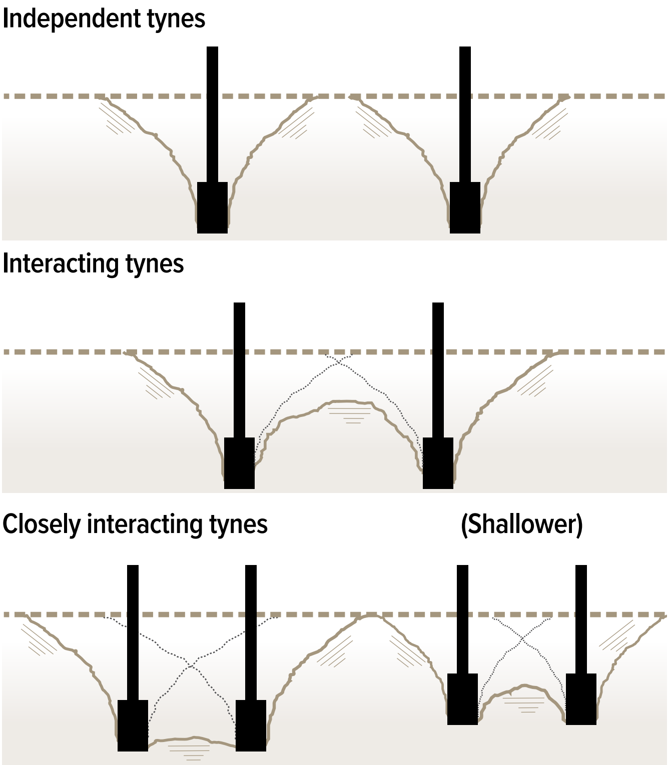



Photo: Hatzenbichler Agro-Technik GmbH

**Photo 2: Parabolic narrow shank ripper fitted with winged high lift points for maximum soil loosening depth capacity.**

**Figure 4: Expected impact of offset shallow leading tynes on increasing the loosened soil area of a winged tyne. Shallow tyne spacing and depth can be optimised for maximum effect, allowing the spacing between deeper winged tynes on the ripper to also be increased.**

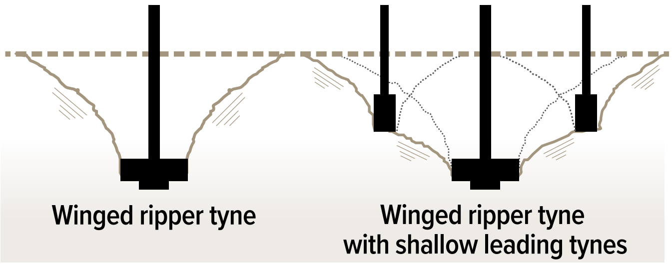
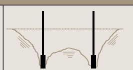
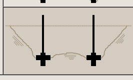
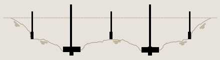



**TABLE 2: Optimum tyne spacing guidelines[+] for maximum loosened soil area and minimum specific resistance.**

| Deep ripper tyne type | Shallow leading tynes (SLT)* | | Deep ripper tyne optimised spacing[t] | Notes |
|---|---|---|---|---|
| **Conventional narrow shank** | No |  | 1.0-**1.5** x depth | Tynes must operate above critical depth |
| **Winged narrow shank** | |  | 1.5-**2.0** x depth | For example, wings extending to 300-420mm overall width<br>- Specific resistance is reduced |
| **Offset SLT layout ahead of winged narrow shank**  | Yes – depth = 40-60% of full ripping depth<br>Spacing = 125-250% of full ripping depth | | 2.0-**2.5** x depth | - Reduced deeper tyne draught with minimal/no change in total draught<br>- Large potential increase in loosened area<br>- Specific resistance very significantly reduced<br>- Maximum effects at wider SLT spacing and deeper SLT depth |

*SLT located at a minimum 1.5 x depth of ripping distance ahead of deep ripper tynes;
[t] Expected range to guide in situ validation by soil condition.

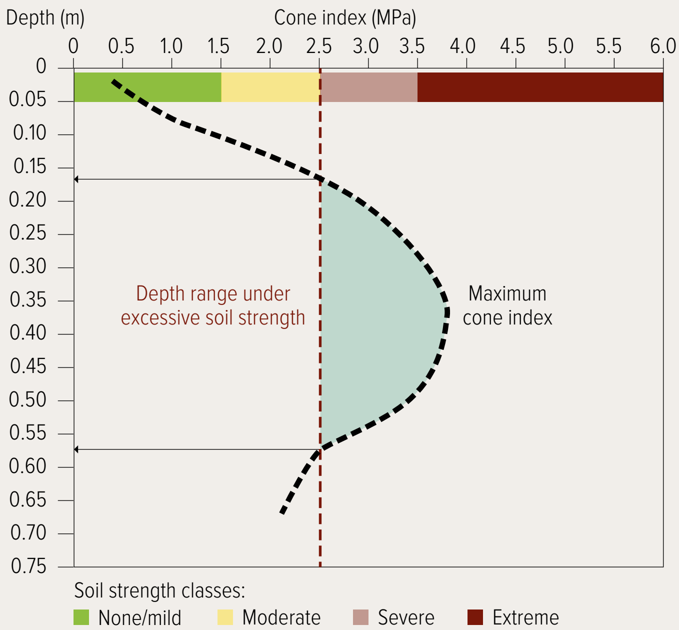
[+]Source: clay soil data after Spoor and Godwin 1978; Godwin et al. 1984

Photo 3: Curved slanted narrow shank ripper for low disturbance loosening.

Photo: Jack Desbiolles

A continuous wave of soil upheave can be obtained when tynes operate in unison, side-by-side on a single rank. A commercial application optimised with narrow shank tynes fitted with large, low-lift wings and offset points (for example, *Agrisem* TCS blade) reports significant draught savings per metre width. Research is underway to shed light on the above under Australian sandy soil contexts.

**Figure 5: Example cone penetration resistance highlighting excessive soil strength (shaded portion > 2.5MPa) and the required depth of loosening – about 0.6m*. Note: The severity of excessive soil strength arises from the maximum cone index value and the associated depth range. The energy required to loosen the soil profile increases with the total area under the cone index curve, particularly in the deeper part.**




*The required ripper depth will vary according to its ability to extend soil loosening into the zone between tynes. High efficiency tyne design and layouts minimise the extra depth setting below the identified depth of constraint.

## Paddock guide

### Cone penetration data

The ripper draught requirement is a direct function of 'soil strength', critically affected by soil moisture and exacerbated by physical soil compaction (packing density) and hardsetting behaviour. The cone penetration resistance – measured at field capacity – quantifies the severity of 'excessive' soil strength (cone index > 2.5 Megapascals [MPa], see Figure 5) significantly impacting root growth and plant vigour, and identifying the depth of loosening required for remediation purposes.

### Tractor considerations

The tractor's ability to deliver drawbar power is controlled by its weight and tractive efficiency, the latter being a function of the traction device (tyre/track) and the soil surface conditions. In high draught tillage operations, the tractor can be either traction or power limited.

*Traction-limited* situations occur when there is not enough grip at the soil surface to deliver the required pull at the drawbar. This is very common when ripping deep and in soft surface sand conditions. Increasing traction capacity requires extra weight onto the driving axles (for example, ballast or via weight transfer) and improved traction device efficiency (for example, lower tyre pressures, use of high flex tyres, duals/ triples, tracks). A balance between slippage and rolling resistance losses is required for optimising tractor power use efficiency.

*Power-limited* situations occur when good traction under heavy weight loading is available relative to the implement draught requirement (for example, narrower ripper or shallower ripping in firm soil conditions). This situation allows for higher ripping speeds up to the limit of the available tractor power.

Tractor–implement matching is always important to avoid power-limited conditions at low ripping speeds, where the tractor transmission can be overloaded under excessive torque, leading to damage over time. In this instance, reducing the implement draught load (for example, narrower width) is the safest approach that also allows higher speeds to match the initial work rates.

## In-paddock checks

When assessing ripper performance in the paddock, consider the following:

- Adjust deep ripping depth from the unripped surface, probing to the lowest point in the profile, adjust the ripper front to back and across to achieve uniformity.
- The surface upheave is a key indicator of reduction in soil bulk density from the extent of loosening and clod rearrangement within the profile. Operating below critical depth will show minimal upheave, while low-disturbance, even-lift subsoilers may also leave a flat finish with limited signs of loosening, except a reduction in soil strength.
- Using a simple 12mm diameter push rod (feeler probe with handle), assess the loosened profile by gauging every 50mm across rip lines for the shape and depth of the unripped boundary. Adjust the ripper depth to ensure the full depth of soil strength constraint is loosened between rip-lines.
- An open pit is useful to visualise the extent of clod rearrangement, clod size and soil layer mixing within the profile.

## USEFUL RESOURCES

Godwin R.J. (2007). **A review of the effect of implement geometry on soil failure and implement forces**. *Soil and Tillage Research*, 97(2): 331-340.

Keller T. and A.R. Dexter (2011). **Plastic limits of agricultural soils as functions of soil texture and organic matter content**. *Soil Research* 50(1): 7-17.

Weill A. (2015). **A Guide to Successful Subsoiling**. cetab.bio/wp-content/uploads/2015/11/weill_2015._guide_to_successful_subsoiling._cetab.pdf.

GRDC fact sheet: ***Physical Soil Constraints*** (2022). grdc.com.au/resources-and-publications/all-publications/factsheets/2022/physical-soil-constraints-fact-sheet.

GRDC fact sheet: ***Diagnosing Sandy Soil Constraints: High Soil Strength*** (2022). grdc.com.au/diagnosing-sandy-soil-constraints-high-soil-strength-south-west

GRDC fact sheet: ***Inclusion Ripping Technology*** (2022). grdc.com.au/inclusion-ripping-technology-national

GRDC Update Paper: ***Ameliorating sandy soils to overcome soil constraints and improve profit*** (2022). grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2022/07/ameliorating-sandy-soils-to-overcome-soil-constraints-and-improve-profit.

GRDC Update Paper: ***Deep ripping – where it will work (and where it won't)*** (2020). 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.

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Godwin R.J., Spoor and M.S. Soomro (1984). **The effect of tine arrangement on soil forces and disturbance**. J. Agric. Eng. Res. 30: 47-56.

Hamza M.A., G.P. Riethmuller and W.K. Anderson (2013). **Experimental subsoiling by in-line shallow and deep tines**. *Soil Research* 51:477-483.

GRDC (2021). **Deep Ripping Fact Sheets** –
**Northern region:** grdc.com.au/resources-and-publications/all-publications/factsheets/2022/correcting-layers-of-high-soil-strength-with-deep-tillage-northern-region.

**Southern region:** grdc.com.au/resources-and-publications/all-publications/factsheets/2021/correcting-layers-of-high-soil-strength-with-deep-tillage-southern-region.

**Western region:** grdc.com.au/resources-and-publications/all-publications/factsheets/2021/correcting-layers-of-high-soil-strength-with-deep-tillage-western-region.

## MORE INFORMATION

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