Revegetation site-preparation
in the WA Wheatbelt

Ripping and Mound ploughing

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DEPARTMENT OF Conservation AND LAND MANAGEMENT
Conserving the nature of WA

Bushcare
The National Vegetation Initiative

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Cover photographs: A multi tyned ripper and a two-disc mound plough. Inset photo's show the progression from undisturbed soil to ripped soil to mounded soil. Photo's taken at Dongolocking and Toolibin in the WA wheatbelt.

Photos by G D Mullan unless otherwise stated.

Contents

Overview

This report explores the reasoning behind applying a particular site-preparation regime. It is designed to enable farmers and those involved with delivering best practice establishment techniques to make appropriate decisions.

Ripping and mound ploughing for revegetation establishment are techniques used to improve the success (survival and growth rates) of planted seedlings. To optimise the benefits of ripping and mound ploughing in the wheatbelt, machinery suited to the range of conditions is required.

In addition to improving establishment success, using this machinery correctly will greatly improve the ease and speed of the two common planting methods (i.e. using a machine planter or tube type hand planters).

Improving the ease and speed of planting is critically important to:

- minimise seedling mortality caused by the planting operation. For example, there is an increased risk of parts of the seedling root plug being out of contact with the soil when planting into a hard 'cloddy' soil.
- facilitate planting large numbers of seedlings.
- being able to take full advantage of the planting opportunity in ‘windows’ of suitable planting conditions (the lower the rainfall, the more important this is).
- encourage the development of a local pool of skilled planting personnel.
- minimise planting costs.

Section 1. RIPPING

Interpretation of Ripping

Ripping is addressed in terms of its contribution to optimal plant growth and survival.

Ripping aims to:

- fracture the hardpans imposed by agricultural activities, i.e. 'cultivation' and 'traffic' hardpans.
- minimise mixing of the subsoil with topsoil.
- be part of an approach that prepares the soil surface suitable for herbicide application (for chemical weed control).
- minimise costs by ripping only to the minimum depth required.

1.1. The need for ripping (a - e)

a) **Fracture agricultural hardpan(s).**
Either one of two types:

Research shows that most agricultural soils will have a hardpan that justifies ripping. For example, a traffic hardpan can develop after as few as 5 – 10 passes with agricultural machinery.

The two types of hard pans and their impacts are:

- **‘cultivation’ hardpan**. Severely restricts water (and nutrients) and root penetration (fig. 2).
- **‘traffic’ hardpan**. Severely restricts root growth, however, water (and nutrients) can move through a traffic hardpan (fig. 3).

Fracturing these hardpans will allow an easy path for rapid root penetration. This is critical to seedling survival, particularly in the first summer.

b) **Reduce waterlogging and drought risks**.

Improved water infiltration and root penetration reduces the risks associated with both shallow sub-surface waterlogging and drought conditions. Seedlings are particularly vulnerable in the year of establishment. An exception to this may exist with ripping duplex soils (see 1.4 (a)).

c) **Water harvesting**.

Ripping allows interception of surface water flow, especially when rip lines are parallel or near to the contour.

d) **Provides planting line**.

Ripping defines the orientation of revegetation within the site and in part, the density of the planting. Note that ripping in advance of planting allows time for site planning compared with a one-pass operation (combined ripping and planting). For example, soil characteristics observed during ripping may enable an improved choice of species distribution across the site.

e) **Soil loosening**.

Most soils require some form of ripping or cultivation to enable penetration of tree planting tools such as pottiputki's and machine planters. Soil loosening is particularly important in preparing soil for mound ploughing (see 1.5 (d) Benefits:).

1.2. Caution needed in some soil types (a - b)

a) **Shallow duplex soils**.

A rip line in a shallow duplex soil can act as a reservoir for moisture and may result in waterlogging. For example, where the sub-surface soil texture change occurs within 30 cm of the surface.

Waterlogging in a rip line in this soil type promotes the depletion of soil oxygen and the build up of fungus. Soil oxygen is necessary for plant survival and fungus build up is detrimental to root development. Constructing a mound in these situations will eliminate this problem.

The above problem is encountered in higher rainfall areas (greater than 600 mm), however, is not yet confirmed in the less than 600 mm zone. Given that a substantial area of the wheatbelt has shallow duplex soils, we recommend interpretation of the waterlogging risk at each site.

b) **Deep sands with low mechanical strength**.

- **Tree stability**. Ripping extremely sandy soils in windy areas has been reported as a problem for tree stability, especially in the first five years of growth. However, we consider that this problem is more likely to be a result of poor seedling root form.

  Conversely, not ripping a sandy area can also result in tree instability. We consider that a traffic hardpan will exist in this soil type, and so we recommend ripping as the preferred option.

- **Sandblasting of seedlings**. Where strong winds are likely, ripping should aim to disturb as little topsoil as possible. Constructing a furrow (a 'v' shaped depression) and planting into this minimises the exposure of seedlings to sandblasting.

  Alternatively, deep sandy soils are the one area in the wheatbelt where a single pass rip-scalp-plant appears appropriate.

1.3. Direction of ripping (a - b)

a) **Reducing risk of erosion**.

We recommend ripping on or very near to the contour to minimise or eliminate erosion risk (fig. 1). Ripping along the contour also contributes to establishing nutrient cycling processes through increasing water infiltration and the retention of leaf litter. These factors all reduce the loss of natural resources from the site and improve the foundations for ecological functioning.

The practice of ripping across the contour increases both the risk and severity of erosion. That is, up and down slopes of about 2% or greater.

Figure 1. Contour ripping. Contour lines were surveyed and ripped on this breakaway slope to eliminate erosion risk and aid water and nutrient retention.

b) **Reduced need for contour banks**.

In situations where block areas are ripped with little catchment up-slope, contour ripping can reduce the need for contour banks. For example, arable land immediately down-slope of breakaway areas often requires some form of surface water run-off protection. After ripping such a breakaway slope at closely spaced intervals we observed little surface water run-off (at least in the first few years) (fig. 1).

1.4. Ripping depth

Our ripping depth recommendations are based on the principles developed for plantation establishment in the south-west of Western Australia (greater than 600 mm rainfall zone). We have shown these principles to be readily transportable to wheatbelt conditions and that they apply equally as well.

It is unnecessary to rip any deeper than 10 cm below the 'traffic' or 'cultivation' hardpan for optimal plant growth. For example, the maximum ripping depth will be 30 cm in soils with a cultivation hardpan. Where a traffic hardpan exists the maximum ripping depth will be 45 – 50 cm (fig. 2 and 3).

Ripping deeper for other purposes may be appropriate in some circumstances. For example, on short steep inclines such as breakaways where surface water run-off is high and water harvesting is both necessary and beneficial.

Ripping to the minimum depth required has two main advantages. These are:

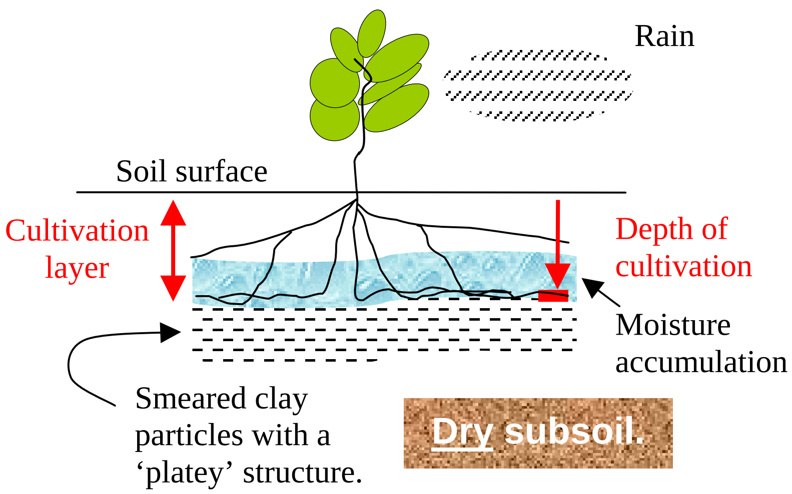
- Minimises subsoil mixing with topsoil. Excessive ripping depth contributes to the lifting of subsoil boulders into the topsoil layer. Diluting the topsoil reduces the availability of plant nutrients.

- Minimising the cost of ripping.

Note that there is no substitute for matching species to soil type / soil conditions, e.g. ripping a hard clay soil will provide few advantages to a species that normally thrives in sandy loam.

Agricultural hardpans that affect plant growth
The two types of hardpans, 'Cultivation' and 'Traffic', are a result of physical subsoil compaction

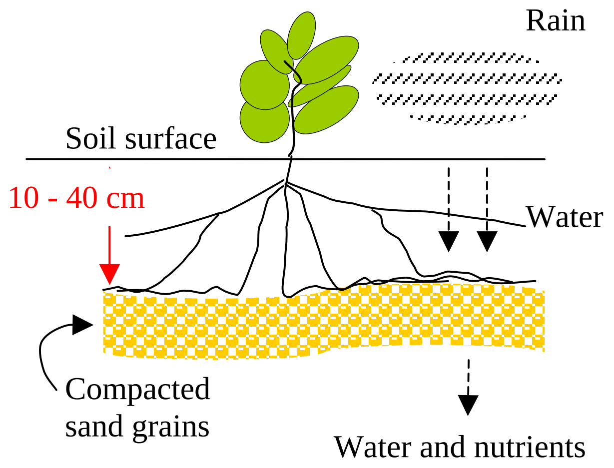
Cultivation hardpan



- Occurs in fine textured (***clay***) soils.
- Caused by the collective structure of moist clay soils breaking down through cultivation. Smearing of clay at the cultivation depth also results from cultivation.
- Occurs immediately below the cultivation layer.
- Clay aggregates often form a characteristic 'platey' structure.
- The hardpan inhibits moisture (and nutrient) movement and severely restricts root penetration.

Figure 2. Effect of a cultivation hardpan on plant root growth and water and nutrient infiltration.

Traffic hardpan



- Occurs in poorly structured ***sands and sandy loams*** (less than 30 % clay) and duplex soils with clay or gravel at greater than 30 cm depth.
- Caused predominantly by heavy machinery. A traffic hardpan can develop after 5 – 10 passes with a tractor.
- Occurs in the 10 to 40 cm zone below the soil surface.
- Sand grains compact and interlock. The soil structure becomes rigid. This severely restricts root penetration but allows water and nutrient penetration.

Figure 3. Effect of a traffic hardpan on plant root growth, water and nutrient infiltration.

1.5. Not just any old ripper will do!

There are four main ripper designs to choose from. These are listed and each of their benefits and disadvantages identified.

a) **Single tyne; rigid tyne assembly; three point linkage (3PL),** (fig.4).

Photo: Wilson Engineering

Figure 4. A basic single tyne, three-point linkage ripper showing rigid tyne construction.

Benefits:
- Relatively cheap to buy or construct.

Disadvantages:
- rigid tyne is at risk of breaking, particularly when connected to a large and / or 4WD tractor.
- Many wheatbelt farm tractors don't have 3PL.
- Requires loading onto, and unloading from, a road vehicle for transport between farms.
- A single tyne fractures a limited width of the agricultural hardpan.
- Seedling placement options are limited with a single rip line.

b) **Single tyne; rigid tyne assembly; trailable** (this type includes tree planting machines), (fig 5 and 6).

Figure 5. A single tyne, trailable ripper with rigid tyne construction.

Benefits:
- It's trailable on the open road.

Disadvantages:
- rigid tyne is at risk of breaking, particularly when connected to a large and / or 4WD tractor.
- A single tyne fractures a limited width of the agricultural hardpan.
- Seedling placement is limited to a single rip line.

Photo: Dan Huxtable

Figure 6. A one-pass tree planting implement. It has a single rigid tyne and is trailable.

The benefits and disadvantages of the above tree planting implement are the same as for figure 5. Note, this is based on its use as a ripper only.

c) **Multi-tyne; shear pin breakout tyne assembly; 3PL** (fig. 7).

Figure 7. A five tyned 3PL implement with shear pin tyne breakout.

Benefits:

- The multi tynes fracture a wider area of the agricultural hardpan as compared to a single tyned implement.
- The multi tynes allow for a greater surface area of the revegetation site to be planted (using hand - tube type - planters).
- Minimises erosion from surface water run-off on the revegetation site.
- Increases water conservation on the revegetation site.
- Rips to the width of the digging discs of a mound plough. This greatly increases the capacity to construct a well formed mound.
- The shear pin tyne breakout gives tyne and structural protection.

Disadvantages:

- In hard soil, the shear pins require replacing often. This reduces the speed of the ripping operation.
- Shear pins can easily be replaced with non-compliance (higher shear rating) pins. This is essentially a disadvantage as it risks tyne and implement damage.
- Requires loading onto, and unloading from, a road vehicle for transport between farms.
- Requires tractor 3PL.

d) **Multi-tyne; hydraulic breakout tyne assembly; trailable** (fig. 8).

Figure 8. A seven tyned trailable implement with hydraulic tyne breakout.

Benefits:

- The multi tynes fracture a wider area of the agricultural hardpan as compared to a single tyned implement.
- The multi tynes allow for a greater surface area of the revegetation site to be planted (using hand - tube type - planters).
- Minimises erosion from surface water run-off on the revegetation site.
- Increases water conservation on the revegetation site.
- Rips to the width of the digging discs of a mound plough. This greatly increases the capacity to construct a well formed mound.
- The hydraulic tyne breakout optimises protection to the tynes and the implement structure.
- The hydraulic tyne breakout contributes to making this implement suitable for sharing, i.e. there is increased structural security and so less likelihood of major damage.
- It's trailable on the open road with a light truck or similar.
- Doesn’t require tractor 3PL.

Disadvantages:

- Relatively expensive to purchase. However, we consider overall, this implement offers superior value for money, especially if shared.

e) **An alternative**.

Given moist soil conditions, and in some soil types, a regular farm scarifier will rip to a sufficient depth. However, as scarifiers are not designed for this use, we consider their application to be minimal.

In tough soils a scarifier can be put to good use by applying a shallow pre-rip. This has the benefit of easing the load on the dedicated ripper.

1.6. More on multi tynes (in case you're not convinced yet!).

We contend that fracturing the agricultural hardpan for all the roots (not just vertical roots) is worthwhile (Fig. 9 and 10).

The two main benefits to a seedling of fracturing the agricultural hardpan across a revegetation site are:

- **Improved root access**: All seedling roots have improved access to the subsoil.
- **Removal of risk factors to plant survival**: An unfractured agricultural hardpan contributes to waterlogging and drought in the soil profile above it. We have observed that the use of a multi tyned ripper has contributed to seedling survival in a below average rainfall year in the wheatbelt (note that below average rainfall is a common occurrence!). We also expect that seedling performance (growth rate) will benefit.

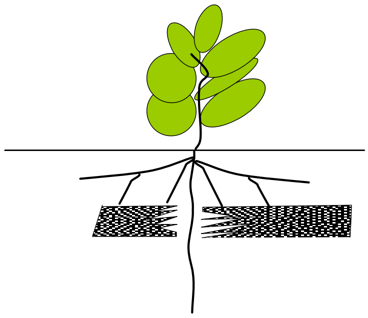


Figure 9. Diagrammatic representation of a seedling, seedling roots and an agricultural hardpan after being ripped with a single tyned implement. Note that the lateral and diagonal roots will be influenced by the undisturbed agricultural hardpan.

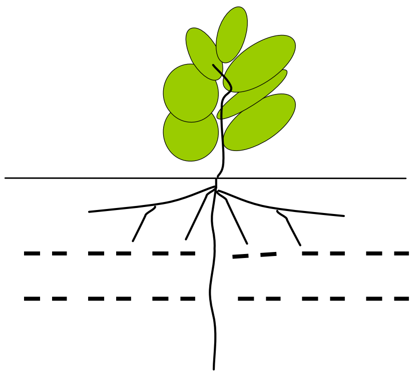


Figure 10. Diagrammatic representation of a seedling, seedling roots and an agricultural hardpan after being ripped with a multi tyned implement. Note that the lateral and diagonal roots have unrestricted access to the subsoil.

1.7. When to rip (a - c)

a) **You need to know the background**.

For ease of hand planting (tube type), and effective herbicide weed control, we strongly recommend a flat and smooth soil surface. A flat and smooth soil surface is fundamental to:

- achieving effective herbicide weed control (see 2.1, (b)).
- minimising the risk of herbicide damage to seedlings. Damage occurs when rainfall concentrates residual herbicides after it's applied to an uneven or rough soil surface.

b) **Does soil type matter? Yes!**

If the soil surface is very rough after ripping, then it's going to need some attention. This is where an understanding of the soil type really matters. For example, clay soil boulders will shatter only if dry enough. We have successfully used a roller for this operation (fig. 11).

Conversely, if clay boulders are moist, shattering is often impossible. The result of rolling or driving over moist clay boulders is a flattened mass of clay that is very difficult to form into a mound (if mounding) and extremely difficult to plant into.

Therefore, we recommend ripping clay type soils in the driest months, i.e. Jan - April. A down-side of this approach is that wear and tear on ripping machinery will be at its greatest during this time.

An alternative is as follows:

1. Rip clay type soils in late spring or when subsoil moisture is moderate (or after summer rain).
2. Roll surface boulders anytime during driest months.

Figure 11. This roller was used successfully to shatter 'dry' clay boulders on the soil surface. It was also used for lowering (flattening and smoothing also) the profile of a mound (see mound ploughing section).

c) **Availability of a suitable ripper**.

The ripping implement that we recommend (multi tyned with hydraulic tyne breakout) is currently the only one of its kind in the wheatbelt as at October 2002 (that we are aware of). This implement is based at the Department of Conservation and Land Management's Narrogin District Office. It is hired out from this office.

Demand for this ripper in its first year of operation was concentrated in the months of May, June, July and part of August. This resulted in demand exceeding the ability to supply the ripper.

The message: we recommend ripping outside of the traditional peak demand period. For example, during the Spring months or after a Summer rain.

In Brief – key points of ripping

Key points	• There is little advantage in ripping deeper than 10 cm below the cultivation or traffic hardpan (about 20 – 30 cm and 45 – 50 cm respectively). • Increased ripping depth (beyond the requirements for optimal plant establishment) may be appropriate in some situations. For example, a breakaway with steep clayey soils where minimising surface water run-off is essential. • Multi-tyned ripping has many advantages.
Benefits	• Fractures hardpan allowing plant root penetration (cultivation or traffic hardpans). This action also reduces waterlogging and drought risks. • Harvests water (especially when oriented on the contour). • Provides a planting line. • Loosens soil for ease of planting.
Caution needed in some soil types	• Ripping shallow duplex soils may increase the risk of waterlogging of seedlings. However, mound ploughing will eliminate this problem. • Deep sands with low mechanical strength (plant stability and sandblasting issues).

Section 2. MOUND PLOUGHING

Interpretation of mound ploughing.

Mound ploughing is the practice of '*surface cultivation that concentrates or builds up the surface of the land*'.

Raising the soil above ground level is only a requirement to reduce the effects of waterlogging on seedlings. Where waterlogging is not an issue, mounds can be constructed with less height or rolled down to just above ground level.

An effective mound has:

- concentrated topsoil.
- either a flat and smooth top no less than 0.5 m wide or a 'v' notch surface.
- aerated soil.
- reduced soil density.

2.1. Is mound ploughing effective in the wheatbelt? Yes! Why? (a - f)

a) **Increases nutrient availability**.

The process of heaping topsoil into a mound concentrates the topsoil. Research shows that the higher organic matter in the concentrated topsoil gives seedlings increased access to nutrients.

The extra organic matter also increases the soil water and nutrient holding capacity. In addition, decomposition of the extra organic matter adds further organic colloid (very fine organic matter particles) to the soil and thus increases total soil nitrogen and available phosphorus.

These increases are all substantially greater than those in a similar depth of non-mounded soil. Note: we do not recommend incorporating high levels of surface organic material into mounds, e.g. crop stubbles or green material. We have observed this to interfere with herbicide effectiveness and create dry zones and toxicity problems within the mound.

Within the mound there is also an increase in topsoil depth, e.g. accumulating topsoil can easily double its original depth. The mound height is proportional to the width apart of the mounding discs, i.e. the greater the width of topsoil used to build the mound, the greater the depth of topsoil achieved in the mound. For example, a mound plough incorporating six off-set disks (fig. 12) will produce a mound with greater depth (and volume) of topsoil than a machine with fewer discs and less width (fig. 13).

We have only tested the implement with two off-set disks (fig. 13) on a multi tyned rip line. This has produced successful results so far. We cannot comment as yet, on the comparison between a two-disc mound plough and other mound ploughs with greater than two disks.

Photo: Peter White

Figure 12. A mound plough with six off-set digging disks.

Figure 13. A mound plough with two off-set digging discs.

b) **Improves effectiveness of herbicide weed control.**

The ideal soil surface to apply a residual herbicide is flat and smooth (fig. 14). This is hard to achieve without first raising the soil into a mound. The mound plough press-wheel is therefore very important in shaping the top of the mound (fig. 20).

Residual herbicides commonly used for weed control prior to revegetation (e.g. Simazine and Atrizine) depend on forming a 'blanket' type layer in the top few millimetres of soil. This herbicide layer acts on the fine roots of germinating weeds, i.e. the mode of herbicide activity is via root uptake.

Two problems with an uneven or rough soil surface are:

- A proportion of the soil surface will be hidden from spray droplets when applying herbicide. This means that weeds can germinate and grow unaffected (fig. 15).
- Concentration of residual herbicides before and after planting. For example, a residual herbicide applied over an open rip line will concentrate, especially in the lowest part of the rip line (after rainfall). Seedlings planted into this or exposed to this after planting will usually die or suffer severe herbicide damage (fig. 15).

  Note that as a consequence of herbicide concentration, some of the soil surface will lack herbicide and therefore give no barrier to weed growth.

Figure 14. A flat and smooth topped mound. This surface is ideal for effective herbicide weed control.

Figure 15. An open rip line is an unsuitable surface for effective herbicide weed control. Image shows a dozer implementing a single rip line. Also note the subsoil boulders in the centre of the rip line are now mixed with the topsoil. This is a result, in part, of excessive ripping depth.

c) **Minimises waterlogging**

One of the key reasons for mounding is to improve drainage of the zone of planting. This is achieved by raising the soil above ground level. This allows seedling roots to develop in an unsaturated soil zone.

Plants growing in salt-affected soils are most affected by waterlogging. Plants experiencing a lack of soil oxygen through waterlogging can't manufacture enough energy required to displace salt (NaCl) from their roots (except for salt loving plants). Seedling mortality occurs very rapidly in these salty and waterlogged conditions.

The height of the mound should be proportional to the expected waterlogging potential, i.e. constructing high mounds where waterlogging is expected (20 cm + above soil surface, after settling). Conversely, where drainage is not an issue, there is no necessity to leave the mound raised above ground level. We have tried rolling mounds with excellent results (fig. 16 and 17).

Figure 16. In areas without the threat of waterlogging, rolled mounds were very successful. We observed improved weed control, increased speed and effectiveness of planting, elimination of the risk of residual herbicide damage and improved survival (planted with pottiputki's). Image shows four month old York gum (*Eucalyptus loxophleba*) seedlings on rolled mounds.

Figure 17. Rolled mounds were also very successful in sandy and sandy gravel soils. We observed improved weed control; increased speed and effectiveness of planting; elimination of the risk of residual herbicide damage; and improved survival (planted with pottiputki's). Image shows four month old York gum (*Eucalyptus loxophleba*) seedlings on rolled mounds.

d) **Leaches salt from soil**

Mounds built with a 'v' notch press-wheel create conditions that aid the leaching of soil salt (NaCl) from immediately below the 'v' impression (Fig. 22). Leaching of salt is important to improve seedling survival and early growth rates in saline soil.

Leaching is particularly important when establishing vegetation from seed, i.e. direct seeding. Most seeds require conditions relatively free from salt to germinate. This includes many halophytic species (species adapted to saline conditions). Note that studies have shown that the leaching effect created by the 'v' notch press-wheel will not persist (effect is negligible after 12 months). We strongly recommend planting in the year of mound construction.

The use of a 'v' notch press-wheel is appropriate only when leaching of salt is required. In all other instances, we recommend the use of a flat press-wheel giving a flat and smooth topped mound.

Note that the use of a residual herbicide is not recommended with a 'v' notch mound. For example, harvesting water from a 10 cm wide 'v' notch and concentrating this water into the middle 5 cm zone effectively doubles the concentration of the residual herbicide. In this instance, 4 L per ha becomes 8 L per ha in a localised area around the seedling. This places the seedling at high risk of herbicide damage or death.

Using lower rates of herbicide to counteract the problem of concentration is an ineffective approach. There are two aspects to consider. These are:

- It's risky estimating how much concentration will occur, i.e. it will vary each year.
- By definition, when herbicide concentration occurs, other parts of the mound will lack herbicide and so, lack effective weed control. In this instance, the 'v' shoulder is likely to develop a weed burden.

e) **Reduces soil density**

Soil conditions are improved for plant root development when the density of agricultural soil is reduced. Machinery, cultivation and stock have caused compaction and thus increased density of most agricultural soils. Increased soil density raises the risk of waterlogging damage to plants.

f) **Aerates the soil**

Soil aeration promotes root growth and development. Plant roots and soil organisms require a regular and adequate supply of oxygen.

Compacted soils or soils with a high water table are those most at risk from a lack of oxygen. Mounding these soils greatly improves soil aeration.

2.2. Is mound ploughing beneficial in all soil conditions? No. Which conditions are these? (a - d)

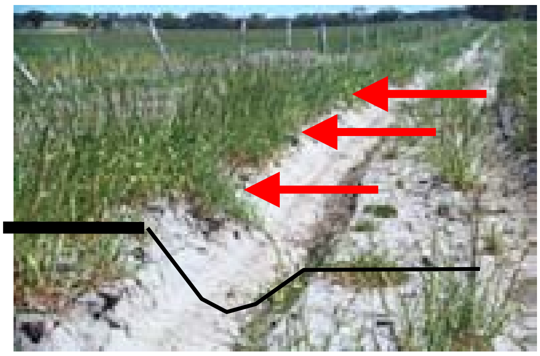
a) **Non wetting soils**

As the mounding process increases the effective depth of topsoil, this will also increase the depth of non wetting soil. The top 10 cm is often the most non wetting or water repellent. The main problems are:

- very poor herbicide weed control, i.e. residual herbicide is often washed or blown off, or is inactive through the absence of moisture (fig. 18).
- poor plant survival through dry soil conditions.

Alternatives to mound ploughing include topsoil scalping and creating a 'v' shaped furrow for seedling placement. The furrow traps and concentrates water and improves the chances of soil wetting.

Note that furrows can also concentrate herbicide. Scalping will, however, remove the weed burden and remove the requirement for pre-planting herbicide weed control.



Arrows and thickened line indicate mound top surface.

Figure 17. Mounded water repellent soil showing very poor herbicide weed control, despite being sprayed with a residual herbicide prior to weed germination.

b) **Deep sands with low mechanical strength**

Plant stability is the issue here. Two factors contribute to this. These are soil strength and wind exposure.

Only wind exposure can be managed in this instance. Raising the soil profile to any degree will raise the seedling further into the elements. Therefore we recommend not to mound.

c) **Some valley floor situations**

When an alley-farming layout is intended on a valley floor, surface water management should be the first consideration. Valley floors are characterised by having little gradient and scattered shallow depressions (areas of water ponding). The direction of surface water movement in such areas is often difficult to determine.

We have witnessed a valley floor area where an extensive network of mounds (as per alley farming layout) impeded the natural flow of surface water. This caused added water ponding and potential for recharge.

The minimisation of on-site recharge should be a major objective in such areas. Therefore, we recommend that any form of earthworks, other than for surface water management, should be avoided (i.e. mounds).

We have implemented an oil mallee alley layout on a valley floor. The water ponding and surface water flow was managed by a surveyed 'W drain' (fig. 19). Planting lines were prepared flat (at ground level) to ensure no obstruction to surface water flow (fig. 20).

The above site preparation worked effectively and we strongly recommend this approach on valley floors.

Line indicates 'W drain' cross section.

Figure 19. A 'W drain' was used to manage surface water flow and drain ponded water on a valley floor site. Note that the location of the 'W drain' influenced the alley layout, i.e. it was important to design the water management layout before the alley layout.

Figure 20. Planting lines were prepared flat (at ground level) to ensure no obstruction to surface water flow.

d) **Used as contour banks**

Mounds should not be used as contour banks or located without upslope surface water protection. The outside trough of a mound has a low volume capacity and can not cope with any upslope water catchment in a large runoff event. Erosion will result if mounds breach.

Even when surface water protection is in place we recommend leaving regular staggered gaps in the mounds (e.g. every 50 m) to further minimise the risk of erosion.

The two types of mound surfaces

Line indicates mound cross section

Figure 21. A flat top mound and the flat press-wheel used for its construction. The press-wheel, as shown here, allows for weight adjustment (filling with water). The press-wheel is constructed from a 13 mm thick section of 560 mm diameter steel pipe (inset). This gives the press wheel weight and durability. We recommend that the press-wheel design also incorporates positive downward pressure. Note: the mound shows a smooth and flat surface (about 50 cm wide) suitable for herbicide application and walking along during the planting operation.

Line indicates mound cross section

Figure 22. A two-year-old ‘v’ notch mound and the press-wheel used for its construction. This design is used in saline soil conditions where temporary leaching of soil salt is necessary for establishment of seedlings or seeds.

In Brief – key points of mound ploughing

Key points	• Mound ploughing gives multiple benefits. • Mounded soil will benefit plant growth and survival in the majority of soil types and site conditions.
Benefits	• Increased nutrient availability. • Improved effectiveness of herbicide weed control, including minimising risks of herbicide concentration. • Minimises waterlogging. • Use of a 'v' notch press-wheel allows leaching of salt and freshens salt-affected soils in the year of construction. • Reduces soil density. • Aerates the soil.
Conditions where mounds are NOT appropriate	• Non-wetting soils. • Deep sands with low mechanical strength. • Some valley floor situations. • Used as contour banks.

Other considerations not previously mentioned:

Spacing.	Incorporate access for spraying and / or harvesting operations (tree harvesting).
Alley farming layouts. Breaks for access/mustering.	Incorporate access gaps at intervals less than or equal to 100 m.

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