Spading to overcome non wetting soil

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FAST FACTS

- Spading improved the germination of crop and weeds and increased crop grain yield
- Seeding into spaded soil is difficult
- Wind erosion is a big risk. Ensure high stubble load before spading and sow a cereal cover crop as early possible

Farm details

FARM NAME	"Tree View" & "Calleen"
FARMERS	Michael & Julia O'Callaghan
LOCATION	Marchagee
AVERAGE RAINFALL	350mm
FARM SIZE	5550 ha (3550 ha owned; 1000 ha share-farmed; 1000 ha leased)
ENTERPRISE MIX	5000 ha cropping, Dorper sheep stud
SOIL TYPES	Deep sand and deep loamy sand

The Problem

Water repellence is a common problem on sandy-textured soils. It is caused by water repellent waxes and other organic plant residues that coat the soil particles making a water repellent layer that prevents water from readily entering the soil. Typically water repellence results in delayed, staggered and uneven establishment of crops and weeds (Davies 2010).

Michael O'Callaghan suspected non wetting sands were constraining crop production after observing poor germination and dry patches in the soil. "We knew we had a problem when we found lupin seeds in the soil ungerminated 2 years after the crop was planted. The lupin quality was as good as if they had been stored in a silo." Michael, like many other growers, believes the non wetting problem is getting more severe over time. This could be because minimum tillage is concentrating organic matter on the soil surface and the organic matter contains waxy residues that contribute to non-wetting. While this is a logical theory and is supported by similar observations by many other growers there is no scientific research to support these observations at this stage. It is also possible that late season breaks and reduced winter rainfall are making the problem more apparent.

There are a number of methods for overcoming non wetting soils and it is still unclear which methods might be best suited to specific soil types. Recent research and grower trials indicate that the one-off use of a rotary spader to deeply cultivate and bring subsoil to the surface may be an option for overcoming non wetting soil. Depending on the soil type, this subsoil can also have a higher clay content which can also be beneficial for overcoming non wetting. The 'spade' on rotary spader tynes can partially invert as well as mix the soil to a depth of 25-30cm. It is estimated that the rotary spader buries two-thirds of the topsoil with the remaining one-third mixed through the topsoil (Davies, 2010).

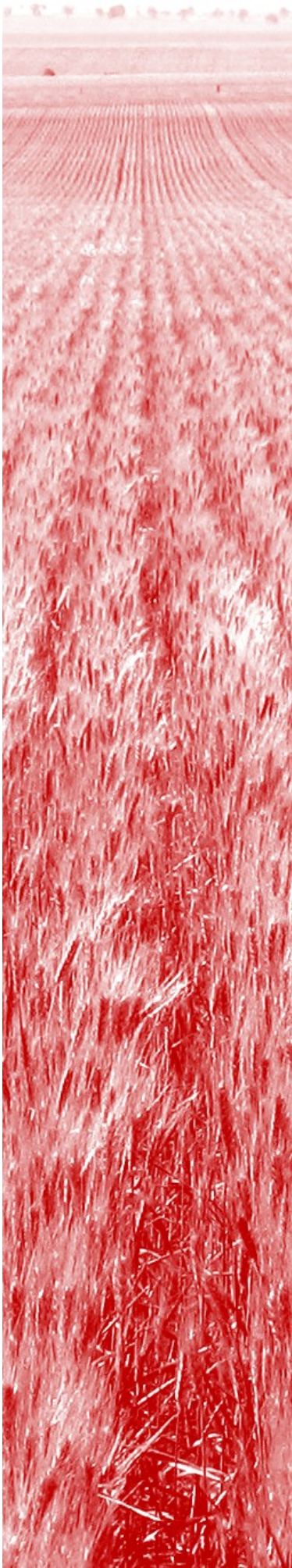
Initial idea

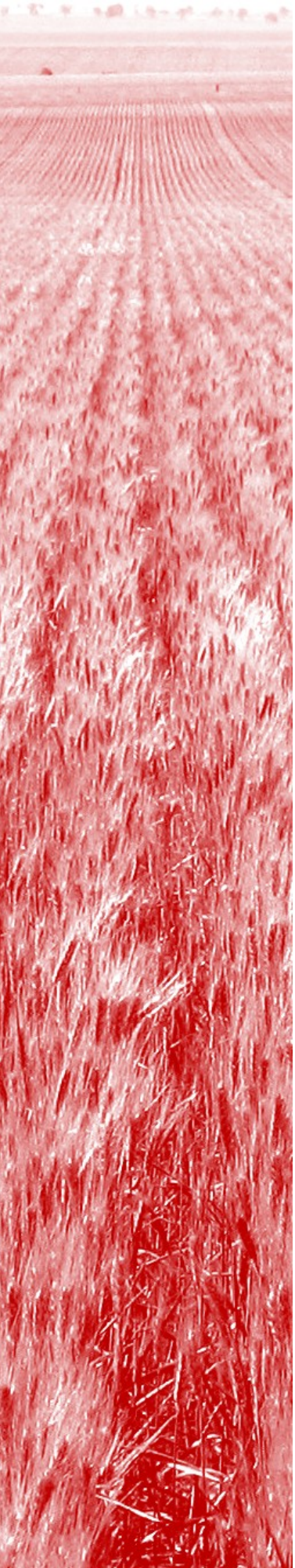
In 2009 Michael visited a grower trial at Badgingarra which compared rotary spading on a sandy soil with and without the addition of clay. The results from that trial indicated that spading could improve water infiltration without the addition of clay, therefore saving on costs. Mouldboard ploughing was also considered as a tool after observing it at Mingenew and while Michael felt the plough did a good job of burying non wetting soil and weed seeds he considered the risk of wind erosion after using a mouldboard too great. "One big wind and the paddock would have blown away, at least with a spader some of the stubble remains on the surface". Michael was also concerned that complete soil inversion could bring too much acid subsoil to the surface.

In the past Michael has tried claying some of the non-wetting areas on his property but was not happy with this technique because it was expensive and the applied clay-rich soil was hard to incorporate. Therefore in 2010 Michael decided to try spading, he hired a local contractor to spade a few paddocks and collaborated with the Liebe Group and Stephen Davies at the WA Department of Agriculture and Food, Geraldton to monitor the results.

Will my soil respond to spading?

Not all soils respond equally well to spading. Soil with some clay (>5%) within the spading depth and good subsoil water holding capacity are preferable. The benefits of spading are not as great on pale deep sands with low water holding capacity and could be uneconomical. Use of spaders on soils with loam or finer texture may result in damage to the soil structure (i.e. aggregates and pores) and is not recommended (Davies, 2010).





Identifying non wetting soil—conducting the Droplet Test

Scrape off the top 2-3mm of soil then gently place a drop of water on the dry level soil. If the droplet remains as a bead for more than 10 seconds and does not infiltrate the soil then it is non-wetting. The soil needs to be tested when it is dry, usually in summer, as moisture already in the soil will result in an inaccurate estimate the water repellence.

The machine

The spader, made by the Dutch company IMANTS, is 4.5m wide with 60 spades. Spades mix the soil to a depth of 300 - 350 mm. The spader is pulled by a 250 horse power tractor with PTO drive and operates at 7-9 km/hr. According to the machine's owner it requires a lot of time and money to maintain.

Conducting the spading

Paddock selection is important and needs to be carefully planned to minimise the risk of wind erosion. Michael acknowledges that: "We are one big wind away from disaster" so he makes every effort to reduce this wind erosion risk.

Spading into paddocks with thick stubble is ideal because some of the biomass may remain on the surface and protect against wind erosion. Michael begins planning the spading 12 months in advance by planting a high biomass crop with a bulky stubble residue that can protect the soil after spading.

Michael was pleasantly surprised at how well the spaded soil settled after spading. However, for the first few months after spading Michael was careful not to drive on the paddock unnecessarily.

Paddy Melons turned out to be a headache and should be avoided as the melon vines got wrapped around the spade and reduced its depth. If melons are an issue spading in the middle of a hot day will assist in breaking up the vines.

Although the paddock was deep ripped in 2006 it was not deep ripped prior to spading in the 2010 season as is sometimes requested by the spading contractors. Deep ripping prior to spading can make the process of spading a little faster. However, Michael decided he did not want the added cost of deep ripping.

When to spade

Ideally spading should be conducted as close to seeding as possible in order to minimise the risk of wind erosion. Spading should be conducted when the soil is wet to allow for the quick establishment of a cereal cover crop which will minimise the wind erosion risk. Fitting spading around other farm operations such as spraying and seeding can be difficult as the operation ties up a tractor and an operator.

Seeding into a spaded paddock

Seeding into a spaded paddock was much harder than Michael anticipated and on the first attempt 80% of the seed was sown too deep for about 100 metres. A better seeding depth was achieved by putting the hydraulic depth control on the seeder to 'float' mode, thus ensuring the weight on the tynes was as low as possible. However, because spading leaves the soil with very little resistance and the tynes can build up soil and root material very easily the first two rows of crop were filled in by the following tynes, reducing emergence. After approximately two hours experimenting with the contour drill the correct balance was achieved and Michael could confidently seed the paddock.

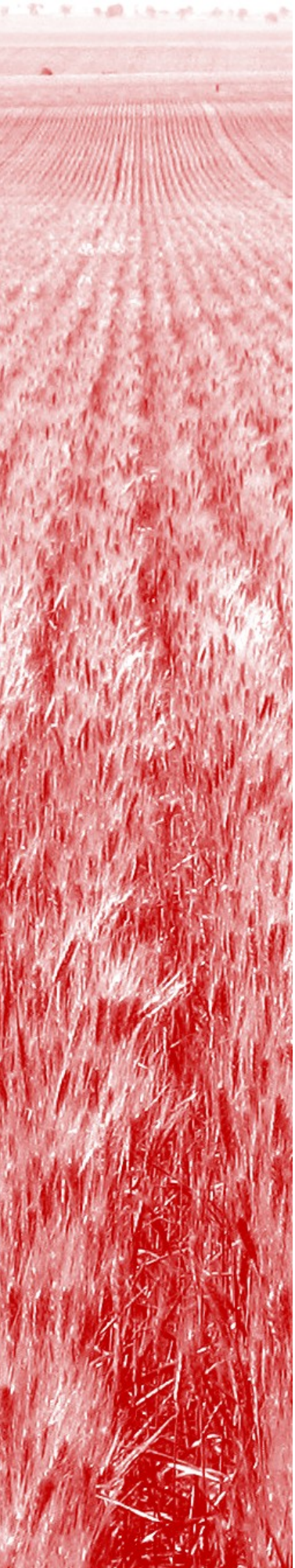
Unspaded (left) and spaded soil (right). The crop has improved germination in the spaded soil

Wheat and barley are considered the best crops to plant into newly spaded soil because they are less sensitive to seeding depth than other crops, can recover better after sandblasting and leave a thick and persistent stubble after harvest. Michael planted Magenta wheat on his spaded paddock at 65 kg/ha, which was an effective rate to achieve good cover. Poor sandblast recovery, seeding depth difficulties and poor stubble cover make canola and lupins a risky choice.

Weed control

Spading did improve weed control for Michael. The amelioration of the non-wetting layer resulted in a more even weed germination that was able to be controlled through a knockdown. In addition the mixing action of spading buried some of the weed seeds. However spading only controls 60-70% of weeds and should not be relied upon for weed control, if weed control is the objective mouldboard ploughing is a better option (Davies, 2011). In fact an influx of weeds can be observed after spading because the soil wets up more quickly resulting in an increase in weed germination. Transplants are a risk because weeds that get pulled up by the spader end up back in the loose, moist soil and regrow. The paddock was sprayed before spading to eliminate transplants.

Michael feels there is a risk that chemicals may wash into the furrow, or that herbicides may act differently on spaded soil, however is unsure whether the interaction is a positive or negative. While Michael did not experience any damage this year, other growers, including the spading contractor, have reported seeing plants with chemical damage. This area requires further study.



The result

Michael feels his first attempt at spading worked exceptionally well and plans to spade more of his property in 2011. In conjunction with the Liebe Group and Stephen Davies from DAFWA, Michael conducted a trial which compared spading to non-spading side by side. The spaded plots had reduced water penetration time, meaning water infiltrated the soil more quickly. Spading also increased the clay content of the top 10 cm from 4.6% to 6.2% clay through the lifting of subsoil with higher clay contents (Davies, 2011). Crop and weed germination was improved after spading and grain yield increased by 0.8 t/ha. Michael observed that during a heavy rain shower the water went straight into the spaded soil with no runoff, whereas water ran off a neighbouring, unspaded part of the paddock.

Spading does not always increase yield

Another spading trial nearby did not increase grain yield despite ameliorating the water repellence of the soil.

Soil type, seeding depth and plant damage from wind blasting could all have been contributing factors.

How long do the benefits of spading last?

It is unclear how long the benefits of spading will last or what happens to the non-wetting soil when it is buried. The WA Department of Agriculture and Food is currently conducting GRDC-funded research into this area. Benefits are expected to last between 5-10 years. However, there is currently no research to support this. Second year benefits to spading have been seen in farmers paddocks at Badgingarra. Spading should not be conducted too often as this will result in greater losses of organic carbon and may result in more even mixing of the buried repellent topsoil, potentially negating the benefits of the wettable subsoil that has been lifted to the surface by the spading process.

The cost

Michael used a local contractor who charged $350hr + GST. The spader can cover between 2-4 ha/hr depending on soil type and the length of the runs. Michael estimates spading costs him $130 ha including fuel which he had to supply.

Cost Benefit Analysis by Rob Sands, Farmanco Consultant

The cost benefit analysis shows that spading in 2010 on this site was a very profitable operation. For an investment of $130/ha the grower received a benefit of $234/ha. Effectively paying for the operation and making an additional $104/ha. We would call this type of investment a “no brainer”, as any additional benefits in future years are not needed and therefore the risks are minimal and the potential benefits huge. Any other investment that gave you a 180% return on investment in the first year and a potential IRR (Internal Rate of Return) of 155% over five years would be regarded with a great deal of suspicion. The payback period is a useful measure to indicate risk.

Table 1: Cost benefit analysis of spading based on yield benefit of 0.78 t/ha

Item	Not spaded	Spading
Spading Investment ($/ha)		$130
Yield Benefit (t/ha)		0.78
Crop	wheat	wheat
Yield (t/ha)	2.14	2.92
APW Farm Gate Price ($/t)	$300	$300
Income (Farm Gate)	$642	$876
Standard Variable Costs ($/ha)	$110	$110
Fertiliser	$148	$148
Herbicides	$66	$66
CBH (Rec Fee $10/t & Rail Freight $21/t)	$66	$91
Gross Margin	$318	$552
Fixed Costs	$125	$125
Operating Surplus (before spading cost)	$193	$427
Net Benefit ($/ha)		234
Payback Period (years)		0.56
Return on Investment year 1		180%
IRR over 5 years		155%

The shorter the payback period the less risk of parameters changing and making the investment unprofitable. The spading investment with a payback period of 0.56 years is low risk (Table 1.).

The cashflow projections make the following assumptions. The first year will be the best year due to the extra mineralistion of nutrients that won't necessarily be there in future years. We have assumed that this will reduce the benefit by $34/ha/yr and that re-compaction of the soil will reduce the benefits by around 100kg/ha/yr or $30/ha/yr. So the second year will be $64/ha less which drops the benefit to $170/ha and the third will be $140/ha and so on (Figure 1).

This analysis projects a possible benefit over a five year period to be $604/ha. If the grower was to spade within a tramlining system the recompaction losses would be minimal and the potential benefit over a five year period could be as high as $900/ha which is an IRR of 169%.

These cashflow projections are based on average seasons over the next five years. However, the benefits potentially will continue to flow whether we have wet or dry seasons, although the magnitude of the benefit may be lower in dry years. The magnitude of the benefit is not that crucial because the "safety margin" of the investment is so large. If the potential investment return was only 20% then we would need to be more certain of the potential benefits and the risks that those benefits may be reduced.

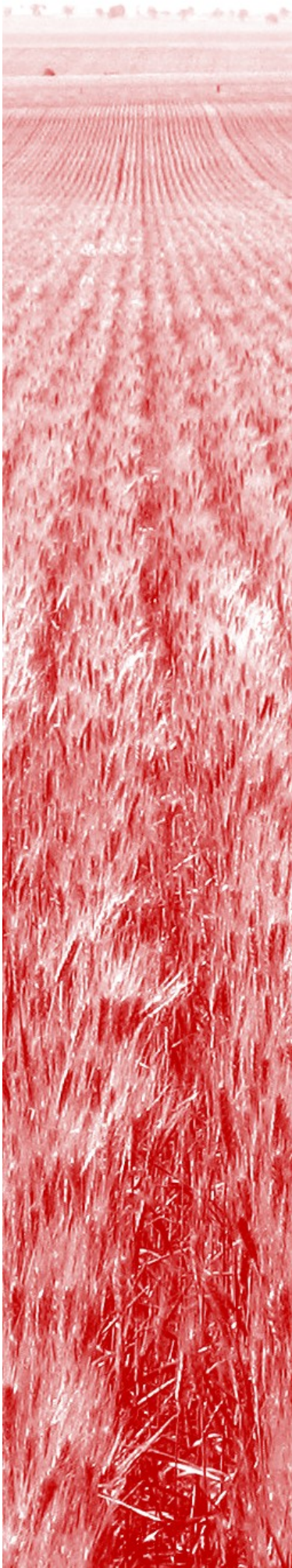


Table 2: Sensitivity of net benefit ($/ha) to fluctuating grain prices & variable yield advantage of spading .

Grain Price ($/t)	Yield Advantage t/ha 0.250	0.500	0.750
$260	$65	$130	$195
$280	$70	$140	$210
$300	$75	$150	$225
$320	$80	$160	$240
$340	$85	$170	$255

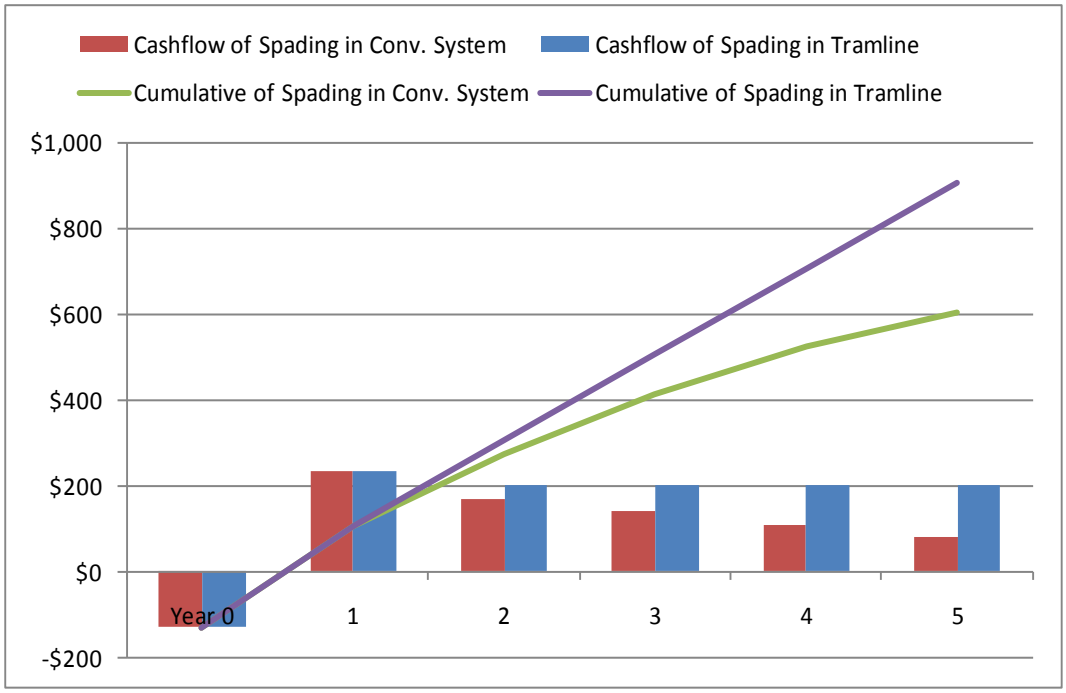


Figure 1: Annual and cumulative cash flow over five years in a spading system with and without tramlines based on an average season

Tips for successfully spading

- Plan 12 months in advance.
- Need to spade into thick stubble and choose a suitable cover crop, usually a cereal, to prevent wind erosion
- Choose the right soil type
- Watch seeding depth, fluffy soil makes it easy to sow too deep
- Apply lime before spading
- Use a knockdown before spading
- Try to only spade in daylight hours so less mistakes are made

Benefits

- Overcoming non-wetting soil
- More even crop and weed germination
- Opportunity to incorporate lime into subsoil
- Less wind erosion risk over the longer term and operation time is more flexible than mouldboard plough

Risks/ Negatives

- Wind erosion
- Seeding difficulties due to soil softness
- Spading the wrong soil type could cause damage and is uneconomic
- Poorer weed control compared to a mouldboard plough
- High cost
- Long term implications are unknown

References

Davies, S. (2011). Rotary Spading pays on water repellent deep yellow sandplain at Marchagee in Local Research and Development results (pp.117-120).Dalwallinu: The Liebe Group

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Acknowledgements:

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Paper reviewed by: Stephen Davies, DAFWA

For further information:

Contact Stephen Davies, WA Department of Agriculture and Food Geraldton (08 9956 8515.)

A calculator to investigate possible scenarios and likely economic benefits of rotary spading and mouldboard ploughing is available on the Soil Quality website (www.soilquality.org.au/calculators).