Rotary spading pays on water repellent deep yellow sandplain at Marchagee

Stephen Davies, Research officer, DAFWA, Geraldton
Chris O'Callaghan, Executive Officer, Liebe Group, Dalwallinu

Aim

To assess the impact of rotary spading non-wetting sandplain soil on soil properties and on crop growth and productivity.
To assess the use of strip trial techniques for on-farm assessment of agronomic management options using Precision Agriculture tools.

Background

Water repellence is common in the sandy-textured soils of the wheatbelt. It is estimated that 3.3 million hectares of WA's agricultural soils are at high risk of exhibiting severe water repellence with a further 6.9 million ha at moderate risk (DAFWA Soil Map Unit database 2008). Management options for non-wetting soils have included furrow sowing, use of in-furrow soil wetting agents or spreading and incorporation of clay – rich subsoil into the water repellent surface layers. Alternative management options are starting to be investigated.

Water repellence is a problem that is concentrated at the soil surface as a consequence of the deposition and decay of plant residues and release of hydrophobic waxes and other compounds into the surface soil. Tillage tools can be used to move or displace this water repellent surface layer thereby allowing for improved water entry into wettable soil. Mouldboard ploughs completely invert the soil with associated benefits of nearly 100% weed seed burial when done correctly, while rotary spaders use rotating spades which carry some non-wetting topsoil down into the profile, while lifting some wettable subsoil to the surface. This mixing is not even (not homogenous) and spaded soil tends to end up with a heterogeneous mix of repellent topsoil and wettable subsoil. Observations suggest that the seams of subsoil the spader creates through the non-wetting layer act as preferred pathways for water entry into the soil allowing the soil to wet up quicker.

There is increasing interest in these technologies as farmers search for solutions to increase productivity on underperforming sandplain soils. These tools have a fit in minimum tillage farming systems, utilizing them as a one-off paddock renovation to reduce weeds, improve wettability and incorporate lime and/or clay.

Trial Details

Property	O'Callaghan property, Marchagee
Plot size & replication	900m x 12m, non-replicated
Soil type	Deep Yellow Sand and Deep Yellow Loamy Sand
Soil pH	0-10cm = 5.1; 10-20cm = 4.4; 20-30cm = 4.3; 30-40cm = 4.5; 40-50cm = 4.7
EC	0-10cm = 0.14 dS/m; 10-20cm = 0.03 dS/m; 20-50cm = <0.03 dS/m
Sowing date	22/5/2010
Seeding rate	65 kg/ha Magenta
Fertiliser	22/5/2010: 75 – 135 kg/ha (VRT) Mallee/MOP 5:1; 53 L/ha Flexi N 12/7/2010: 70 L/ha Flexi N
Paddock rotation	08 Wheat, 09 Canola
Herbicides, Insecticides & Fungicides	14/5/2010: 1.7 L/ha Glyphosate; 400 mL/ha Ester 800; 40 g/ha Triasulfuron; 40 mL/ha Oxyflurafen; 215 mL/ha Alpha Duo, 21/5/2010: 2.1 L/ha Treflan; 520 mL/ha Sprayseed, 800 mL/ha Gramoxone; 115 g/ha Diuron; 29/7/2010: 800 mL/ha Precept; 500 mL/ha Brom MA;
Growing Season Rainfall	177mm

Results

Water repellence at this site tended to be exhibited in patches. There were areas of good establishment and crop growth in the untreated area but there were also large patches with poor crop establishment and a high weed burdens. Water repellence at the site was moderate to severe, with an average water droplet penetration time of 182 seconds, spading reduced this to 5 seconds (Table 1).

The soil at the site ranged from deep sands with clay contents < 5% to deep loamy sands in which the clay content tends to increase with depth to levels between 5-10%. The action of the rotary spader in burying some of the topsoil while lifting some subsoil can increase the clay content of the surface soil. This is reflected in an average increase in the clay % of the top 10 cm from 4.6 in the control to 6.2% (Table 1). Typically when applying clay-rich subsoil to water repellent soils (claying) the aim is to increase the clay content to a level which overcomes the water repellence typically 5-7% in most situations. Thus the increase in clay content as result of spading in this trial will also help improve water infiltration in addition to the preferred pathway and dilution mechanisms.

Table 1: Soil particle size analysis conducted on untreated and rotary spaded deep yellow sand from Marchagee, 2010.

Treatment	Water Droplet Penetration Time (secs)*	Particle Size Analysis (0-10cm)			
		% Clay	% Fine Sand	% Coarse Sand	% Silt
Control	182	4.6	10.2	83.2	2.0
Spader	5	6.2	13.9	78.6	1.3

* Water droplet penetration times were measured under standard laboratory conditions for 0-5cm soil samples that were collected separately.

Both the topsoil and subsoil pH at the site were acidic and below the recommended target pH levels of 5.5 in the surface and 4.8 in the subsoil (Fig. 1A). Peak subsoil acidity occurred in the 20-30cm layer with a pH of 4.3 (Fig. 1A). Rotary spading alters the soil pH profile by partially burying the higher pH topsoil which has increased the pH in the 10-30cm layer, however subsoil pH is still lower than the target level of 4.8 (Fig. 1A).

Rotary spading loosens the soil to the depth of working, in this instance spading reduced soil penetration resistance to <2 megapascals to a depth of 26cm (Fig. 1B). This effectively gives the crop roots an additional 6cm of soil with little physical restriction, effectively similar to a partial deep ripping effect.

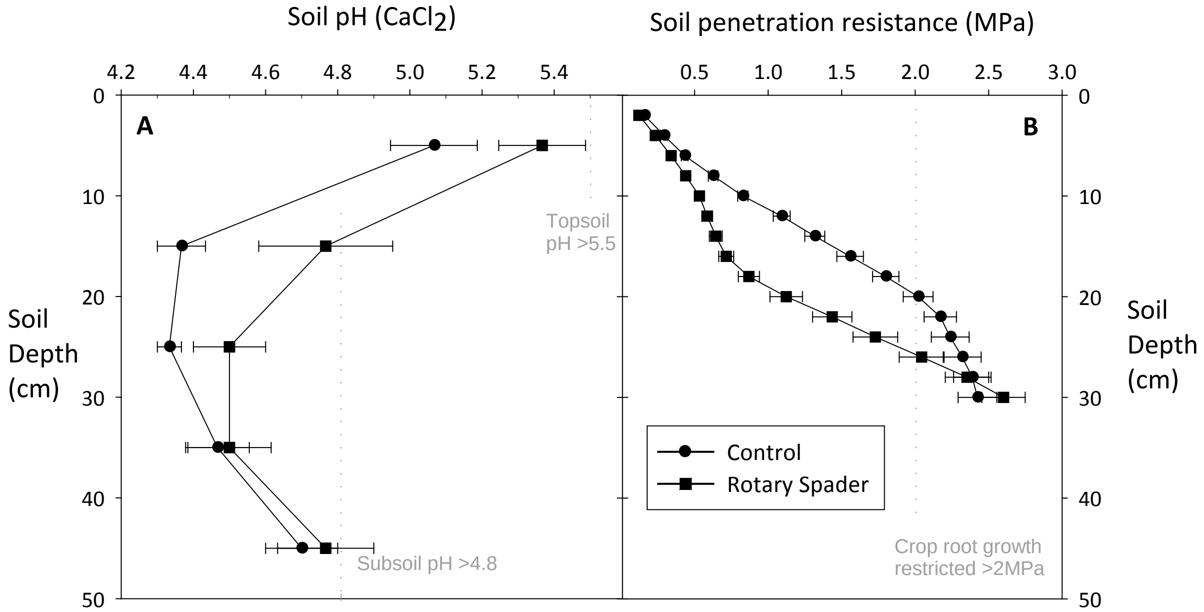

Figure 1: Impact of rotary spading of a deep yellow sand on: A) soil pH (CaCl2), note target pH levels for topsoil (pH>5.5) and subsoil (pH>4.8) shown as dashed lines; and B) soil penetration resistance measured using a cone penetrometer when the soil was wet. Note that at 2MPa or more crop root growth rates are reduced.

It was observed that spading reduced the number of weeds, particularly ryegrass but due to the partial nature of the inversion process significant ryegrass populations remained in the treated area. Enhanced weed control was most likely a combination of weed seed burial and stimulation of a more synchronous early weed germination allowing for a better knockdown. This paddock had a high weed seed bank after poor canola establishment in 2009.

Table 2: Impact of rotary spading of deep yellow sand on wheat yield components from hand harvest cuts and machine harvest grain yield, Marchagee, 2010.

Treatment	Hand harvest cut data					Machine harvest		
	Total Shoot Biomass (t/ha)	Number of Heads (#/m2)	Average Head weight (g/head)	Kernel Weight (mg)	Grain Yield (t/ha)	Grain Yield* (t/ha)	Grain Protein (%)	Screenings (%)
Control	5.6	243	0.78	39.1	2.4	2.14	9.8	4.7
Spader	8.0	309	0.72	36.2	3.5	2.92	9.0	3.5

* Machine grain yields taken directly from the header yield monitor and is an average yield for the 900m strip.

In combination these numerous soil changes resulted in substantial improvements in crop growth and productivity. Total above-ground (shoot) biomass determined by hand cuts was increased by 2.4 t/ha (43%) as a result of spading (Table 2). In the spaded area the crop had 66 more heads/m2 (Table 2) reflecting the improved plant establishment and crop vigour. With spading resulting in a larger biomass crop with more heads and more grains coupled with a relatively dry finish to the season average head weight and kernel weight was reduced by spading (Table 2). Spading increased machine harvest grain yield by 780 kg/ha, a yield increase of 36%. Spading tended to decrease grain protein by 0.8% to 9.0% compared with the control but also decreased screenings by 1.2%.

Comments

When looking at the spaded crop the most obvious thing was its consistent establishment resulting in an even crop compared with the crop in the untreated area which was variable with a mix of good and poor patches of growth. This is reflected in the increased biomass, head numbers and grain yield of the spaded crop. Improved establishment is due to a reduction in water repellence as measured by the lower water droplet penetration time. Higher crop growth and yield in the spaded situation is likely driven by a large combination of factors including reduced soil constraints such as water repellence, compaction, subsoil acidity together with higher N mineralisation, altered nutrient availability, reduced weed competition and possibly reduced soil and stubble-borne pest and disease levels. With higher yields as a result of spading grain protein was reduced, indicative of the need to possibly apply more N to crops growing in spaded areas because of the higher potential yield.

Spading and ploughing can be very useful for incorporating lime into acid subsoils and spreading of lime prior to spading would be very appropriate at this site given its subsoil acidity problem. Typically spading results in a decline in the topsoil pH as more acidic subsoil is brought to the surface but this wasn’t apparent in this trial (Fig. 1A). This is most likely due to inadequate sampling. It would be recommended that a minimum of 2 t/ha of good quality lime be spread prior to spading with subsequent testing of soil pH the following year to assess if further surface lime applications are required. Increasing the pH through addition of lime may also improve the chemical environment for the wax degrading microbes that can potentially reduce the severity of the water repellence. It should be noted that while spading may assist weed control other research suggests it controls only 60-70% of the weeds and if weed control is a priority then full-inversion tillage using a mouldboard plough may be a better option as weed control is often >95%.

This trial has enabled the grower to assess the benefits and problems of spading and to consider how it may be incorporated into the farming system. Fitting spading in a cropping program can be complicated and costly as it is best to spade or mouldboard the soil when it is wet so a cereal cover crop can be established immediately to reduce the wind erosion risk. This often means that the paddocks or areas to be treated will often be sown last and if growers buy their own spaders or mouldboard ploughs they will need access to a tractor of sufficient size to pull the implement plus an operator.
This may compete with demands from other spraying or seeding operations at this time. Despite this the potential benefits of these tools is large and they have the capacity in some instances to make unprofitable and unproductive soils profitable to crop.

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Contact

Chris O'Callaghan, Liebe Group
chris@liebegroup.asn.au
(08) 96610570