The effectiveness of soil mixing by tillage implements

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KEY MESSAGES

- Soil inversion with a mouldboard plough, rotary spader and one way plough created equally patchy soil.
- The one-way plough created the most vertical redistribution of the surface 10 cm of soil.
- At least ten soil samples are required to gain a reliable mean for soil pH after inversion.

BACKGROUND

While we have a reasonable understanding of how soil inversion with mouldboard ploughs, rotary spaders and disc ploughs buries the surface layer of soil, we have limited understanding of how these implements mix soil through their working depth. Mixing is an important consideration when lime, nutrients or other amendments are being applied because the way the soil is mixed will determine how these products are distributed through the soil and how effective they will be. We developed a new method to quantify how the implements above mix soil. First, we installed trenches (1 x 0.1 x 0.1 m) of a colored synthetic soil at a field site near Moora. The trenches were installed in a direction perpendicular to the ploughing direction. Second, we applied the tillage treatments which were; mouldboard plough, deep ripping (35 cm) + rotary spader, one-way plough and offset discs + deep ripping (35 cm). Third, we dug pits where the colored sand was buried and advanced the pit face in 5 cm slices, taking a digital photo of each slice. Finally, we used digital image analysis to locate the colored sand in each slice, and build a 3-dimensional picture of how soil is being mixed by these treatments.

RESULTS

The one way plough caused the most vertical redistribution of the 0 to 10 and 10 to 20 cm layers (Table 1 and Figure 1). The depths we quote here (e.g. 10 to 0, 0 to -10) are depths relative to the soil surface before ploughing and we found colored sand above the previous soil surface level because the loosening created by the tillage had reduced bulk density and 'lifted' the soil.

Table 1: Percentage of soil from 0 to 10 cm before tillage located at different soil depths after tillage treatment.

Soil depth (cm)	One-way plough	Rotary spader	Mouldboard plough
+10 to 0	6	1	0
0 to -10	38	36	17
-10 to -20	46	53	62
-20 to -30	10	10	21

Analysis of the 'blobs' of color in each slice of soil revealed that the soils created by these implements were equally well mixed, or equally as patchy. We used the ratio of perimeter to area of the colored blobs to quantify soil mixing – a low ratio (big blobs of colored soil) occurs when poor mixing is achieved and vice versa. A comparison of the ratio of perimeter to area for all blobs we identified showed that the mean and range was about the same for all tillage treatments (data not shown here).

An analysis on the number of soil samples required for inverted soils to achieve a reliable mean for soil pH also suggests that the rotary spader and mouldboard plough create equally patchy soils (data not shown here).
We used soil samples from four depths (0 to 10, 10 to 20, 20 to 30 and 30 to 40 cm) from our long term water repellence management x nutrition trial at Badgingarra to calculate the probability of the mean pH we measure falling within the 95% confidence interval of the actual mean pH. At least 10 samples were required for a 90% probability of the mean we measure falling within the 95% confidence interval of the actual mean.

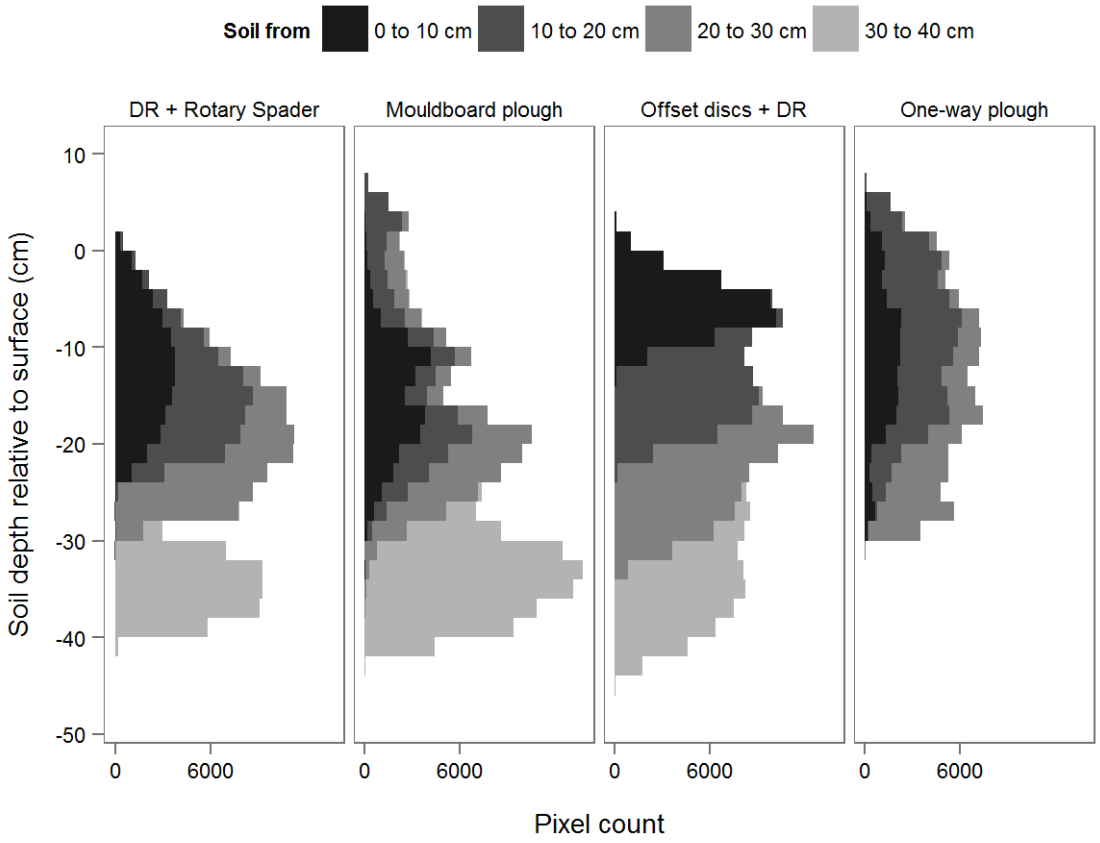

Figure 1. Redistribution of soil from layers 0 to 10, 10 to 20, 20 to 30 and 30 to 40 cm by; deep ripping (DR) + Rotary Spader, Mouldboard Plough, Offset discs + DR and One-way plough.

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