1-1-1996

No-till sowing: helping to keep cropland soils in place

Kevin Bligh

Paul Findlater

Follow this and additional works at: http://researchlibrary.agric.wa.gov.au/journal_agriculture4

Part of the Agronomy and Crop Sciences Commons, Soil Science Commons, and the Sustainability Commons

Recommended Citation


Available at: http://researchlibrary.agric.wa.gov.au/journal_agriculture4/vol37/iss2/4
Soil formation rates are known to be extremely slow. It takes at least one hundred years for one millimetre depth of soil to form in southern Australia.

Erosion rates higher than soil formation rates effectively mine the soil. In many Western Australian agricultural areas only 10 to 50 centimetres of loamy sand or sandy loam overlies a dense sandy clay subsoil.

**Water erosion**
The most severe cases of water erosion in Western Australian agricultural areas occur on tilled cropland. Erosion rates of about 1 millimetre depth have been recorded during intense storms. Rill erosion, caused by run-off, can remove topsoil to the depth of tillage. Sheet erosion may also be severe, but is generally less obvious.

Irrespective of the form of water erosion, most occurs in a few, widely spaced rainstorms. For example, about half of the soil lost from plots in a 30-year period in New South Wales occurred in about one per cent of the runoff events. Therefore we must not be lulled into a false sense of security because erosion seems to be infrequent.

Tillage has a major effect on water erosion. For example, during one storm, 35 times more soil was lost from multiple tillage (work-up, work-back and seed) in the Chapman Valley, north-east of Geraldton, than from no-till sowing using narrow ‘inverted T’-shaped points. In this event 52 millimetres of rain fell in six hours, which occurs once in nine years on average. By contrast, only 100 kilograms of soil per hectare (0.007 millimetre depth) was lost under no-till sowing, consistent with estimated topsoil formation rates of one millimetre depth (15 tonnes per hectare) in 100 to 1000 years.

Repeated erosion of tilled land can lower crop and pasture yields because of reduced available moisture and nutrient storage. Kevin Bligh and Paul Findlater look at the causes of water and wind erosion and the role of no-till sowing in minimising erosion.

In this event, about 2 tonnes per hectare of coarse sediment was deposited below rills in slight depressions between the contour banks on the multiple-tilled bays. A further 1.5 tonnes per hectare of fine (clay and silt size) sediment left the multiple-tilled bays suspended in runoff. No rill erosion occurred on the no-till sown bays.

Total nitrogen lost was equivalent to about 12 kilograms per hectare of urea, and total phosphorus, 15 kilograms per hectare of superphosphate. Only one-tenth as much nitrogen and phosphorus was lost from the no-till sown bays. Runoff was about halved on the no-till bags.
Technical Officer Herman Ortiz checks the depth of flow over a runoff – measuring weir in a grade bank channel. Note the laptop computer on the bank for downloading runoff data from the blue, electronic water-level recorders, and the adjacent bottles to catch samples for soil and nutrient analyses.

Severe water erosion on tilled land between contour banks in the Chapman Valley north-east of Geraldton.

Sowing on the contour

Even under no-till sowing, preferential removal of clay and silt size particles (to which plant nutrients are attached) in runoff may pose a problem in the long-term. Therefore, minimising runoff by sowing on the contour is essential.

With no-till sowing on the contour, a channel in each seed row intercepts overland flow and sheet erosion from the inter-row areas during bursts of intense rainfall. Also by sowing at least approximately on the contour, water cannot flow down the channels formed in the seed rows, washing out seed and fertiliser, as well as soil.

Contour grade banks or seepage interceptor drains are required even under no-till sowing, because substantial runoff will still occur during intense storms, or in a wet winter after soil profiles become saturated. Grade banks lead runoff

Water erosion over nine years averaged about 40 kilograms per hectare per year under the no-till wheat-pasture rotation between grade banks on the 5 per cent land slope. If true of the long-term, about 4 tonnes per hectare (0.3 millimetres depth) would be lost in 100 years.

About 20 centimetres of loamy sand overlies dense, sandy clay at the Chapman Valley site. Over time, tillage and erosion would progressively reduce topsoil depth and productivity in repeatedly-ripped areas. The loss of about 4 millimetres of topsoil has resulted in a 20 per cent cereal yield reduction on some soils in Western Australia.

At West Dale, 35 km south-west of Beverley run-off and erosion were measured from reverse bank seepage interceptors, spaced 100 metres apart to reduce waterlogging. Infiltration rates into the sandy loam surface soil were relatively high. As a consequence, run-off seldom occurred before the soil profile became saturated.

Predictably, rill erosion was relatively minor at West Dale, even in relatively rare, intense storms. Soil lost as suspended sediment totalled only about 0.02 millimetres over seven successive years under multiple tillage, and less than 0.01 mm under direct drilling, no-till sowing and permanent pasture.
Ian Edwards, and son Sam, of Beverley stand on no-till contour-sown land where water erosion was negligible in 1995. However, a little erosion occurred where three rounds were sown initially to allow turning at the ends (left).

across the slope at a safe velocity to a permanently grassed waterway, for protection against rill and gully erosion.

As fences are renewed, it may be possible to re-fence into longer paddocks according to soil type. Below grade banks or seepage interceptor drains. By placing water supplies at the ends of longer paddocks, most stock tracks will then be close to the contour, because sheep, in particular, tend to follow header tracks after harvest. In this way erosion down stock tracks will be minimised.

Where grade banks or seepage interceptor drains have not yet been constructed, working up-and-back should be considered, rather than round-and-round a paddock. Some farmers do two or three rounds first in an uncontoured paddock. Then they sow up and back, approximately on the contour, lifting the seeder out of the ground at waterways and for turning on the already-sown ends. Some water erosion may still occur at the ends, but less than if all of the paddock were sown round-and-round.

Earthworms
Earthworms and other invertebrates are important components of soil fauna, and can indicate improved soil health. Earthworm numbers have increased under continuous cropping with reduced tillage, particularly in higher (more than 400 mm average annual) rainfall areas. Termites have also been observed to increase in lower-rainfall areas. Such increases may indicate satisfactory conditions for beneficial soil organisms.

Earthworms rely on organic matter for food. At West Dale, multiple-tillage reduced soil organic-carbon levels from 2.8 per cent to 1.8 per cent after three years. Annual maximum numbers of earthworms per hectare averaged only 0.15 million from the fifth year under multiple tillage. 0.5 million under direct drilling, 0.8 million under permanent pasture and 1.4 million under no-till sowing.

The total mass of earthworms peaked at an average of 440 kilograms per hectare in late winter under no-till sowing and permanent pasture, 170 kilograms per hectare under direct drilling, and 40 kilograms per hectare under multiple tillage. Therefore no-till sowing increased both earthworm numbers and mass under the continuous cereal-legume cropping rotation by a factor of about three over direct drilling, and by about ten over multiple tillage.

Earthworms that now thrive under no-till sowing were unintentionally introduced by European settlers in potted garden plants, or as earthworm eggs wedged in the hooves of horses, cattle or sheep.

Earthworm species better adapted (and potentially more advantageous) to agriculture in the Mediterranean climates of southern Australia are currently being studied by CSIRO and Flinders University in South Australia, with a view to determining if more favourable species can be introduced.

Wind erosion
Wind erosion is an ever-present hazard, particularly on sandy-surfaced soils. Severe wind erosion occurred during the summer of 1994/95 over large parts of the south-west of Western Australia, particularly in the Great Southern and Northern Agricultural Regions (see Journal of Agriculture WA, 36(3), 1995, Storm).

In seven hours, up to 2 million tonnes of fertile top soil were blown away in the Great Southern, equivalent to 70 thousand trucks dumping a load of soil into the ocean. The cost to the industry from this one storm was about $2 million.

Such soil loss is not unusual in one storm. Storms of similar magnitude have been observed previously in the Great Southern, and also in South Australia, Victoria, New South Wales and Queensland. Nor was the extent of the erosion in 1995 unusual; widespread wind erosion occurs about once in 5 or 10 years in Western Australia. Severe erosion on some paddocks occurs every year and soil loss from individual paddocks can be substantial. In Western Australia, as much as 20 millimetres of top soil has been lost from parts of some paddocks during a single storm. This is thousands of times greater than the rate of soil formation.

Earthworm numbers and mass increase under reduced tillage and, particularly, no-till sowing and permanent pasture.
Agricultural systems predisposed to wind erosion

Soils left exposed and loose during strong winds will blow away. Ground cover such as plants, stubbles, cloths and gravel reduce erosion in two ways. Firstly, ground cover increases the roughness of the surface, absorbing energy from the wind. The increased friction slows the wind and reduces the erosion rate. However, if the rough surface is composed of loose soil, wind erosion will increase.

The second mechanism by which ground cover reduces erosion is by physically shielding loose soil from strong winds and flying particles, which initiate further erosion.

Figure 1 shows that about 50 per cent of prostrate ground cover is required to minimise wind erosion relative to a bare, loose surface. The erosion rate decreases markedly as the percentage cover increases up to about 50 per cent. After 50 per cent, comparatively little extra benefit is gained from more ground cover.

This level of cover applies to all soils and all plant residues. If plant residues are detached or easily blown by the wind, for example, pea stubbles, then much higher levels are required for wind erosion control. If the stubbles are standing then as little as 20 to 30 per cent cover is required to reduce the risk of erosion, because the standing stalks greatly reduce the wind speed at the soil surface.

The total amount of soil lost from an exposed paddock depends on the depth of loose soil, whether a protective armouring layer is produced, and the duration of strong winds. The most effective means of reducing wind erosion is to keep stubble cover above 50 per cent.

Stubble levels on farms

A summary of stubble levels on about 100 farm paddocks in the Northern Agricultural Region in 1990 and 1991 is shown in Figures 2a and 2b. The level of wheat stubble in freshly sown lupin crops was 10 per cent cover or less, on about 90 per cent of farms (Figure 2a), whereas at least 50 per cent is required to control erosion. Similarly, nearly all farms had 10 per cent or less of lupin stubble cover from the previous year’s crop by July (Figure 2b). Even before sowing (April-May) few, if any farms have sufficient levels of lupin stubbles to minimise erosion. Furthermore, any protection provided by the stubble was subsequently destroyed by tillage at seeding time.

Effects of traditional seeders on surface stubble cover

The level of stubble reduction depends on a number of factors including the number of passes, machine type, stubble type and condition, and soil type and moisture.
Evaluating a no-till seeder

When evaluating no-till seeders the following points should be considered, in addition to considerations such as mechanical reliability and price. The features listed relate to the ability to establish a good crop, and so indirectly control wind erosion through increased grain and stubble yields.

1. Does the seeder leave stubble standing?
2. Does the seeder operate effectively when stubble levels are high, without clumping?
3. Is hair-pinning* of stalks minimised in the seed zone?
4. Is the stubble left on the surface even when stubble levels are low?
5. Can seed depth be controlled adequately?
6. Can some of the fertiliser be placed away from the seed, and deeper?
7. Is there good seed-soil contact?
8. Is there cultivation below and around the seed zone (to minimise effects of rhizoctonia root rot)?
9. Are herbicides adequately incorporated into the soil (e.g. by soil splatter or harrows) if required?

* Hair-pinning is the process whereby a disc fails to cut the stubble stalk and pushes the stalk into the seed slot.

Table 1. Surface stubble reduction by various tillage machines

<table>
<thead>
<tr>
<th>Implement</th>
<th>% Reduction in stubble cover</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disc plough (125 millimetres deep)</td>
<td>70</td>
</tr>
<tr>
<td>Disc plough (75 millimetres deep)</td>
<td>30</td>
</tr>
<tr>
<td>Offset disc</td>
<td>50</td>
</tr>
<tr>
<td>Chisel plough</td>
<td>25</td>
</tr>
<tr>
<td>Sweep plough</td>
<td>15</td>
</tr>
<tr>
<td>Blade plough</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 1 shows typical cereal stubble levels remaining after seeding with a range of machines used in the USA and New South Wales. The amount of stubble remaining on the surface will vary with machine type and location. They contrast with those shown in Figure 3 for the northern agricultural area of Western Australia; the percentage of stubble buried in the northern agricultural area is higher. Traditional seeders, even with direct drilling, may not leave enough cover for adequate protection against wind erosion.

Each grower should make an independent judgement about the performance of the particular seeders used, and ensure sufficient stubble is left on the surface to minimise the risk of erosion.

No-till sowing

No-till sowing, if used correctly, will minimise erosion. It aims to maintain ground cover and reduce soil disturbance, so is well suited to controlling wind erosion.

No-till sowing is one of a number of complementary farming systems, including windbreak networks and feedlotting, that can be adopted for total wind erosion management.

Some no-till seeders bury as little as 10 per cent of the stubble and leave many of the stalks standing, providing even greater protection against wind erosion. Under the conditions of a trial at Wellstead in 1993 (Table 2) tined no-till seeders tended to bury more stubble than discless no-till seeders. However, some discless no-till seeders will bury significant proportions of dry lupin stubbles in sandy soils.

The commonly-used full cut-out tine, or offset-disc or culti-trash seeders, bury as much as 80 per cent of the stubble in the first pass (see Figure 3). Such tillage can reduce stubbles from a 2 tonne per hectare lupin crop with 30-40 per cent cover, to less than 10 per cent, even with direct drilling - well below levels required for adequate wind erosion protection.

An extra tillage pass will not significantly affect the percentage cover, because the stubbles have already been mixed with the top soil. Additional workings merely turn the soil over, bringing some of the already-buried stubble to the surface, and burying more.

Figure 3. Surface reduction of lupin stubbles with a number of commonly-used seeders. The lupin crop yielded 2 tonnes per hectare of grain, and its stubble was not grazed over summer.
Table 2. Percentage reduction of ground cover in a cereal stubble with various no-till machines. The loamy sand was wet during seeding.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Total stubble</th>
<th>Standing stubble stalks/m²</th>
<th>% Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% Before</td>
<td>After</td>
<td>Buried</td>
</tr>
<tr>
<td><strong>Tined seeders</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No-till knife points® (180 mm row spacing)</td>
<td>81</td>
<td>26</td>
<td>55</td>
</tr>
<tr>
<td>No-till Conserva-Pak® (225 mm row spacing)</td>
<td>76</td>
<td>30</td>
<td>46</td>
</tr>
<tr>
<td>Narrow points at 360 mm spacings</td>
<td>81</td>
<td>35</td>
<td>46</td>
</tr>
<tr>
<td><strong>Disced seeders</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cross-Slot®</td>
<td>83</td>
<td>67</td>
<td>16</td>
</tr>
<tr>
<td>Biomax® (Germinator®)</td>
<td>80</td>
<td>76</td>
<td>4</td>
</tr>
<tr>
<td>Gt Plains®</td>
<td>77</td>
<td>80</td>
<td>-3</td>
</tr>
<tr>
<td>Gt Plains® with wavy front coulters</td>
<td>75</td>
<td>72</td>
<td>3</td>
</tr>
<tr>
<td>Morris® (double-disc)</td>
<td>83</td>
<td>79</td>
<td>4</td>
</tr>
</tbody>
</table>

**Conclusions**

Rates of soil loss from wind erosion under current tillage practices are much larger than soil formation rates. Direct drilling may not leave sufficient vegetative ground cover to minimise wind erosion. However, no-till seeding can minimise erosion if sufficient levels of stubble and pasture residues are present before seeding.

Sowing on the contour with stubble retention is still required to minimise water erosion under no-till sowing, preferably between contour grade banks or seepage interceptor drains. If water erosion rates under contour no-till sowing are borne out in the long-term, and wind erosion is minimised, then soil erosion on no-till cropland may be reduced to about the same order of magnitude as soil formation rates. Sustainable agriculture may therefore be possible in the long-term.

Earthworm numbers increase substantially under reduced tillage practices, particularly under no-till sowing and permanent pasture in medium and higher-rainfall areas. Such increases probably indicate a more healthy environment for soil organisms.

**Further reading**


Kevin Bligh can be contacted at South Perth on (09) 368 3893 and Paul Findlater at Geraldton on (099) 21 8555.