Tips and Tactics

Strategic tillage in no-till systems

Northern Region

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Timing the most important factor determining strategic till outcomes

No-till farming systems that include minimal soil disturbance and stubble retention offer a wide range of economic, environmental and soil quality advantages compared to conventional tillage systems. However, there is growing evidence that strict no-till is unsustainable due to implications from the lack of soil disturbance.

KEY POINTS

- The occasional strategic till can be a viable management option to minimise constraints from no-till systems without impacting on long-term soil health benefits.
- Consider the balance between soil erosion and degradation impacts from tilling against short-term profitability.
- Plan well. Timing is the major factor determining the success of strategic tillage.
- Watch the weather forecasts. Rainfall after the tillage operation determines the success of strategic till in no-till systems.
- There is a range of impacts from tilling and they change over time.

Constraints of no-till systems

Weeds

Build-up of annual ryegrass, barnyard grass, liverseed grass, windmill grass and fleabane. Herbicide resistance can be a significant problem.

Insects

Build-up of soil insects such as *Helicoverpa*, armyworms and black field earwigs in the surface soil.

Diseases

Build-up of pathogens causing diseases such as crown rot of wheat, yellow spot of wheat, ascochyta blight of chickpea, stalk rot of sorghum.

Subsoil nutrition depletion

Subsoil nutrient removal and regular shallow application of immobile nutrients (phosphorus, potassium and zinc) result in relatively enriched surface soil and depleted subsoil (nutrient stratification). High evaporation dries surface soil impeding the ability of crop roots to access nutrients.

Figure 1: The biological and physical constraints associated with no-till systems.

Can a till help deal with no-till constraints?

Adoption of continuous no-till has grown steadily in Australia and particularly in Queensland and northern New South Wales (NSW).

There are concerns regarding the long-term sustainability of such systems due to both biological and physical constraints (Figure 1).

Interest is increasing in the use of occasional strategic tillage (ST) to combat these constraints in no-till (NT) farming systems.

Growers have raised questions about the possibility of irreparable soil and environmental damage from occasional ST in otherwise exclusive NT systems. Fifteen trials have been conducted in the region to respond to these questions using tine and disc tillage implements.

Disc tillage (top) and tine tillage (bottom). (Source: Yash Dang)

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Finding the balance

No-till systems do improve soil physical, chemical and biological health, however there is increasing evidence that a strict no-till regime is unsustainable due to challenges related to the lack of soil disturbance.

Introducing occasional ST in otherwise NT systems may offer opportunities to improve productivity by:

- overcoming nutrient stratification
- managing diseases
- managing herbicide-resistant weeds.

The adoption of ST by the grains industry will be driven by the interactions between three aspects:

1. system costs and profitability
2. soil health
3. environmental benefits.

Use of any tillage operation in NT systems must consider the balance between soil erosion and degradation impacts from tillage against short-term profitability (Figure 2).

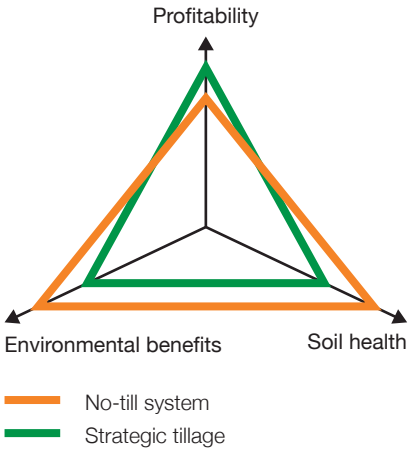

Figure 2: A representation of the generalised level of benefits across profitability, soil health and environmental benefits for strategic tillage and no-till systems in the short term.

Tillage impacts in no-till systems

The impacts of a tillage operation (either chisel tines, offset discs or chain harrows) in otherwise NT systems are summarised in Figure 3 and discussed below.

It is important to remember that impacts vary depending on soil type, soil moisture, existing weed seed bank and the timing and frequency of tillage.

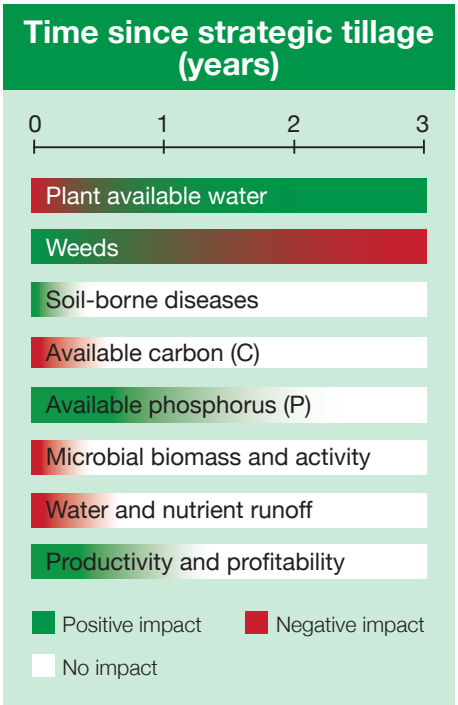

Figure 3: A visual representation of the negative and positive impacts over time across many factors affected by a tillage operation.

- **Soil water is lost through evaporation, but these losses are generally replaced in subsequent rainfall events and effects are typically short-lived**

  In extreme cases, this loss of water may result in crops establishing poorly or a missed sowing opportunity.

  There was lower soil water by 10–15 mm immediately following ST. In most cases, there was slight improvement in soil water after one year due to increased water infiltration.

  Grower recommendation: Check the weather forecast before tilling to ensure rain is coming afterwards.

- **Weeds are reduced in the short-term but there is a negative or negligible long-term impact**

  In some cases, tillage moved buried seed to the soil surface, providing a more favourable environment for weed seed germination.

  Grower recommendation: Know your weed seed bank. You can reduce your reliance on herbicides if ST operations are conducted at a time that minimises the risk of reduced soil water at seeding.

- **Soil-borne diseases decrease slightly short-term but there is no significant impact**

  Grower recommendation: Maintain disease control measures. You can reduce your reliance on pesticides if ST operations are conducted at a time that minimises the risk of reduced soil water at seeding.

- **Nutrients can be reduced in subsoil**

  Strategic tillage causes a slight initial decline of soil organic carbon for a short period due to oxidation, which also releases carbon dioxide.

  Also, one-time tillage tends to slightly decrease the amount of available phosphorus (P) in the surface 0–10 cm of soil and slightly increase the amount of available P at 10–20 cm soil depth. However, this effect is unlikely to counteract existing P-deficiency.

  Grower recommendation: Occasional deep placement of P fertiliser (at approximately 15–20 cm) may be needed to meet the nutrient requirement of the crops.

- **Microbial biomass and activity is generally unaffected**

  Total microbial enzymatic activity and soil microbial biomass did not differ significantly at any site between tillage treatments and NT.

  Grower recommendation: No action related to strategic tilling required.

- **Water and nutrient runoff increases when rainfall occurs soon after tilling**

  More water and soluble nutrients are lost when rainfall events occur soon after tillage due to the protective surface cover being removed. Trials showed an increase in runoff in Dermosol and Sodosol soils following ST but no impact in Vertosols.

  Grower recommendation: Use of ST in soils that exhibit texture contrast properties (Sodosols) and weakly structured A-horizons (Dermosols) are likely to suffer negative impacts and should be treated with caution.

- **Productivity and profitability are improved, but only in the short term**

  Across all field sites, productivity increased by 100–150 kg/ha following ST operation in the first year. In the second year, there was no significant impact on productivity. Net returns per hectare from ST ranged from $2.50 to $32.80. The highest returns were obtained from chickpea crops.

  Grower recommendation: Consider short-term gains from tilling in the context of enterprise operations, particularly planned crop rotations.

Which soil types are most suited to strategic tillage?

Five dominant soils types cover almost 97% of the cropping soils in the northern region (Figures 4, 5).

Soils that exhibit texture contrast properties (Sodosols, Chromosols) and weakly structured A-horizons (Dermosols) are likely to suffer negative soil health impacts. These soil types should be treated with caution when considering ST.

Generalisations about the impacts of using occasional ST on soil quality indicators in NT systems are difficult to make as soil responses have been inconsistent.

It is also important to consider subsoil constraints. Many soils in the northern region have single or multiple subsoil constraints, especially salinity and sodicity. Use of any tillage implements that invert the soil may have a serious negative impact as salts may be brought nearer the soil surface and could cause yield losses.

When to till?

Timing of a single, strategic till in an otherwise NT system is the most important factor determining its success.

Tillage too close to sowing reduces plant available water. This could result in unreliable establishment or a missed sowing opportunity in marginal rainfall seasons.

Rainfall between ST and sowing or immediately after sowing is essential to replenish soil water lost from the planting zone. A minimum of 75–100 mm rainfall is required so it is important that growers factor in likely rainfall to their tillage schedule.

The probability of receiving 100 mm of rain prior to winter crops sowing in the northern region is 40–55% for a three-month pre-sowing period and 90–95% for a five-month pre-sowing period.

Tilling immediately after the harvest of the previous crop reduces surface cover, which can lead to increased soil erosion. The optimum timing of tillage will be influenced by soil water content and the purpose of the tillage (Table 1). Undertaking a tillage operation after legume crops, which typically produce less stubble cover, can minimise the impacts from loss of cover and reduce difficulties with stubble handling.

How to till?

Tillage implements that invert the soil (such as mouldboard ploughs) are rare in the northern region. Most growers use non-inversion tillage based on tine and disc implements. There were no significant differences between these tillage implements nor the frequencies of tillage passes in field experiments.

Figure 4: Dominant soil types of the cropping soils in the northern region. (Source: CSIRO)

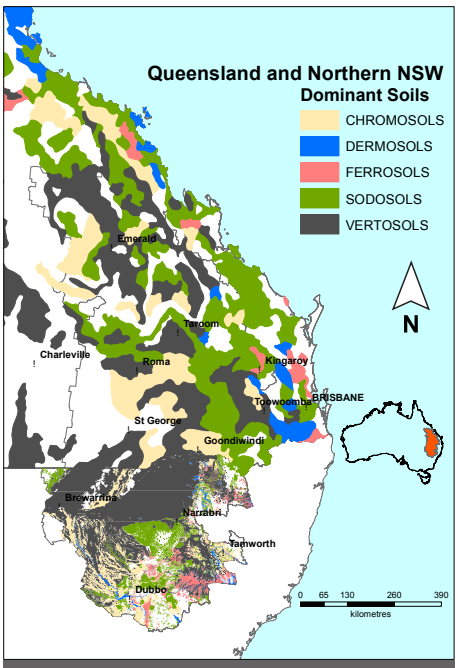

Figure 5: Soil type map of Queensland and Northern NSW (GRDC Northern Growing Region at time of project inception). (Source: Australian Soil Resource Information System, CSIRO)

Table 1: Safe implementation of strategic tillage in otherwise no-till farming systems.

Purpose of tillage	Optimum tillage time	Tillage implement
Disease management		
Fungal disease	Post-harvest, early in fallow	Disc or blade
Root-lesion nematode	Post-harvest, early in fallow	Disc for surface soil (0–0.1 m)
		Frequent tillage for subsoil (0.45 m)
Pest management		
Winter crops	Post-harvest	Light tillage e.g. scarifier
Summer crops	Post-harvest, early in fallow	Chisel, disc to 0.1 m
Weed management		
In-crop	Prior to weed flowering	Shallow tine
Fallow	Prior to weed flowering	Shallow tine
Subsoil nutrient depletion		
Sodic soil	Post-harvest, early in fallow	Para plough
Non-sodic soil	Post-harvest, early in fallow	Deep ripper tine
Stubble management		
	Previous crop harvest	Prickle chain, trash cutter
	Fallow for partial removal	Offset disc
Soil physical constraints		
Surface soil	Early in fallow	Cross tine
Subsoil	Early in fallow	Deep ripping tine

The research

Fifteen on-farm experiments were established in Queensland and Northern NSW during 2012–15. All sites had a long history of continuous no-till.

The research trial sites established were:

- Five core sites with till and no-till treatments in otherwise no-till paddocks in winter 2012.
- Three core sites with treatments involving different timing, frequency and type of tillage implements (in winter 2013).
- Four sites using different types of tillage implements (strip tillage, narrow chisel, and disc) and an experiment to quantify the rate of moisture loss in freshly-tilled soil (in summer 2013).
- Three sites with and without tillage treatments to quantify runoff and loss of soluble nutrients immediately following tillage, under simulated rainfall (in summer 2015).

Soil samples were obtained prior to sowing of crops in 2012, 2013 and 2014 and analysed for physical, chemical and biological properties. In-crop measurements included weed populations. Researchers also recorded grain yield and evaluated profitability.

Farms involved in the research: 'Callitris' Condamine (Rod and Margaret Hamilton); 'Killaloe' Moonie (Nev and Penny Boland); 'Yallambee' Wee Waa (Ken Stump); 'Grandview' Biloela (Darren Jensen); Waverley (Paul and Samantha Fulbohm); 'Luellen' Moree (Geoff Manchee); 'Wyobi' Jimbour West (Warakirri Farming Co).; 'Wondalli' Yelarbon (Paul McNaulty and Paul Caster, Agronomist); 'Kolora' Emerald (Brian and Val Gregg).

Further reading

Dang, Y.P., Seymour, N.P., Walker, S.R., Bell, M.J., Freebairn, D.M. (2015) Strategic tillage in no-till farming systems in Australia's northern grains-growing regions: I. Drivers and implementation, Soil and Tillage Research, Volume 152, September 2015, Pages 104–114, ISSN 0167-1987. URL: http://dx.doi.org/10.1016/j.still.2015.03.009

Dang, Y.P., Moody, P.W., Bell, M.J., Seymour, N.P., Dalal, R.C., Freebairn, D.M., Walker, S.R. (2015) Strategic tillage in no-till farming systems in Australia's northern grains-growing regions: II. Implications for agronomy, soil and environment, Soil and Tillage Research, Volume 152, September 2015, Pages 115–123, ISSN 0167-1987. URL: http://dx.doi.org/10.1016/j.still.2014.12.013

Crawford, M. H., Rincon-Florez, V., Balzer, A., Dang, Y. P., Carvalhais, L. C., Liu, H., Schenk, P. M. (2015) Changes in the soil quality attributes of continuous no-till farming systems following a strategic tillage. Soil Research, 53, Pages 263–273. URL: http://dx.doi.org/10.1071/SR14216

To obtain copies of these papers, please contact Yash Dang.

Useful resources

GRDC Strategic tillage factsheet: www.grdc.com.au/GRDC-FS-StrategicTillage

GRDC GroundCover TV: http://www.grdc.com.au/Media-Centre/GroundCover-TV/2013/09/GCTV11

ABC Country Hour: http://www.abc.net.au/news/2013-06-27/strategic-tillage/4785294

FAQs

Q. I'd like to till but should I just try it in one part of my farm?

A. A strategic till should fit with the objectives of your farm (Table 1). You may wish to trial in a paddock and see the results before applying it more widely.

Q. I consider what I do 'minimum tillage', does this information apply to me?

A. The information and guidance presented here are related to research conducted for long-term continuous no-till farming systems only. To explore what kind of tillage may be appropriate for your situation, talk to your agronomist, contact your state/territory government department or refer to Useful resources.

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