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STRATEGIC TILLAGE FACT SHEET

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NORTHERN AND SOUTHERN REGIONS

IS THERE ROOM FOR STRATEGIC TILLAGE IN A NO-TILL SYSTEM?

No-till has brought benefits in moisture retention and soil structure, but has also contributed to increased incidence of soil and stubble-borne diseases, herbicide resistant hard-to-kill weeds and stratification of immobile nutrients near the soil surface. Growers are asking the question: How much damage is done to soil by occasional tillage, strategically applied, in an otherwise no-till system?

KEY POINTS

- Conservation farming involves reduced tillage, stubble retention and good rotations. This underpins sustainable grain production systems worldwide.
- Current advice on soil tillage management contains apparent contradictions. Some flexibility may be required in the application of conservation farming practices.
- No-till has revolutionised cropping, but has resulted in an increased reliance on herbicides, leading to herbicide-resistant weeds.
- A lack of tillage can cause nutrient stratification and favour diseases such as crown rot, Rhizoctonia and Pseudomonas.
- Conventional tillage can suppress plant parasitic nematode populations, lower the number of snails and slugs prior to canola crops, and lower mice numbers in affected fields.
- From an overall systems perspective, limited and strategically timed tillage could have a tactical role as part of a productive, sustainable system.

PHOTO: SARAH CLARRY

Growers inspecting the plots at a field day in Harden, NSW. The site is host to a CSIRO long-term trial examining the effects of tillage and stubble retention on crop production.

Introduction

Farming practices have been evolving to make best use of new technologies as they become available.

No-till farming with stubble retention is one such practice. It allows better infiltration of water and water retention, less erosion, and reduced labour, machinery and input costs by removing some operations from the cropping program.

However, conventional tillage was effective in managing weeds, and the move to no-till required a shift towards more chemical-based weed-control strategies. As a result, the incidence of herbicide-resistant weeds has grown exponentially.

Compounding this, there are fewer new chemistries and a narrower range of options each time a herbicide group fails.

Accumulation of immobile nutrients such as phosphorus and potassium in surface layers of soil under no-till has been shown in a number of studies. In the northern grains region, a combination of surface enrichment (due to residue return) and subsoil nutrient depletion has occured.

Stubble retained in zero-tillage systems can also favour some stubble and soil-borne diseases such as crown rot, Rhizoctonia and Pseudomonas.

Pests such as parasitic nematodes, snails and slugs, and mice can also be suppressed by tillage.

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The impact of tillage varies with the tillage implement used: inversion tillage using a mouldboard plough, as pictured here, results in greater impacts than using a chisel or disc plough.

To till or not?

Some growers resort to a strategic tillage operation to manage some of these problems. However, growers who practice strict no-till systems are worried that even a single tillage operation may undo positive soil-condition benefits that have taken time to accrue.

To address this concern, GRDC is funding a five-year project, *The strategic use of tillage within conservation farming.* (See below for details of sites and treatments.)

The researchers are investigating the question: How much damage is done to soil by occasional tillage, strategically applied, in an otherwise no-till system?

The theory being tested is: The agronomic and economic benefits of a strategic tillage exceed any agronomic costs caused by soil structure damage. Net benefits accrue from factors such as lime incorporation, mixing stratified nutrients back into the soil, disease control and weed management.

Potential risks and rewards

The potential risks and rewards of occasional strategic tillage in long-term no-till farming systems depend on many interactive factors, which can be broadly grouped into agronomic, climatic, soil and environmental.

Agronomic

Most studies conducted in the US and Europe suggest that introducing occasional strategic tillage in continuous no-till systems could improve productivity and profitability in the short-term; however, in the long-term, the impact is negligible.

Strategic tillage can provide control for herbicide-resistant weeds and those that continue to shed seed throughout the year. Here it has been used for control of barnyard grass in a fallow.

The strategic use of tillage within conservation farming

Sites and treatments, NSW

Harden, CSIRO long-term trial

Eight treatments, 32 plots

There are two long-term direct-drilled treatments at this site, one with stubble retained and one with stubble burnt.

The plots were split, and tillage was introduced on one half of each.

The plots were then subdivided again for the application of supplementary nutrients in an effort to increase the conversion of crop residues (roots and any stubble) into soil organic matter.

This approach enabled eight treatments and 32 plots derived from the original trial, which is allowing researchers to assess the impacts of strategic tillage.

Cootamundra

12 treatments, 48 plots

The paddock selected was coming out of five or six years of lucerne into a cropping cycle, starting with triazine-tolerant canola. This represents a time when farmers might contemplate tillage.

At this site there are three tillage treatments: no-till, scarified (non-inversion) and offset discs (some inversion).

Each treatment is split for the application of supplementary nutrients in an effort to increase the conversion of crop residues into soil organic matter.

The tillage was applied to one set of plots in 2012 (five years of lucerne) and to a neighbouring set of plots in 2013 (six years of lucerne), to assess whether conditions in a given season might influence the response to tillage.

Thuddungra (near Young)

12 treatments, 48 plots

The paddock selected was coming out of wheat in 2011 into canola in 2012. Lime was needed prior to the canola crop; this represents a time when a farmer might consider cultivation.

There are three tillage treatments at this site: no-till, scarified (non-inversion) and offset discs (some inversion).

As at Cootamundra, the treatments are split for the application of supplementary nutrients. Additionally, stubble retention is being compared to stubble burning for each tillage treatment.

Daysdale (near Corowa)

12 treatments, 48 plots

The paddock selected was under continuous cropping, coming out of vetch

The short-term impacts of strategic tillage on soil health and environment include reduced protective cover, soil loss, increased runoff, loss of soil carbon and moisture, and reduced microbial activity. There is little or no detrimental impact in the long-term.

Even in the short-term, the impact varies with the tillage implement used: inversion tillage using a mouldboard plough results in greater impacts than using a chisel or disc plough.

Profitability

Improving production efficiency is a priority for many growers. Reducing production costs can be a major contributor to increasing farm profitability, especially with high volatility in grain prices.

In comparison to conventional tillage, no-till generally offers higher or comparable yields while saving time, labour and fuel costs, which lead to higher economic returns.

However, specific issues that emerge in no-till systems – herbicide resistance or treatment of disease, for example – can affect overall and long-term profitability.

As costs and benefits must be calculated case-by-case and trial work has been limited it is not possible to say which system is most profitable.

TABLE 1 Occasional strategic tine-tillage impacts in otherwise long-term no-till farming systems.

months after tillage	Grey Vertosol		Brown Sodosol		Grey Dermosol		Black Vertosol		Brown Vertosol
	3m	12m	3m	12m	3m	12m	3m	12m	3m
Weeds (#/m^2)	↓	↓	↓	↑	↓	+	+	+	↓
Bulk density$_{0\text{-}10cm}$ (g/cc)	-	-	-	↓	-	+	-	-	-
Soil water $_{0\text{-}10cm}$ (mm)	-	+	-	+	-	+	↓	+	-
Soil organic carbon$_{0\text{-}10cm}$ (t/ha)	-	-	-	-	-	-	-	-	-
Particulate organic carbon$_{0\text{-}5cm}$ (t/ha)	N/A	↓	N/A	-	N/A	-	N/A	+	N/A
Available Colwell-P$_{0\text{-}10cm}$ (mg/kg)	↓	-	-	-	-	-	-	-	-
Total microbial activity$_{0\text{-}10cm}$ (µg/h/g)	+	-	-	+	-	-	-	-	N/A
Microbial biomass$_{0\text{-}10cm}$ (µg/g)	N/A	N/A	N/A	+	N/A	+	N/A	N/A	N/A
Yield (t/ha)	+	+	↑	-	+	+	+	+	+
Net return ($)	-	+	+	+	+	+	+	+	+

↑, significant ($P<0.05$) increase; ↓, significant ($P<0.05$) decrease
+, non-significant increase; - non-significant decrease

Weeds

From a weeds management perspective, the main risk from the reintroduction of tillage is the potential to move buried weed seeds back to the surface, providing a more favourable environment for germination and/or breaking seed dormancy.

Conversely, a one-off tillage that results in weed seed burial below emergence depths is potentially a useful management tactic for difficult-to-control and herbicide-resistant weeds.

In one trial, the emergence of key glyphosate-resistant and difficult-to-control weeds after strategic tillage with harrow, gyral and offset discs was reduced by 61 to 90 per cent compared to no-till. The weeds included flaxleaf fleabane, feathertop Rhodes grass and windmill grass.

Another trial showed significantly lower in-crop weed density (flaxleaf fleabane, wild turnip, wild radish and wild oats) with the imposition of strategic tillage at four long-term no-till sites in north-eastern Australia. See Table 1.

in 2011. At this site there are three tillage treatments: no-till, scarified (non-inversion) and offset discs (some inversion).

As at the other sites, the treatments are split for the application of supplementary nutrients. Additionally, tillage in 2012 is being compared to tillage in 2013.

In contrast to the Cootamundra site, the year of tillage was randomised, so the impact of tillage for each treatment can be statistically assessed.

Timeline

Each site is running for four years of crop and the final soil sampling will occur in 2016. Final statistical analyses and conclusions will be available later that year.

Sites and treatments, Northern grains region

In 2012, five paddocks were selected on long-term no-till farming systems in Biloela, Condamine, Moonie, Warwick and Wee Waa.

At all sites except Warwick, experimental design was a randomised block with four replications. Plot size was a minimum of 100 metres long and wide and with permanent controlled traffic tramlines.

All sites received tillage treatments to a depth of between 15 centimetres and 20cm (chisel tillage, and/or offset disc or Kelly chain) at least once in March 2012.

At the Biloela and Condamine sites, a second tillage was applied in the third week of April 2012.

At the Warwick long-term tillage experiment, a factorial combination was applied: two tillage (conventional or no-till) x two crop residue management practices (retained or burned) x three N rates (nil; 30 kilograms of N per hectare; 90kg N/ha). There were four replications.

In 2012, each plot was longitudinally split in two; half receiving chisel tillage in March 2012 and half left untilled.

In winter 2013, three core sites were established with different timing, frequency and type of tillage in long-term no-till farming systems at Biloela, Jimbour and Moree.

In summer 2013, four sites were established at Yelarbon, Emerald and Goondiwindi with different types of tillage implements (strip tillage, narrow chisel, and disc) and an experiment to quantify the rate of moisture loss with one-time tillage at Felton.

Each site is running for three years of crop and final soil sampling will occur in 2014.

Strategic tillage contributes to more diverse weed control options in an integrated weed management system. It provides an optimum soil environment for the application and incorporation of residual herbicides.

Disease

Disease risks associated with strategic tillage include hastened spread of diseases by moving infected stubble and soil on machinery to other paddocks or farms that may have been clean.

However, the benefits of burial and/or faster decomposition of stubble may outweigh any contamination risks. Movement of infected soil or stubble to other paddocks can be managed through effective on-farm hygiene. Cleaning machinery, cars and even boots and clothing is important to reduce the spread of inoculum.

Disturbance of soil affects not only pathogens but also other soil microbes. Although no-till systems are more conducive to enhancing beneficial soil microbial components that suppress disease, it remains to be seen whether a strategic tillage operation will have sustained impact on the general structure and function of the soil microbial community.

The competition between microbial populations in the root-zone may largely prevent major root diseases from developing under strategically tilled conditions. However, more research is required to understand the impact of strategic tillage practices on beneficial root zone microbes and the effect of soil disease suppression.

Pests

The use of tillage as a cultural control in integrated pest management (IPM) strategies has been successful in reducing some pests.

IPM can decrease reliance on insecticides, thereby lowering the risk of developing insecticide resistance in the pest population.

The adoption of no-till to retain soil moisture and maintain structure can lead to new pest pressures.

However, by disturbing soil habitat and increasing exposure to birds and other land-based predators tillage decreases the number of soil-living predatory insects such as ground beetles, centipedes, spiders and ants as well as reducing numbers of beneficial termites and earthworms.

Carabid beetles, which are effective predators of slugs, wireworms and moth larvae, are favoured in reduced and no-till systems, especially when combined with maintaining uncultivated habitats nearby such as grass margins.

However, some crop pathogens, particularly fungi and nematodes, are depressed by tillage, which dries out the soil and disrupts hyphal networks.

In an experiment on a vertosol in southern Queensland, after 11 years of continual cereal cropping, higher numbers of root-lesion nematodes were recorded in the topsoil (0 to 15 centimetres) under no-till than under conventional tillage.

Project outputs

The agricultural system is highly complex. Tillage may be both beneficial and detrimental to many of the diseases, insects, pests and weeds.

The output of the project will deliver an understanding of the trade-off between damage to soil structure and the maintenance of agricultural production.

The outcome will be more flexibility in the implementation of conservation farming practices. Adoption is likely to be immediate in southern NSW, as farmer groups there are keen to increase management flexibility in a 'horses for courses' approach to conservation farming. And as the output is likely to have national and international relevance, adoption is likely to be on a broad scale.

USEFUL RESOURCES

Strategic tillage (Interview with Yash Dang)
www.grdc.com.au/DAPodcast-StrategicTillage

Ground Cover TV: Strategic tillage, does no-till mean never till?
www.grdc.com.au/GCTV11-StrategicTillage

Occasional tillage (Interview with Mike Bell)
www.grdc.com.au/DAPodcast-OccasionalTillage

MORE INFORMATION

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