REDUCED TILLAGE IN POTATOES

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KEY POINTS

- Reduced tillage can involve reducing:
  - Tillage intensity
  - Number of passes
  - Depth of tillage
  - Area disturbed, *or*
  - Complete removal of tillage from a system
- Reduced tillage is often paired with other regenerative agriculture practices such as
  - Cover cropping and pasture rotations
  - Use of compost and biofertilisers
  - Inclusion of livestock in the rotation
  - Controlled traffic
  - Promoting biodiversity
- Most of the case studies outlined in this article have focussed on reducing the number of passes prior to potatoes, combined with other regenerative practices
- Consider your unique farming system when trying reduced tillage, including rotations, crop residue management, soil type and climatic conditions
- Try reduced tillage on a small area to compare it with your conventional practices.

Reduced tillage agriculture has emerged as a sustainable and innovative approach to farming, offering numerous benefits to both farmers and the environment.

By minimising soil disturbance, reduced tillage practices promote soil health and conservation, leading to improved water infiltration, increased organic matter content, and enhanced nutrient retention. This approach also reduces soil erosion, conserves valuable topsoil, prevents nutrient runoff, and improves water use efficiency. These benefits can lead to improvements in yield, quality, and margins for growers over time.

However, for potato growers there are some challenges. Weed control can become more difficult without regular soil disturbance. Disease and pest management can also be impacted, as crop residues are not buried, potentially increasing disease carryover and pest survival.

Despite these challenges, some potato growers around the world are turning to reduced tillage, usually in combination with other regenerative practices, to improve and /or maintain soil health.

WHAT IS REDUCED TILLAGE EXACTLY?

Reduced tillage can be a reduction in intensity of tillage, the number of passes, tillage depth, area disturbed or the complete removal of tillage in a system. While reduced tillage has long been embraced in grain cropping systems, the uptake among potato growers has been slower as production systems often involve significant tillage to prepare the soil for planting.

Tillage serves multiple purposes including weed management, loosening the soil for planting and harvesting, and making nutrients more available. While tillage can appear to be a prerequisite for growing a good potato crop, there is a rising number of producers who are deviating away from conventional tillage.

CASE STUDIES AND RESEARCH

There are many challenges in adapting reduced tillage to potatoes, however an increased awareness of the importance of soil health and soil conservation worldwide has emphasised the need to consider more environmentally sensitive approaches. Over the past decade a number of studies have examined the impact of reduced tillage on yield and disease pressure, as well as soil quality parameters.

This article shares some examples of growers who have incorporated reduced tillage into their farm practice and research seeking to quantify outcomes when tillage practices are altered.

AUSTRALIA

Garry Kadwell (*Delicious* Magazine Producer of the Year, 2020) grows potatoes near Crookwell in NSW on his family farm *Fairhalt*. After taking over the family property and transitioning to potato production, Kadwell noticed that his soil biology was gradually degrading.

Of the nearly 300ha farm, 32% is set aside for conservation. The remaining hectares produce seed stock potatoes, gourmet potatoes, fat lamb production, and occasionally lucerne/silage fodder production.

Kadwell applies a minimum 5-year cycle management regime to each parcel of land on the property. Potatoes are not planted more often than one year out of every five, with the other four years involving crop rotations of lucerne and pasture grasses.

The changes

With a family history of conservation on the property, Garry was open to practice change to improve the soil health, incorporating the following changes to his farming system:

- An increase in the length of rotations
- The introduction of pastures into rotations, including legumes
- Consistent application of compost
- Rotational grazing of fat lambs to maintain ground cover
- The transition to a one-pass system to reduce tillage

The results

There has been a significant increase in tonnage/ha of potatoes since 2010. Yield has risen by a remarkable 20%, at the same time as maintaining high levels of soil carbon.

While this is the result of applying a number of regenerative farming practices, reduced tillage is a key part of this system. Fairhalt provides an Australian example where reduced tillage equals better potato production.

Soils for Life have conducted a comprehensive economic and ecological assessment, which is publicly available (https://soilsforlife.org.au/garry-kadwell-fairhalt/).

Mallee Sands of Southern Australia

Studies by the CSIRO have shown that use of minimum tillage in South Australia's Mallee region not only reduces erosion risk but supports improved soil nutrition through improving soil carbon and beneficial soil microorganisms.

A significant volume of Australian potatoes are grown in the mallee region on light sandy soils typically low in clay.

The area's Mediterranean climate, including winter rainfall and strong prevailing winds, combined with the sandy soils creates a significant erosion risk. Airborne soil and sand can cause cause abrasion damage to growing potato crops, increasing disease risk. Erosion can also sometimes expose shallow potatoes, resulting in greening and postharvest grading waste.

CSIRO has shown that minimising tillage of the light, sandy soils of South Australia's mallee region can reduce erosion

Limiting tillage can reduce erosion risk, protecting both current and future crops.

Fairhalt Farm, showing one of the functioning wetlands that filter water runoff from the property.

NETHERLANDS

Grower Jeroen Klompe, a leading innovative regenerative farmer from the Netherlands, grows potatoes and a range of other horticultural and grain crops south of Rotterdam in the Netherlands.

Klompe grows 12 different potato varieties across 85ha (of 368ha property) for baking, baby, fresh retail, and food service markets. The diverse rotation also includes red onions, shallots, green protein crops such as kidney beans, brown beans and soya, and combinable crops including winter and spring wheat, buckwheat, oats, oilseed rape and flax, plus grass for seed.

His property hosts the Klompe Farm trials, showcasing a wide range of experimental regenerative practices, including biofertilisers, compost tea, lane cropping, biodiversity margins and strips, no till and more. Working with universities and researchers, the trials generate data on the effects of regenerative practices. These results are complemented by the farms own records – recording the adaptation of farming practices, yields, the effects of the weather on the different plots and so on.

The changes

To avoid planting into compacted soil, Klompe adopted a 3.08m working width controlled-traffic farming system: crops are never sown where machinery has trafficked.
Preparation for potato crops starts straight after the previous wheat crop. The straw is chopped and mulched and organic fertiliser – either compost or solid manure – applied.

If any remedial work is required for the soil, such as drainage maintenance, it is carried out at this point, while the ground is dry.

A cover crop is direct drilled and grown over winter. The species for the cover crop are chosen with a specific purpose in mind. This could mean planting a biofumigant for disease management, or a legume for increased soil nitrogen.

Jeroen Klompe planting into a mulched cover crop and ridging

When mature, the cover crop is mulched and cut. The potato crop is then planted directly into the cover crop residue using a one-pass system. A rotator is used to mix the cover crops and the upper surface of the soil. After the potato seed tuber is planted, the ridges are made in a single action.

Micronutrients are applied as necessary following plant sap analysis. The aim is provide the correct nutrition for crop growth and quality, but also to reduce the use of blight fungicides.

Current reductions in blight fungicide are primarily driven by decision-support systems based on moisture sensors within the crop, weather forecasting and blight detection. However copper, zinc and calcium can all play a role in improving blight resistance.

The results

Klompe has made many observations while slowly increasing the area of reduced till from about 5ha five years ago to almost half of his potato production area today.

One of the key benefits has come from combining reduced till with cover cropping. Higher organic matter has increased infiltration rates and soil water holding capacity.

Reducing the amount of irrigation applied is another way to reduce risk from blight.

Klompe hopes that the use of biofertilisers will promote growth of beneficial fungi and bacteria on the upper parts of the plant. These could potentially compete with *Phytophthora*, also reducing blight risk.

One negative is increased populations of slugs and wireworms. While damage is minor, up to 2% of the potato crop has been impacted. Klompe's agronomist advises that a balance with natural predators will keep the pest problem under control once the system adjusts, . Patience is key!

Klompe says: "In the system we are using, it's not one thing – it's the combination of lots of small things that makes the change extremely strong."

He adds that the ultimate goal is to grow the same yield but using fewer inputs.

"But we are learning that sometimes it is better to accept a slightly lower yield with a higher margin, than a higher yield and a lower margin."

To read more https://www.soilheroesfoundation.com

Wageningen University has been studying reduced tillage for many years. In 2021, the university hosted an open day outlining some of the impacts of reduced tillage on potatoes.

They noted that transitioning to reduced tillage involves some significant changes to farm operations. These include changes to crop rotation as well as management of cover crops to reduce residues as the soil adjusts.

The study

Two studies conducted by Dimitrios Drakopoulos and team at Wageningen University focused on organic potato production. The research explored the impacts of different tillage systems and fertilisation regimes on soil health and potato production (Drakopoulos et al. 2016, Drakopoulos et al. 2018).

Specifically, they assessed the impacts of a rotary hoe to 10 cm (reduced tillage - RT), compared to a rotary hoe to 10 cm followed by a mouldboard plough to 30cm (standard tillage - ST) at various weeks after planting (WAP).

Some results

- The use of RT resulted in higher soil bulk density during the first seven WAP compared to ST, while both tillage systems had similar values at the end of the growing season (13 WAP).
- Over time, soil bulk density values diminished for RT, while increasing for ST.
- The type of fertiliser had no effect on soil bulk density.
- Use of RT improved some soil quality parameters, such as earthworm activity (2–3 times higher with use of RT compared with ST at 4, 8, and 13 WAP).
- Use of RT negatively affected other parameters, with increased soil bulk density proving detrimental in terms of tuber bulking and final yield (Drakopoulos et al. 2016).
- However, over time negative effects on yield may diminish. Soil structure under RT improves due to increased depth and frequency of pores. These are created by the activity of soil biota, such as earthworms, insects and other soilborne organisms.
- As shown in the figure below, concentrations of soil mineral N (NO^{-3} and NH^{+4}) showed similar decline patterns for both tillage systems during the potato growth period (Figure 1).
- However, soil mineral N values in the top part of the rootzone (0-15cm) were significantly higher in the RT system, especially at 4 and 8 WAP
- In contrast, the bulk of soil N was in the mid to lower parts of the root zone (15–30cm) for ST.
- The study demonstrated that soil structure, drainage and soil biology all benefited from reduced tillage.
- While yield was slightly reduced, the researchers suggest yields will return to previous levels once the system adjusts.

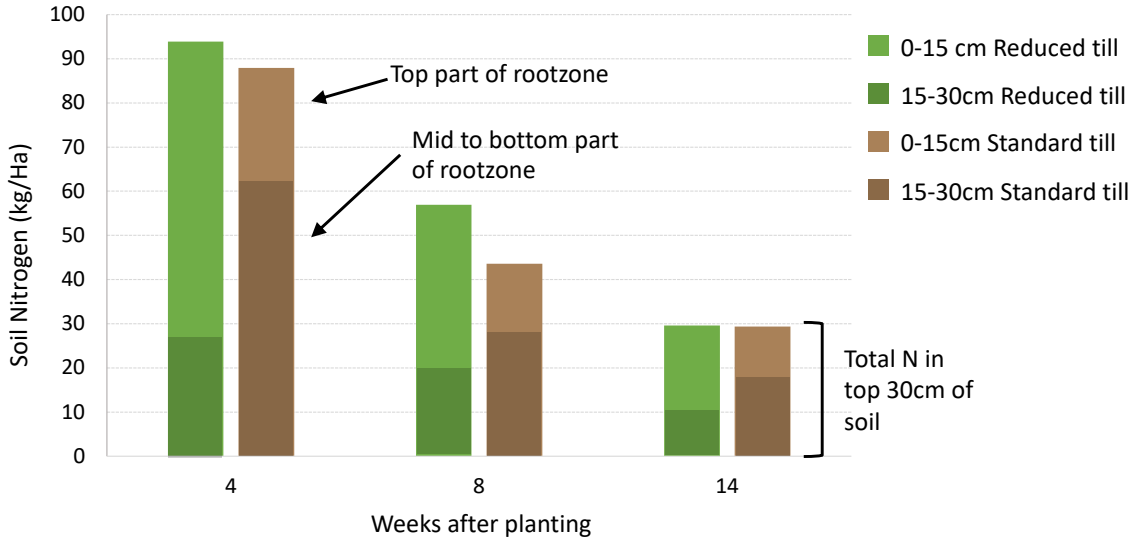

Figure 1. Influence of tillage practice (reduced tillage; standard tillage) on soil Nitrogen held in the top 30cm of soil, split into top (0-15cm) and mid (15-30cm) parts of the rootzone. Data recorded 4, 8 and 14 weeks after planting.

UNITED STATES OF AMERICA

A joint research project by the United States Department of Agriculture and Oregon State University trialled a reduced tillage system in a three-year rotation of sweet corn/ sweet corn/ potatoes. The objective was to develop a reduced tillage system for potatoes using existing field equipment with minor modifications.

The study

The reduced tillage system reduced the total number of passes from nine down to six and soil disturbance operations from seven to four. This retained crop residues as well as requiring less passes with machinery. This translated into savings in time, labour, fuel, and capital (Table 1).

Most of the soil disturbance in the reduced tillage system was caused by the bed splitter, planter, and harvester.

Table 1. Timing of field operations and equipment used in the 2003-2004 tillage trials at Paterson, WA/ Trials conducted in a three-year rotation (sweet corn/ sweet corn/ potato).

OPERATION	CONVENTIONAL TILLAGE	REDUCED TILLAGE
Residue management	Flail chop corn residues	Flail chop corn residues
Pre-planter fertilisation	Valmar™ spreader	Valmar™ spreader
Primary tillage	**2 passes** JD8760™ &13′ Sunflower™ chisel-chopper-packer	**None**
Mark-out	13-shank bed splitter	13-shank bed splitter
Plant	6 row Harriston™ pick planter	6 row Harriston™ pick planter
Drag-off	6 row rodweeder	**None**
Dammer Dike	Dammer diker	Dammer diker
Harvest	3 row potato harvester	3 row potato harvester
Total Passes	9	6

The results

- Compaction was noted as a short-term negative in the reduced tillage system, with an increase in bulk density from 1.2 g/cm^3 to 1.5 g/cm^3. However, over time the bulk density reduced.
- Yields from the conventional and reduced tillage systems were not statistically different, with conventional tillage yields higher than reduced in some years and reduced tillage higher than conventional in others.
- The main benefit noted by the researchers in the reduced tillage system was the reduction in erosion due to residue retention. Damage caused by blowing sand in the conventionally tilled plots was mostly absent in the reduced tilled plots.

For more information:

Extended report 2005
http://bitly.ws/PQ9M

Summary 2013
http://bitly.ws/PQ9S

Potato emergence from conventional tillage (left) and reduced tillage (right). Picture taken following a period of high winds. Photo by M.Seymour USDA-ARS.

CANADA

Agriculture and Agri-Food Canada study

A 10-year study by Martin Carter and team at Agriculture and Agri-Food Canada in the late 1990s and early 2000s investigated different tillage treatments on sandy loam soils (Carter et al. 2009).

The conservation tillage system consisted of one pass with a chisel plough (15 cm deep, with 36 cm sweeps) prior to planting potatoes.

The conventional tillage consisted of mouldboard ploughing (20 cm deep), followed by two or more passes (10 cm deep) with a disc and harrow prior to planting potatoes.

Both the conservation and conventional tillage treatments received the same in-row cultivation for ridging (hilling), fertiliser, pesticide applications and harvesting operations.

The Results

- Contrasting with other results, conducting reduced tillage in a three-year rotation resulted in the lowest bulk density of all treatments.
- Soil organic carbon, total nitrogen, and particulate carbon and nitrogen all increased with reduced tillage.
- Of the studies conducted by Carter's team, no significant impact was observed on yield or quality (Carter et al. 2005, Carter et. al 2009).

Grower Panel

In May 2022, the Canadian potato congress held a grower panel session with three prominent Canadian growers; Harold Perry, Homer Vander Zaag and Chad Berry, each starting to implement reduced tillage practices on their farms.

The main drivers for adoption were to build carbon, reduce erosion and to support fumigation practices for disease management. Cover crops were already used by the growers. Reduced tillage was seen as the next step to achieving their goals.

The changes

Their styles of reduced tillage differed.

- Harold Perry has changed his practice from conventional autumn tillage to direct ridging. Ridging used to involve 2-3 passes to loosen the soil for hill formation in autumn, which was then left fallow. Now, Harold sows an early cover crop to get good growth before winter. In spring the potatoes are planted directly into the stubble in one pass, followed by a schmieser packer to promote good seed to soil contact. This approach has helped him to build carbon and reduce soil erosion, while also promoting soil biology.
- Homer Vander Zaag was facing issues with common scab and early dieing syndrome. To solve this issue he fumigated, however this required minimum soil disturbance. After practicing reduced tillage and the associated benefits, he developed a system capable of undertaking tillage, fertilisation, herbicide application, and planting in one-pass. The one-pass system was a success, offering similar results to a two-pass system and improvements in labour efficiency and soil conservation. However, it did increase the complexity of planting. Moreover, the reduction in tillage meant he had to increase application of grass herbicides. Homer observed that reduced tillage was better suited to lighter, warmer soils, with a controlled amount of organic residue.
- Chad Berry has a soil type that easily erodes. A no-till farmer of grain since the 1990s Berry has been reducing his tillage in his potato crops over the years. While erosion is a major factor leading him to reduced tillage, soil health and biology were also important. A recent demonstration on his farm trialled direct seeding potatoes into canola stubble, which offered two less tillage passes prior to planting. The results showed a reduction in fuel use with no impact on potato yields, specific gravity, disease, or other quality characteristics. Although emergence of direct seeded potatoes was delayed by several days, this did not translate into delays in harvest timing.

All three growers noted that the recent regenerative agriculture pledges by the processors have reinforced their practices. With these pledges, growers may see more support for transitioning to practices like no-till.

Click here to learn about Homer Vander Zaag's operation: http://bitly.ws/PQa8

Click here to learn about Chad Berry's experiences: http://bitly.ws/PQab

Harold Perry conventional autumn ridging (left) compared to direct ridging and planting (right).

SUMMARY OF OBSERVATIONS

Positive

- No consistent trends or changes in yield between reduced tillage and conventional tillage
- Increase in water holding capacity of soil
- Improved soil structure
- Improved drainage of soil
- Increase in soil biology
- Increase in soil carbon
- Reduced erosion
- Increase in root proliferation in topsoil
- Nutrients concentrated in the top 15cm of soil
- Increase in earthworm activity

Negative

- Increased presence of slugs and wireworms
- Higher soil bulk density in short-term
- Slower crop emergence
- Increased application of grass herbicides

HOW CAN GROWERS REDUCE TILLAGE IN AN AUSTRALIAN CONTEXT?

There are several approaches to implementing reduced tillage. Each grower will adopt methods based on their crop rotations, soil types and climatic conditions. In the examples provided, most growers reduced tillage by minimising the number of passes prior to planting potatoes.

Additionally, they combined reduced tillage with other regenerative practices like cover cropping, composting, and integrating livestock into the rotation.

Growers considering reduced tillage can consult with their agronomist, consider the practical aspects of implementing reduced tillage in their specific farming system, and start small to offer a comparison to their conventional practices.

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OTHER RESOURCES:

Garry Kadwell's Fairhalt- a regenerative agriculture case study from Crookwell, NSW- https://soilsforlife.org.au/garry-kadwell-fairhalt/

Growing potatoes without plowing- https://www.thecropsite.com/news/17975/growing-potatoes-without-plowing/

How to grow potatoes using minimal tillage, Jeroen Klompe- https://www.fwi.co.uk/arable/establishment/how-to-grow-potatoes-using-minimal-tillage

Low tillage potato trial showed no impact on yield and quality- https://www.potatopro.com/news/2021/low-tillage-potato-trial-showed-no-impact-yield-and-quality

2022 Ontario Potato Conference, 3 Experiences with minimum tillage on potatoes- https://www.youtube.com/watch?v=f8h4jY6D-_k

Reduced tillage in a three year potato rotation- https://landresources.montana.edu/soilfertility/documents/PDF/reports/Nutrient%20Digest_Winter%202013.pdf

Reducing Tillage but Not Quality- https://spudsmart.com/reducing-tillage-but-not-quality/