Report Title: Hedgehope-Makarewa Crop Establishment Pilot Study Technical Summary

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This report fulfils the requirements for the Thriving Southland Hedgehope-Makarewa Catchment Group Project

1. Introduction

Maintaining soil structure and strength is one potential way in which pugging could be decreased in intensive winter cropping systems. Conventional cultivation is still commonly used to establish many winter crops, particularly fodder beet, because of the high cost and risk associated with crop failure or lower than expected crop yields.

Strip tillage is a form of conservation tillage that combines the advantages of conventional cultivation and no-tillage (direct drilling) by cultivating narrow planting strips and leaving the rest of the paddock uncultivated. The cultivated strip provides an optimum tilth in which to sow the seed and helps ensure even germination, while the uncultivated ground prevents wind and water erosion and maintains soil strength. A LandWISE study showed that the main issue limiting minimum tillage success is compaction in the uncultivated areas, which can restrict root growth and lower yields.

In winter 2020, a cow behaviour study at the Southern Dairy Hub (SDH) indicated that surface water pooling and gumboot scores were reliable indicators of cow lying time and thus cow welfare.

Given the need to decrease pugging in intensive winter grazing systems, and the success of minimum till establishment methods in other regions a Thriving Southland funded, cross-sector pilot study, run by the Hedgehope-Makarewa Catchment Group, with support from a range of stakeholders, was completed in winter 2021.

The aim of the project was to test whether utilising minimum till methods (strip tillage or direct drilling) to establish winter forage crops could maintain soil structure and strength, thereby decreasing pugging and improving animal welfare during winter grazing when compared to conventional cultivation.

2. Methods

In spring 2020 farmers across eleven farms, including the Southern Dairy Hub, established crops using a range of establishment methods. Measurements and observations were made from late May to early August 2021.

Eleven crop comparisons, grazed by a range of stock types and classes, were made across the 10 commercial properties (Table 1). These farms were classified as either Tier 1: six properties with two or more direct comparisons of crop establishment method or Tier 2; four properties utilising alternative establishment method but with no direct comparison.

At SDH two pasture paddocks were chosen for the study. The fodder beet paddock was split in half and then one third of each half of the paddock was established using strip tillage, direct drilling, or conventional cultivation. For the kale paddock, half the paddock was established using direct drilling and the other half using conventional cultivation.

On the commercial farms data was primarily gathered on crop yields, soil characteristics before and after grazing (visual soil assessments, infiltration, soil moisture, compaction, soil profiles) and observations during grazing. Whereas at SDH more detailed daily measurements of pugging depth, gumboot scores and surface pooling were recorded for each treatment.

3. Results

An enormous amount of data was collected and while it was only a pilot study there have been many important learnings.

3.1 Crop Yield

For most of the comparisons a higher yield was achieved with conventional cultivation and establishment, except for a conventionally established fodder beet crop in Mossburn that yielded considerably lower than the two minimum till methods at the same site. This conventionally established paddock was a different soil type and considerably wetter than the other two which may have impacted the yield. The two kale establishment methods at SDH resulted in the same crop yield.

Differences in fodder beet yield at SDH were attributed to the soil and paddock conditions at planting and the grazing history of the paddock. We were unable to get all methods established on the same day which resulted in differences in soil moisture which affected germination and subsequent yields. Factors we identified as important for good crop establishment include:

a. Previous grazing history – SDH paddocks had been grazed by springers then deep ripped in the minimum till treatments prior to planting, however surface roughness resulted in uneven seed depth under minimum till which impacted germination rate.
b. Conditions at the time of planting – if the soil is too wet it results in glazing of the coulter with direct drilling, restricting the development of the bulbs.
c. Spraying regime prior to establishment – too much dead trash provides a haven for insect pests to attack the emerging plant.
d. Weed & grass control post-establishment – delays to spraying for any reason can have a big effect on crop yield due to competition for moisture and nutrients by weeds and any residual grass. Where crops were established with reduced tillage there were higher burdens of slugs and root diseases.

Across all the farms the yields achieved were relative to the amount of time, effort and money spent on crop establishment and post-establishment agronomy. With careful thought and preparation, it is possible to achieve good yields irrespective of establishment method, however, minimum tillage establishment methods do come with a higher risk.

3.2 Crop Quality

The direct drilled fodder beet at SDH had a higher proportion of leaf at the time of grazing however this may have resulted from differences in the time of crop establishment as this area was redrilled in late December due to poor plant survival after the initial sowing. No differences in nutritive value were observed between the establishment methods.

3.3 Soil Characteristics

3.3.1 Visual Soil assessment

Not surprisingly the visual soil assessment deteriorated following grazing and the cropped areas had poorer soil quality than areas under the fence line. This highlighted the importance of considering previous management on soil conditions at planting and the potential impact on crop establishment.

3.3.2 Soil Compaction (penetrometer measurements)

Conventionally cultivated soils were less compacted and easier to push the penetrometer into than direct drilled or strip tilled soils. Grazing increased the amount of compaction resulting in higher readings in the grazed areas.

3.3.3 Water infiltration rates

Water infiltration rates were fastest in the conventionally established treatments and slowest under direct drilling, indicating a more compacted soil structure making it hard for the water to soak in. Saturated soils at the end of winter meant that infiltration measurements could not be completed within the allocated timeframes.

3.3.4 Soil conditions during grazing

In the SDH fodder beet paddock pugging was deeper in the conventionally established areas of the paddock, however, differences in crop yield between the establishment methods means these results are confounded by stocking density during grazing i.e. the cows most likely spent longer grazing on the conventional area because of the higher yield. Pugging depth always increased following rain irrespective of establishment method.

An increase in surface pooling on the direct drilled treatment aligned with the slower water infiltration measurements prior to grazing and the higher penetrometer readings. Rainfall events as small as 10-15 mm significantly increased the proportion of the paddock with surface pooling within 24 hours, however, as soon as the rain stopped it didn't take long for this surface pooling to disappear. The number of consecutive rain days have a big impact on paddock conditions and should be used alongside gumboot scores and proportion of surface pooling to determine when Plan B's are implemented.

3.4 Observations from commercial farms

There is a huge diversity in wintering practices across the region with many factors affecting wintering outcomes. Soil type had a much greater influence on soil conditions and grazing outcomes than was originally anticipated i.e. even when farmers were following recommended good practice on some soil types it was difficult to minimise pugging and prevent prolonged presence of surface pooling. Farming situations where the landowner/decision maker was heavily involved in the daily implementation of winter management tended to have better wintering outcomes.

Farmer observations gave considerable insight into what was happening over the course of the day but as anecdotal observations they cannot be used to draw firm conclusions around the benefits or otherwise of minimum till crop establishment. It was noted that cattle behaviour is potentially influenced by age and familiarity with the daily routine and the people managing them.

Implementation of good management practices varied considerably from farm to farm, especially the use of back fences and portable water troughs. More guidance is required around back fence management in relation to the area allocated and frequency of moving.

4. Key Findings

For all establishment methods, successful establishment is determined by paddock conditions at the time of planting and follow up agronomic practices such as weed and pest control.

Although minimum till options may appear to be more environmentally sustainable (from a carbon and soil structure perspective), observations from this study were of lower yields, greater weed burdens, and increased pest pressure. An unintended consequence of minimal

till establishment was the increased need for chemical weed and pest control to help achieve more sustainable yields.

To provide better soil conditions for animals, where practicable, wintering should be undertaken on soils that are more resistant to waterlogging and pugging. Activities with heavy vehicles during the grazing period should be minimised to limit soil compaction in wet conditions. However, lighter free draining soils are at higher risk for nitrate leaching than heavier soils so still pose environmental risks.

Ensuring that the people implementing the winter plan, i.e., those shifting the breaks and feeding the cows, also understand the plan is critical for better wintering outcomes. All the planning in the world will not result in good wintering outcomes if those on the ground don't understand the plan and how to implement it. Successful winter grazing will be determined by the ability of the people implementing the plan to recognise and mitigate the effects of environmental conditions to ensure good management of both soil and livestock.

A tension exists between maximising crop yields and protecting soils. Lower yields result in a lower stocking density and subsequently lower animal grazing days/ha and lower nutrient loading. However, impending rules limiting winter cropping areas are likely to drive higher crop yields and increased stocking density.

Water pooling is a key indicator for farmers to know when to implement their Plan B or contingency plans such as removing stock from a crop paddock. The firmer soils with minimum till establishment increased the risk of surface water pooling during heavy rainfall events. So, while we may be reducing pugging and keeping cows above ground, the water pooling will impact their lying behaviour.

The observations during this study have highlighted the need for a tool to help farmers make more informed choices about crop type, crop establishment method and grazing management including stock class. Understanding how these factors interact with soil type will help identify the farm specific risks associated with their wintering practices and plan for better winter outcomes across the Southland region.

Our observations indicate that establishment method is not going to be a silver bullet for poor crop husbandry or lack of attention to detail over the grazing period and will not overcome the challenges of heavy poorly drained soils. The daily management of the stock had the biggest impact on paddock conditions and cow behaviour.

5. Recommendations

Based on the observations from this study there are four critical steps for farmers when planning their winter cropping:

1. Good paddock selection, preparation, and agronomic practices to achieve optimum crop yields
2. Involving all the farm team in the planning and implementation process so they understand the 'why'.
3. Implementing good management practices to maximise the time animals spend in better grazing conditions, including use of portable water troughs and back fencing.
4. Having a Plan B that everyone involved with wintering knows when and how to implement.

6. Appendix

Table 1: Data Collection Summary Table of Tier 1 locations & SDH

Location Tier 1	Crop/s	Treatment/s	Stock Class	Pre-graze Yield (tDM/ha)	Pre-graze Soil moisture	Pre-graze Infiltration (seconds)	Pre-graze VSA	Pre-graze Force	Post graze force	Avg. Pugging Depth (cm)	Water Pooling (%)	Gumboot Score (0, 1, 2)
Mossburn	Swedes	Conventional	MA Dairy Cows	13.3	31.1	65	31.8	458	502			
		Direct Drill		13.3	33.8	145	24.0	448	443			
		Strip Till		15.1	33.9	43	31.8	526	521			
Mossburn	Fodder beet	Conventional	Dairy Heifers	16.0	30.4	51	25.5	475	440			
		Direct Drill		27.9	31.4	97	28.7	392	429			
		Strip Till		21.5	29.3	151	22.0	453	420			
Grove Bush	Swedes	Conventional	MA Dairy Cows	15.3	32.2	70	28.0	348	553			
		Direct Drill		6.3	34.2	271	27.0	473	600			
Woodlands	Swedes	Conventional	MA Dairy Cows	7.4	30.4	104	31.0	400	367			
		Strip Till		6.7	31.0	202	27.0	337	355			
Otapiri Gorge	Swedes & Multispecies	Conventional (swedes)	Hoggets	12.2	33.1	30	26.8	368	334			
		Direct Drill (multispecies)		5.9	40.3	142	31.0	502	307			
Oreti Plains	Fodder beet	Conventional	Dairy Heifers	11.6	32.3	30	26.8	451	373			
		Strip Till	R1's	12.4	33.9	142	31.0	457	373			
SDH	Fodder beet	Conventional	MA Dairy Cows	22.3	31.3	125	26.0	374	382	5.6	32	0.57
		Direct Drill		10.8	31.2	187	25.8	418	395	2.6	38	0.60
		Strip Till		14.8	32.4	151	26.0	449	412	4.2	34	0.58
SDH	Kale	Conventional	MA Dairy Cows	10.2	30.1	71	27.5	321	343	3.5	38	0.56
		Direct Drill		10.2	30.3	199	24.5	407	409	3.7	42	0.57