Report Title: Findings from the crop establishment pilot study at the Southern Dairy Hub

Prepared for Thriving Southland by Dawn Dalley, Roshean Woods, Teresa Anderson & Natasha Lundin

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

Contents

1 Executive summary

This study was conducted at the Southern Dairy Hub (SDH) as part of the 2021 crop establishment pilot study conducted for Thriving Southland, a community-led group with the aim of creating a more prosperous and environmentally healthy Southland. The purpose of this study was to examine the effects of three different winter crop establishment methods for fodder beet and kale on soil and crop characteristics and animal welfare during winter grazing in Southland.

A paddock at SDH was divided into six equivalent treatments that were established in fodder beet with two replicates of each conventional, direct drill (and aerated) and strip tillage methods. In another nearby paddock, kale was established by a direct drill method in one half and conventional method in the other.

Measurements and data for the each of the treatments were collected and analysed by DairyNZ Research Technicians following industry-standard operating procedures. These measurements included crop yields (leaf and bulb) and utilisations collected over the period of mid-March to the end of the grazing period. Visual soil assessments (VSA), penetrometer readings, infiltration times and soil moisture were measured pre and post grazing in similar areas. Pugging depth, water pooling and gumboot scores were recorded daily during grazing.

The conventional fodder beet treatment achieved higher crop yields than the other fodder beet treatments, which were affected by insect damage, highlighting the importance of timely pesticide use in minimum-tillage establishment methods. Kale showed similar results between establishment methods, despite insect damage in the direct-drilled treatment. Post-grazing utilisation measurements showed no differences between the fodder beet treatments or between the kale treatments, suggesting that crop establishment method did not affect the ability of stock to graze the crop. Grazing caused VSA scores to decrease considerably in all treatments, indicating it had an adverse effect on soil structure regardless of the crop type and establishment method.

Penetrometer readings showed that the conventional fodder beet treatment became more compacted following grazing but was less compacted than both the direct-drill and strip-tillage treatments. The direct-drill treatment showed the smallest change in compaction between pre and post grazing of the fodder beet treatments. Infiltration rates also indicated that the conventionally cultivated fodder beet was less compacted than the other treatments. This is consistent with the lower surface pooling observed during grazing in the conventionally cultivated fodder beet compared with that in the minimum till treatments. A consequence of the lower pre-graze compaction in the conventionally cultivated fodder beet was that it was more susceptible to pugging than the other treatments. However, the tendency of the cows to spend more time in the conventional treatment because of its higher yield may have also affected these results. No obvious trends were identified for the kale treatments, with the conventional and direct-drill treatments achieving similar yield, utilisation, VSA, gumboot score, pugging depth and surface pooling results despite infiltration and penetrometer readings suggesting that the soil was less compacted in the conventional treatment than in the direct-drilled one.

Overall, there were only small differences between the soil structure and animal welfare indicators collected for both the fodder beet and kale treatments with different crop establishment methods. The results indicated that using minimum-till crop establishment methods alone may not be sufficient to either protect soil structure or improve animal welfare during intensive winter grazing.

Further studies could compare how different soil types behave when established using different crop establishment methods. In any future studies, it will be important to achieve consistent crop yields across the different establishment methods to remove the confounding effects of yield and grazing pressure on wintering outcomes.

This pilot study did not consider the effects of good wintering practices such as contingency plans, extra feed, bedding, back fence management, grazing direction, on-off grazing during adverse weather events, portable trough management and restricted vehicle use on soil structure or animal welfare. This information could help farmers refine their paddock choice and wintering set-up based on their soil type, cultivation method, crop type and winter grazing management plan.

2 Introduction

Maintaining soil structure and strength is one potential way in which pugging could be decreased in intensive winter cropping systems. Conventional (CON) 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 (ST) is a form of conservation tillage that combines the advantages of CON cultivation and no-tillage 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 ST success is compaction in the uncultivated areas, which can restrict root growth and lower yields. It is recommended to ensure at least 4-6 weeks spray fallow in ST systems to decrease pest pressure.

A study by Plant and Food Research at the Lincoln University Research Dairy Farm comparing CON cultivation establishment of fodder beet and kale with direct-drilled (DD) establishment reported that high yield crops of fodder beet and kale could be achieved with no tillage (10-13% yield penalty in fodder beet but 25-40% yield advantage with kale). An attractive feature of DD is that it has lower establishment costs than those of CON cultivation. During feeding, crops established by no-tillage had improved crop utilisation, resulting from more dry matter (DM) being consumed by cows on the no-tillage kale treatment than those on the conventionally cultivated crops. Following grazing, a catch crop of oats was established in all treatment areas. Less soil compaction under the no-tillage fodder beet and kale resulted in better catch-crop establishment, DM production and uptake of nitrogen by the forage oats compared with those grown in the conventionally cultivated treatment areas.

Given the need to decrease pugging in intensive winter grazing systems, the success of ST systems in North Island cropping systems and the benefits of no-tillage systems in Canterbury, the Southern Dairy Hub (SDH) identified an opportunity to test the effectiveness of these establishment methods to decrease pugging in crop paddocks grazed in winter 2021.

In winter 2020, a cow behaviour study was undertaken at SDH in which cow activity was tracked using accelerometers (HOBOs) and in-paddock soil measurements including gumboot scores, soil moisture, pugging depth and surface pooling were conducted. Results of this study indicated the surface water pooling and gumboot scores were reliable indicators of cow lying time and thus cow welfare.

We hypothesised that by utilising ST or DD to establish fodder beet crops and DD to establish kale crops, soil structure and strength would be better maintained compared to the case after CON cultivation. These improved soil conditions would then result in better lying conditions for the cattle.

Key Project Objective

To test whether utilising strip tillage or direct drilling to establish fodder beet crops and direct drilling to establish kale crops maintains soil structure and strength, thereby decreasing pugging and improving animal welfare during winter grazing compared to the situation for conventional cultivation.

Short Description

In spring 2020, two pasture paddocks at the Southern Dairy Hub were selected; one was sown in fodder beet and the other in kale.

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 as per the best practice for each establishment method.

For the kale paddock, half the paddock was established using direct drilling and the other half using conventional cultivation as per best practice for each establishment method.

3 Methods

Both the fodder beet and kale paddocks had been used to graze springers prior to calving in spring 2020 so areas of the paddock were pugged. There was variable pasture cover across each paddock depending on the degree of pugging. The fodder beet paddock was sprayed out with glyphosate on October 24th and again on November 9th, 2020.

Fodder beet areas to be established using minimum or no tillage were aerated at an angle on November 2nd, 2020. The CON area was ploughed on November 17th and then surface worked with a rotacrumbler and roller on November 19th. We were unable to get all the drills on farm on the same day, with the CON, DD and ST areas being established on November 25th, 20th and 24th, respectively. At the time of drilling, a considerable amount of dead pasture trash remained in the DD and ST areas. The fodder beet paddock was planted in Jamon; however, the DD area was replanted on December 20th with Bangor.

In the kale paddock (Figure 1), following spraying out on the 9th of November, the CON area was ploughed on November 16th, power harrowed on November 25th and drilled on December 4th. The DD area was established on December 7th. The kale cultivar used was Firefly.

Fertiliser applications were planned to be the same rate and timing for each treatment; however, there were some issues with the implementation of the plan. The same was true for the herbicides and insecticides.

The fodder beet paddock was divided into six equal areas (two replicates of each treatment) with a 10-m grass buffer on each edge of the paddock and through the centre between the two replicate groups (Figure 2). These grass buffers were used to place the baleage during grazing.

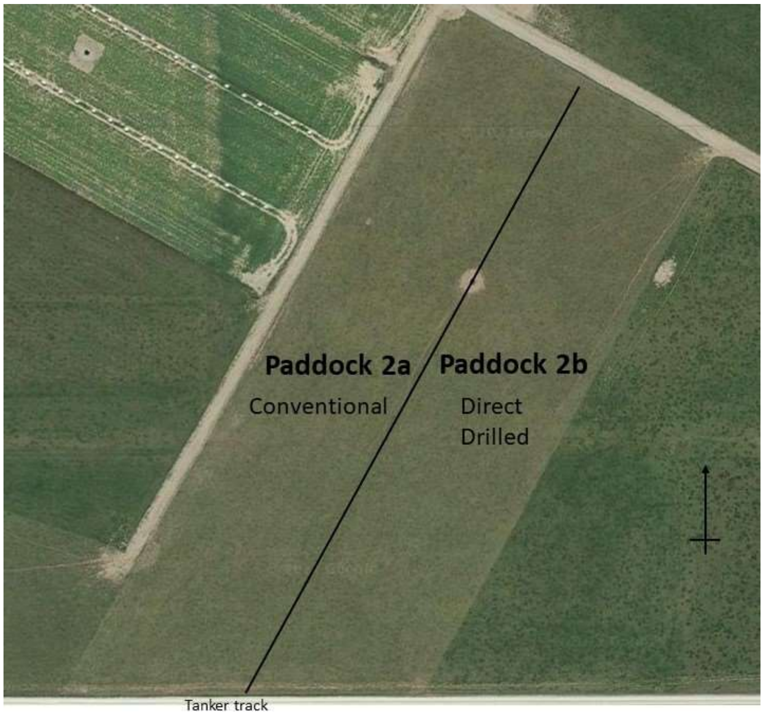


Figure 1 Treatment layout of the kale trial paddock at SDH in winter 2021

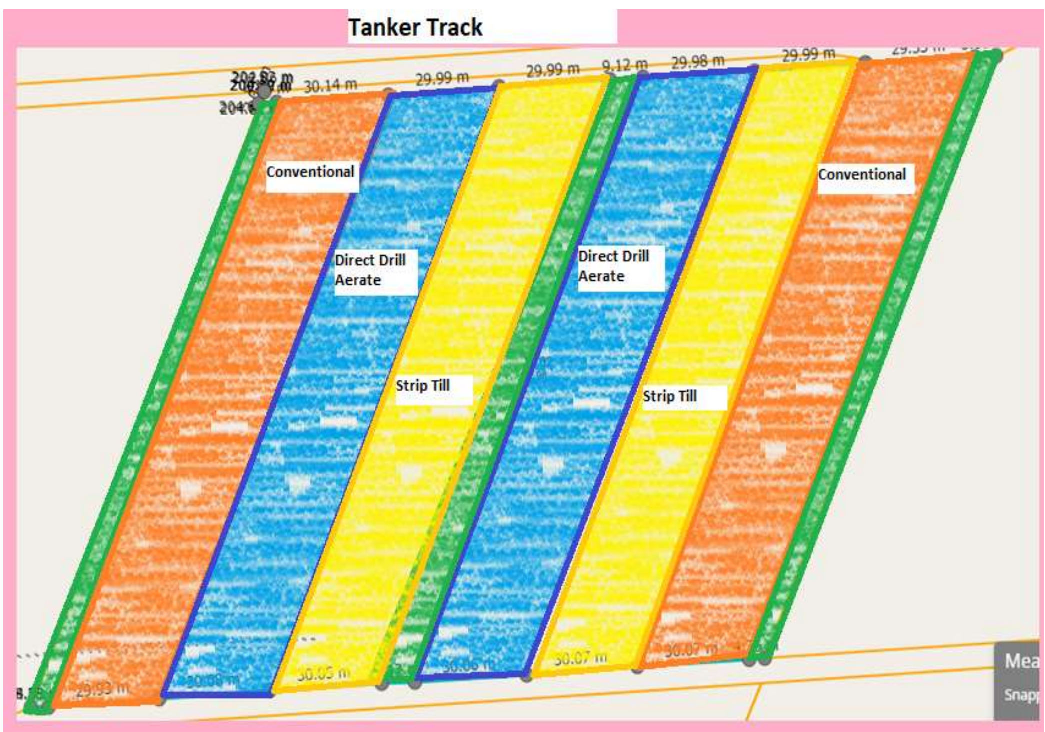


Figure 2: Treatment layout of the fodder beet trial paddock at SDH in winter 2021

A range of measurements were undertaken to determine whether the establishment method impacted crop yield, soil conditions before, during and after grazing and crop utilisation.

Crop yields were undertaken monthly from mid-March until the end of the grazing period for each treatment according to standard operating procedures (Appendix). For fodder beet, this involved sampling each replicate area and measuring the leaf and bulb separately. Kale yields were assessed in each treatment area.

Visual soil assessments (VSAs) were undertaken according to a published procedure (Shepherd, T.G. 2000: Visual Soil Assessment. Volume 1. Field guide for cropping and pastoral grazing on flat to rolling country. horizons.mw & Landcare Research, Palmerston North) in each treatment area before and after grazing along with baseline assessments under nearby fence lines.

Infiltration measurements (Appendix) were attempted before and after grazing using infiltration rings and water; however, this method was only moderately successful. A penetrometer was used to assess the compaction of each treatment pre- and post-grazing. In both paddocks, penetrometer readings were taken within or between the rows before grazing and in a similar area of the paddock after grazing.

Soil moisture was determined by collecting ten soil cores from each treatment before and after grazing. Soil profile was assessed by digging a trench approximately 30-cm wide and spade depth across two rows of fodder beet keeping the edge to be photographed as straight as possible.

Daily measurements were collected during the grazing period in all treatments as follows. Commencing at 9 am each day (or after the frost melted), the pugging depth, gumboot score and surface pooling at 13 sites per treatment were measured. Starting at the back fence from the previous day, 13 sites at predetermined positions on a pre-defined upside-down “W” in each treatment were monitored. Areas disturbed by vehicles and water troughs were avoided. Site 1 was located at the lower right-hand corner of the break. The measurements were representative of the same parts of the paddock in all treatments, i.e., the same number of measurements was collected in each quadrant of the treatment. Depending on the shape of the break, the shape of the “W” varied; however, measurements were always taken at the same points on the “W”. The gumboot score at each measurement point was recorded as dry (1; soil was friable and crumbly), wet (2; soil was the consistency of a mud pie, i.e., able to hold its shape) or sodden (3; soil was too wet to hold its shape). Pugging depth was recorded in front, beside and behind the right gumboot at each measurement point. A 30-cm plastic ruler was pushed vertically into the soil until resistance was felt. The depth was recorded in cm. If the ruler went all the way into the soil without meeting resistance, the value was recorded as >30 cm. Surface pooling in the immediate vicinity of each measurement point was recorded as present or absent. Photographs were taken at the left, middle and right of each treatment during daily measurements to capture how the soil conditions changed relative to the weather conditions and the state of the area accessible to the cows.

4 Results

A few timing issues with establishment, weed and pest control affected the results of this pilot study at SDH. These issues provided opportunities to learn about the importance of paddock preparation and timing of establishment of ST and DD fodder beet crops. The issues were primarily related to the complexity of the paddock layout, soil conditions and timing.

- Direct drill
    - soil conditions were too wet at the time of planting,
    - too much dead trash remained after spraying, which provided a haven for insects,
    - poor plant survival caused by insect damage,
    - pasture and weed competition following redrilling.

- Strip tillage
    - soil conditions were too wet at the time of planting,
    - too much dead trash remained after spraying, providing a haven for insects,
    - poor germination caused by uneven seed depth,
    - poor plant survival resulting from insect damage,
    - considerable competition from grass caused by poor spray out and mistimed follow up sprays.

Crop yield

A large contributor to the differences in crop yields between the treatments was the number of seeds that germinated and survived. In both the minimum-tillage establishment treatments, insect damage soon after germination resulted in poor plant populations. Despite redrilling the DD crop, we were unable to achieve good yields (Figure 3).

At grazing, the CON fodder beet yield averaged 22.3 t DM/ha (range 21-25 t DM/ha) with 24% leaf. This compares with 10.8 (8-15) t DM/ha with 33% leaf and 14.8 (13-17) t DM/ha with 28% leaf for DD and ST areas, respectively. Average kale yield at grazing was 10.2 t DM/ha for both treatments.

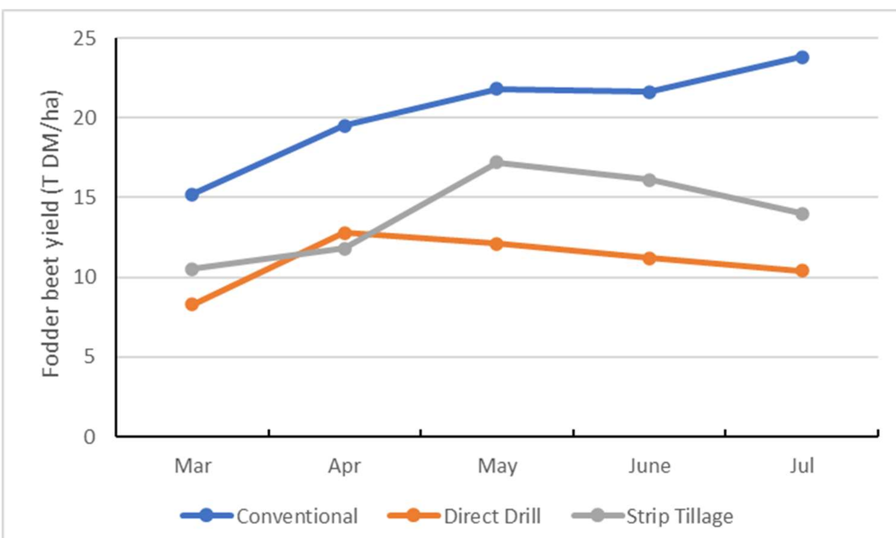


Figure 3: Dry matter yield for conventional-, direct drill- and strip tillage-established fodder beet at SDH from March 2021 until the end of grazing in July 2021

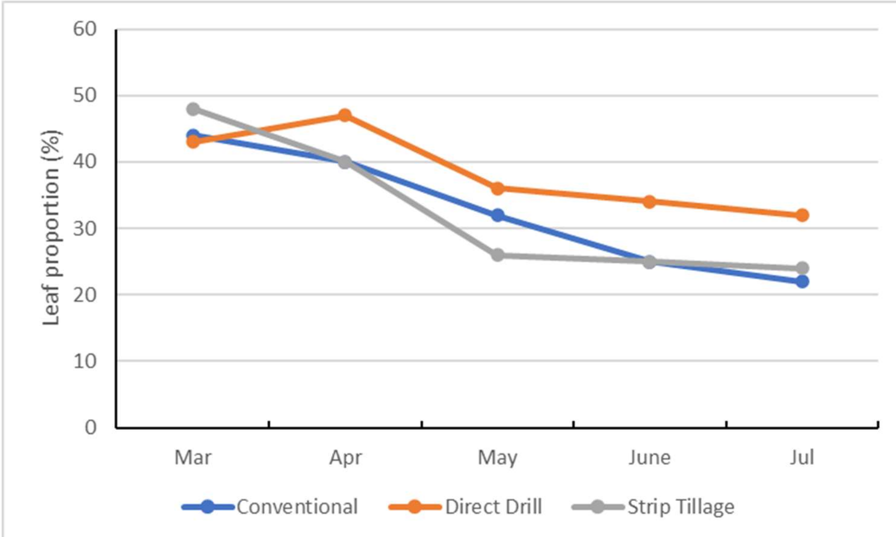


Figure 4: Proportion of leaf for fodder beet grown by conventional, direct-drill and strip-tillage establishment methods at SDH from March 2021 until the end of grazing in July 2021

The DD fodder beet crop maintained a higher proportion of leaf than that grown by the other establishment methods throughout the growing and feeding period (Figure 4).

Delays with weed spraying limited the CON kale crop yield through the early part of the growth season until the weeds were under control. By the start of grazing in June, there were no differences in average yield between the two establishment methods (Figure 5). A different result may have been observed if the two establishment methods had the same timing for weed control.

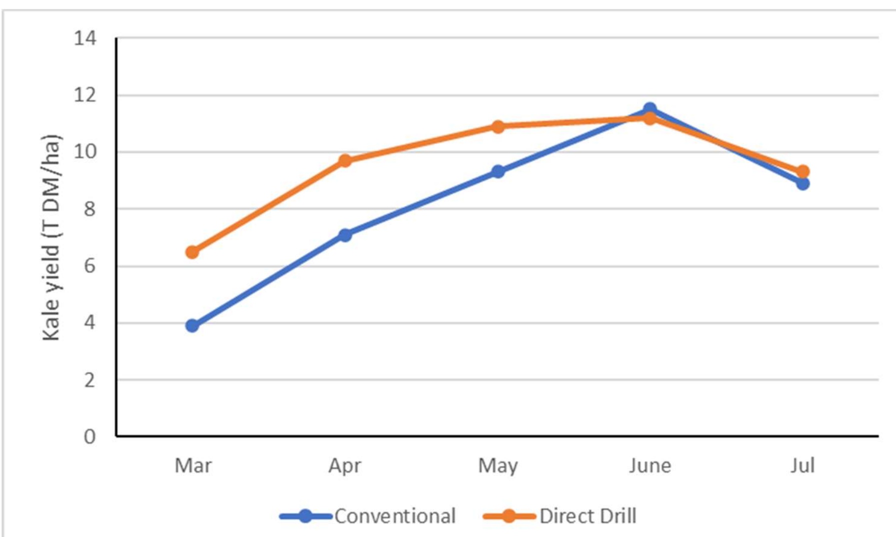


Figure 5: Dry matter yield for conventional and direct-drill established kale at SDH from March 2021 till the end of grazing in July 2021

Despite the observation of broken-off bulbs (Figure 6) in both the ST and DD areas of the fodder beet paddock, there were no differences in crop utilisation observed between the establishment methods. Post-crop sampling measurements indicated that utilisation ranged from 94 to 99% across the fodder beet treatments.

Figure 6: Remnant of a crop bulb in the fodder beet trial paddock

Similarly, in the kale paddock there were no differences in utilisation between the treatments. However, utilisation in the second period (82-84%) was poorer than that measured in the first period (93-96%). Because of the lower yield of the kale trial paddock compared with that of other kale paddocks at SDH, the crop allocation in this paddock was lower than that of other kale paddocks. The herd in the kale trial paddock was offered more baleage to compensate for this lower kale yield.

Visual soil assessment

There were no differences measured between the establishment treatments in VSAs conducted prior to winter grazing in either the fodder beet or kale paddocks. In both paddocks, the VSA scores within the paddock were considerably lower than those from samples collected under fencelines (Table 1). This result demonstrates the effect of grazing while in pasture on soil characteristics.

Table 1: Average visual soil assessment scores pre and post grazing for paddocks established in fodder beet and kale using a range of conventional and minimum tillage methods.

	Pre-graze	Post-graze
Fodder beet		
Fenceline	30.5	
Conventional	26.0	15.1
Direct Drill	25.8	17.9
Strip Tillage	26.0	17.5
Kale		
Fenceline	29.3	
Conventional	27.5	15.5
Direct Drill	24.5	16.5

In the fodder beet paddock, the post-grazing VSA scores for the CON areas were lower (indicating poorer soil structure) than those in the DD and ST areas but all results were much lower than the pre-grazing measurements (Table 1). The trends were less clear in the kale paddock, where a lower VSA was recorded post grazing in the CON area but a lower VSA was recorded pre grazing in the DDI area (Table 1). Again, VSA scores decreased in both kale treatments after grazing compared with those before grazing.

Penetrometer

A penetrometer was used to measure the force required to push a stainless-steel rod into the soil in both paddocks pre and post grazing. This force is related to soil compaction. In the fodder beet paddock, the force was lower in the conventionally established areas than in the minimum-tillage establishment areas (Table 2), indicating less soil compaction in the conventionally cultivated areas than the other areas. The pre-graze trends were also observed post grazing although the differences were smaller. Similar trends were observed in the kale paddock.

Table 2: Average penetrometer force readings (N) within and between rows pre and post grazing for paddocks established in fodder beet and kale using conventional and minimum-tillage methods

	Fodder beet			Kale		
	Pre-grazing		Post-grazing	Pre-grazing		Post-grazing
	Between	Within		Between	Within	
Conventional	374	341	382	321	332	343
Direct Drill	418	444	395	407	359	409
Strip Tillage	449	427	412			

Infiltration

The rate of water infiltration was faster for the conventionally cultivated areas before grazing in the fodder beet and kale paddocks compared with those of the minimum-tillage areas (Table 3). The DD areas showed the slowest rates of water infiltration with the ST treatments being intermediate between those of CON and DD areas. All paddocks were waterlogged after grazing so no infiltration measurements were completed within the time limit of 15 minutes.

Table 3: Average infiltration time(s) pre-grazing for paddocks established in fodder beet and kale using conventional and minimum-tillage methods

	Pre-graze
Fodder beet	
Conventional	125
Direct Drill	187
Strip Tillage	151
Kale	
Conventional	71
Direct Drill	199

Soil moisture

Unsurprisingly, the soils in both paddocks and across all treatments were drier pre grazing than post grazing (Table 4). There were no clear trends in soil moisture between the establishment methods either pre- or post-grazing.

Table 4: Average soil moisture content (%) pre- and post-grazing for paddocks established in fodder beet and kale using conventional and minimum-tillage methods

	Pre-graze	Post-graze
Fodder beet		
Conventional	31.3	34.1
Direct Drill	31.2	33.9
Strip Tillage	32.4	34.6
Kale		
Conventional	30.1	33.3
Direct Drill	30.3	32.1

<u>Soil profile assessment</u>

It was difficult to quantify any effects of establishment method from the soil profile photos taken before and after grazing. Differences in the amount of compaction were observed between the pre- and post-graze profiles, especially in the top few centimetres (Figure 7-11).

Figure 7: Conventionally established fodder beet pre- and post-grazing profiles

Figure 8: Direct-drilled fodder beet pre- and post-grazing profiles

Figure 9: Strip-tillage fodder beet pre- and post-grazing profiles

Figure 10: Conventionally cultivated kale pre- and post-grazing profiles

Figure 11: Direct-drilled kale pre- and post-grazing profiles

Climate

Weather conditions during the grazing of the crop were typical for winter in Southland. Soil temperature fluctuated between 6 and 10 °C and there was a total of 126 mm of rainfall across the 41 measurement days. The largest individual rainfall event was 15.4 mm on the 8th of July (Figure 12).

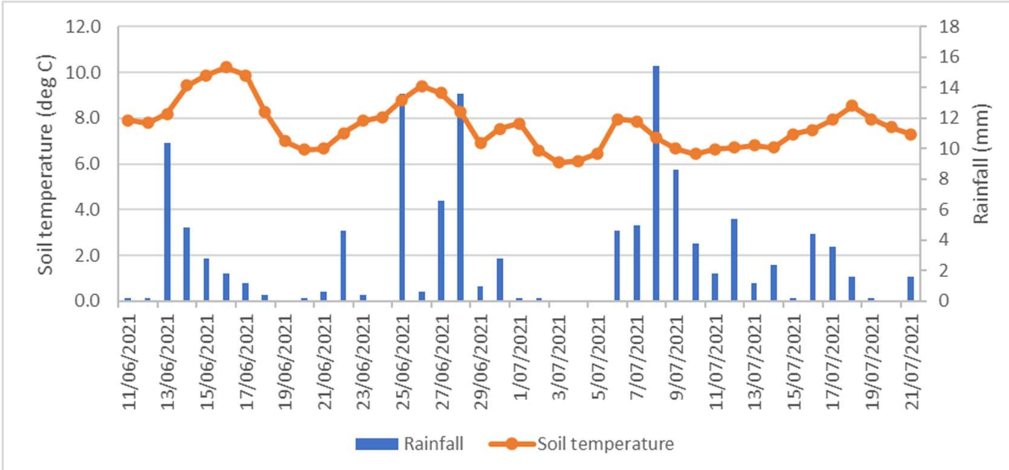


Figure 12: Daily rainfall and soil temperature throughout the crop grazing period

<u>Soil conditions during grazing</u>

In the fodder beet paddock, pugging depth was deepest for the CON treatment, followed by ST and then DD (Table 5). A smaller proportion of the CON measurement points were scored as wet and there tended to be less surface pooling in this treatment compared with the case in the other treatments. The DD areas had the highest proportion of sites with surface pooling but the lowest pugging depth of the treatments.

Differences between treatments were smaller in the kale paddock, with no clear trends evident (Table 5).

Table 5: Average pugging depth, gumboot score, soil wetness and pooling for paddocks established in fodder beet and kale using conventional and minimum-tillage methods

Fodder beet	Pugging depth (cm)	Gumboot score (0-2)	Dry (%)	Wet (%)	Sodden (%)	Pooling (%)
Conventional	5.6	0.57	57	29	14	32
Direct Drill	2.6	0.60	52	36	12	38
Strip tillage	4.2	0.58	55	32	13	34
Kale						
Conventional	3.5	0.56	58	27	14	42
Direct Drill	3.7	0.57	57	29	14	38

Pugging depth, gumboot scores and surface pooling all rose with rainfall (Figure 13-16). Within one day of a large rainfall event or consecutive days of smaller rainfall events, increases in gumboot scores, pugging depth and surface pooling were observed. For all these metrics, values dropped within a couple of days of each rainfall event. In the fodder beet paddock, pugging depth was consistently highest for the CON treatment and lowest for the DD. Daily trends in gumboot scores and surface pooling were less evident between treatments (Figure 13-16). Fodder beet treatments tended to have higher surface pooling for longer after rainfall events than kale treatments (Figure 16 and 20), possibly due to the smaller daily break size in the fodder beet paddock that the kale paddock as a result of the higher fodder beet yield.

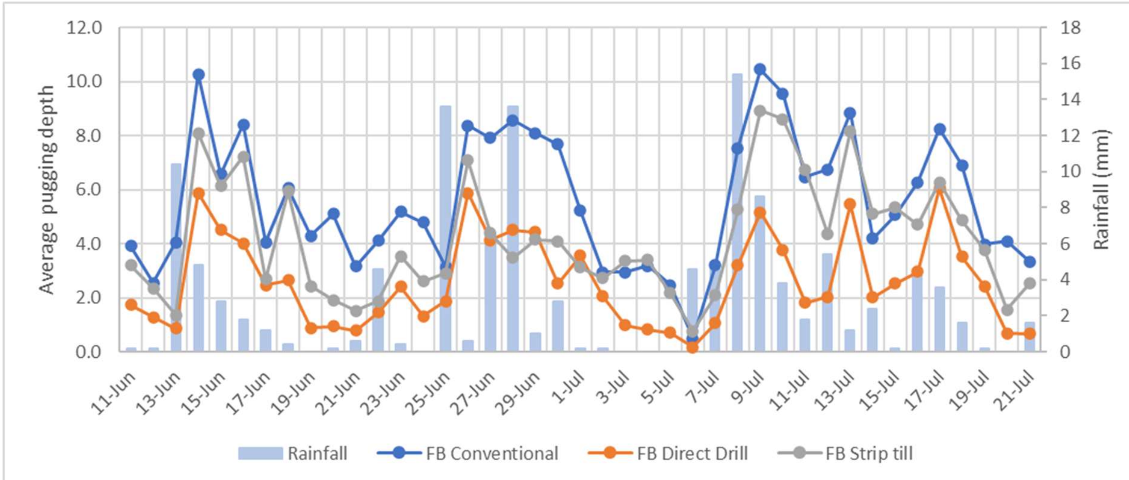


Figure 13: Relationship between average daily pugging depth and rainfall for the fodder beet treatments during the grazing period

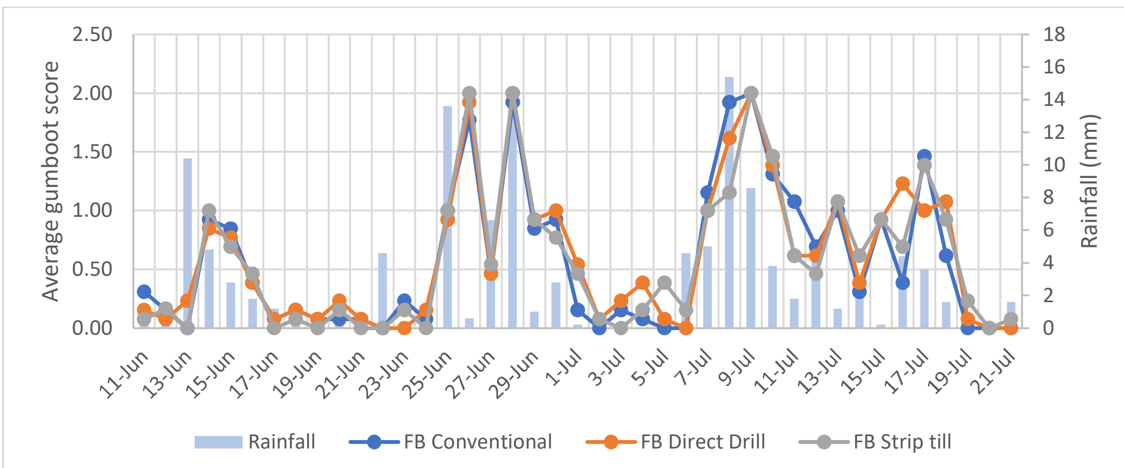


Figure 14: Relationship between average daily gumboot score and rainfall for the fodder beet treatments during the grazing period

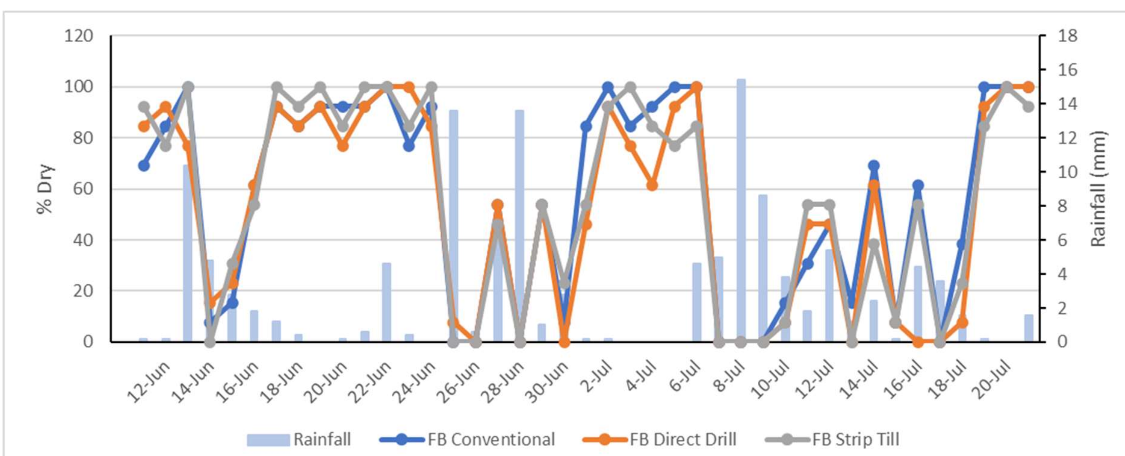


Figure 15: Relationship between the proportion of the grazing break scored “dry” and rainfall for the fodder beet treatments during the grazing period

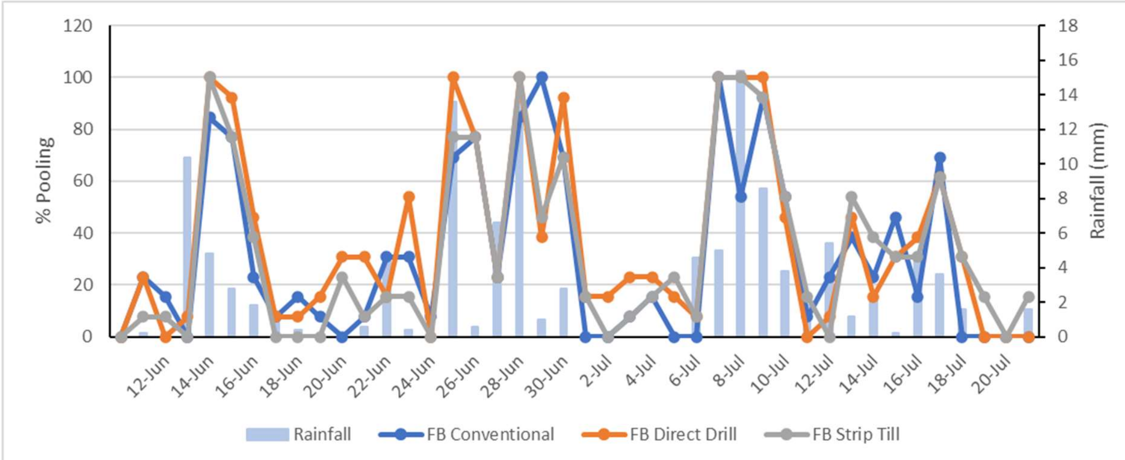


Figure 16: Relationship between the proportion of the grazing break with surface pooling and rainfall for the fodder beet treatments during the grazing period

In the kale paddock, the soil conditions responded in a similar way to rainfall events as they did in the fodder beet paddock (Figure 17 & Figure 18); however, the average pugging depth was lower than that measured in the CON and ST fodder beet treatments. It appeared that surface water pooling dissipated more quickly following rain in the kale paddock than in the fodder beet treatments. There were no clear differences between the pugging depth, gumboot score and surface pooling of the CON and DD kale treatments.

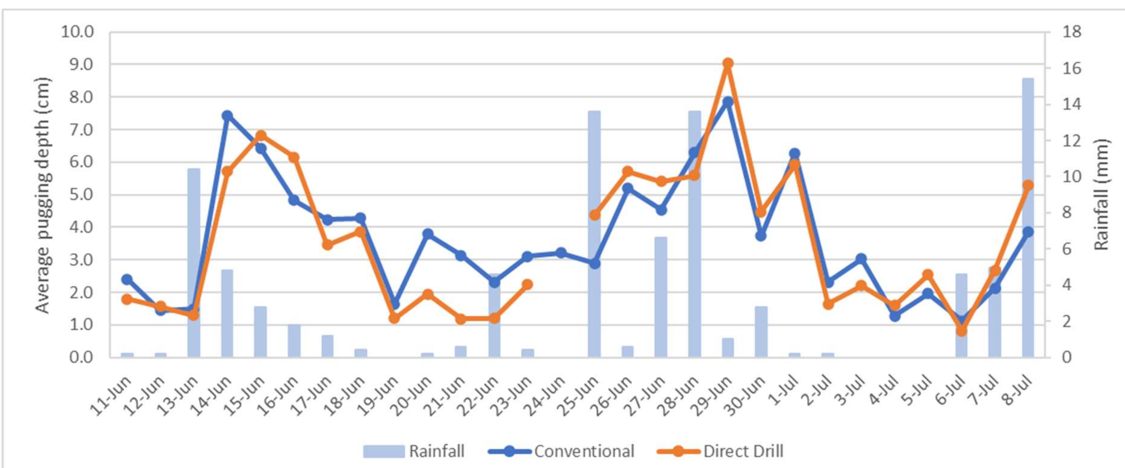


Figure 17: Relationship between average daily pugging depth and rainfall for the kale treatments during the grazing period

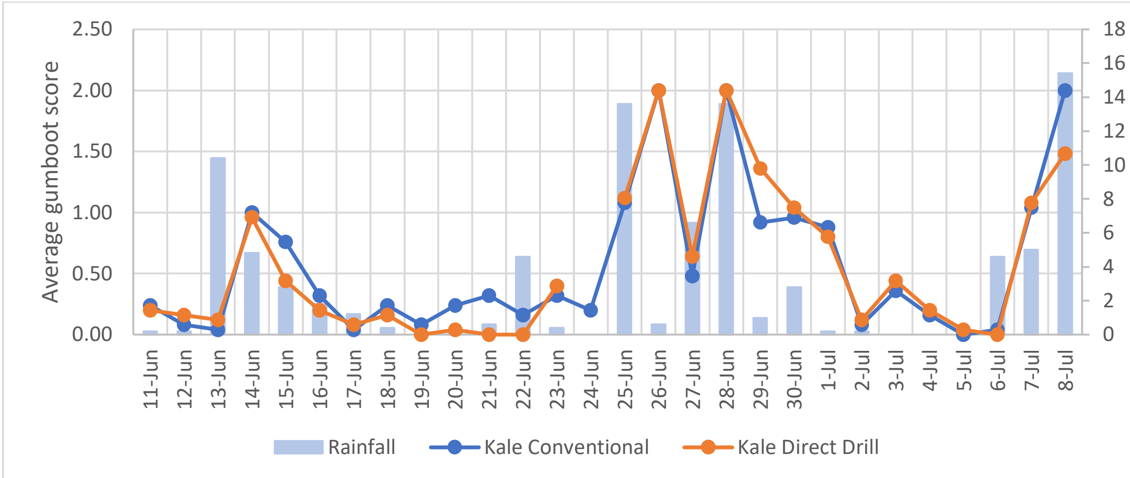


Figure 18: Relationship between average daily gumboot score and rainfall for the kale treatments during the grazing period

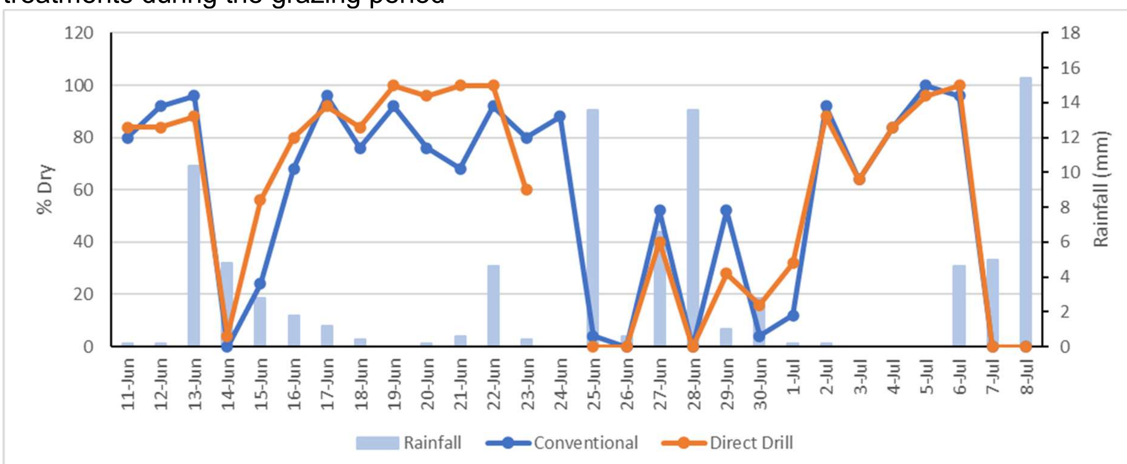


Figure 19: Relationship between average proportion of the paddock scored dry and rainfall for the kale treatments during the grazing period

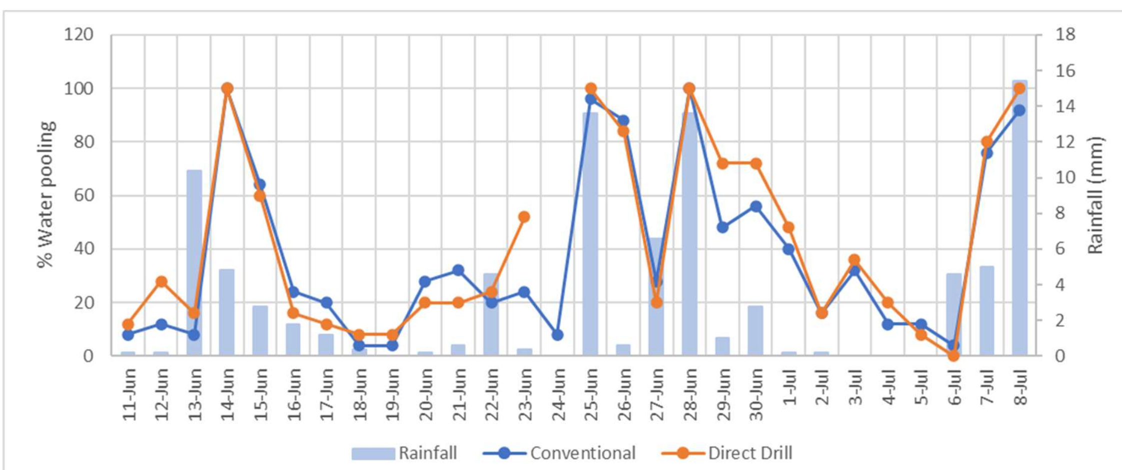


Figure 20: Relationship between average proportion of the paddock with surface pooling and rainfall for the kale treatments during the grazing period

5 Discussion

Crop yields during grazing were higher for the CON treatment than the minimum-tillage treatments in the fodder beet paddock. This situation was caused by insect damage in the ST and DD treatments, highlighting the importance of appropriately timed spraying of both existing cover before sowing and insect pests when using minimum-tillage establishment methods. Yields were similar for the two treatments in the kale paddock at grazing, but again may have been affected by insect damage in the DD treatment. These results are disappointing when considered against a previous study at the Lincoln University Research Dairy Farm, which achieved fodder beet crop yields 10-13% lower than CON and kale yields 25-40% higher than CON when using minimum-tillage establishment methods.

Visual soil assessment scores for cultivated areas were lower than those under fencelines in both fodder beet and kale paddocks before grazing. Grazing during winter caused VSA scores to decrease considerably in both paddocks, indicating grazing had an adverse effect on soil structure regardless of the crop type and establishment method.

The CON fodder beet treatments were less compacted than the ST and DD treatments, as evidenced by their lower penetrometer forces and higher infiltration rates. This is consistent with the lower surface pooling observed in the CON areas during daily measurements; that is, the friable soil surface in these areas soaked up water more readily than the compacted soil surface in the minimum-tillage treatments. However, the softer soil in the CON areas appeared more susceptible to pugging than the more compacted soil in the minimum-tillage treatments. Although the pugging depth results for the fodder beet paddock are logical based on initial soil structure measurements, cows would have spent more time on the CON area because of its higher yield than those of the other treatments. The direction of the prevailing wind also meant that cows congregated in poor weather on the CON area during the first half of the trial, which may explain the large increase in pugging depth measured for the CON area compared with that of the minimum-tillage areas from June 26th to July 1st.

Penetrometer and infiltration results for the kale paddock indicated that the soil was less compacted in the CON treatment than in the DD area. However, these differences did not lead to obvious trends in the daily measurement results for the kale paddock, with the CON and DD treatments achieving similar gumboot score, pugging depth, and surface pooling.

One concern about intensive winter grazing systems is that the lying time of cows may be limited in wet conditions. Indeed, the lying time of cows shows a negative relationship with surface pooling, which means that surface pooling can be used as a simple visual tool to assess the likelihood that cows are able to express natural lying behaviour. Surface pooling was strongly linked with rainfall events, even small ones, in all treatments, highlighting the importance of monitoring cow welfare during and after rain. Surface pooling appeared to decrease faster after rain in the kale paddock than in the fodder beet one. However, this may be related to the larger break width in the kale paddock than in the fodder beet paddock, which meant that cows spent less time in each area of the former than in each area of the latter.

The limited differences between the responses of the treatments with different crop types and establishment methods to winter grazing indicates that using a minimum-tillage method of establishment may not be sufficient to either protect soil structure or improve animal welfare during intensive winter grazing. The results of this pilot study were affected by the poor initial establishment of the minimum-tillage treatments resulting from insect damage and soil conditions being too wet during establishment. For future research in this area it will be important to achieve comparable crop yields in the minimum-tillage treatments to remove any confounding when assessing the impact on grazing conditions and animal welfare.

6 Acknowledgements

We greatly appreciate the assistance, often in pretty inhospitable conditions, provided by technical staff, especially Sharon Anaru Hill, Grace Blackburn, Jenna Rule, Andrea Hayston and Nicole Coulter. Our thanks also go to the SDH farm staff who willingly accommodated our requests during the planning and implementation of the research. Thanks to Louise Cook (SDH General manager) for preparing to take a risk in allowing this project to happen at SDH when the impacts on the farm operation could have been high.

7 Appendices

7.1 Fodder beet yield assessment SOP

DairyNZ *Standard Operating Procedure:* **Fodder Beet Sampling**	**Site:** Southern Dairy Hub **Page:** 1 of 4 **SOP No.:** Fodder beet **Last Reviewed:** 15/9/2021 **Persons Implementing:** Technicians

Background:

Fodder beet is a bulb crop grown as a supplement for cattle and sheep. It is grown for feeding to lactating cows in autumn and spring and as a winter feed crop for non lactating cows. It is either grazed in situ or lifted and fed in a pasture paddock or on a feed pad. It can have yields as high as 30 t/ha. In autumn it typically has 30-40% of the dry matter in the leave and the remainder in the bulb, however due to leaf drop through late autumn and winter and increase bulb size the proportion of leaf can drop to as low as 15% late in winter.

The leaf contains most of the protein in the crop with the bulb being high in soluble sugar.

Fodder beet cultivars vary in the dry matter content of the bulb so it is important that DM analysis is completed for each paddock each time a crop yield estimate is done. It is also important that the DM test is done from plants collected on the day of assessment and the samples are processed on the same day as rainfall can change the bulb DM% by 1-3% units.

Low DM cultivars have a softer bulb and more of the bulb tends to be above ground. As the bulb DM content increases the bulbs get harder and more of the bulb is below ground. DM% can range from as low as 10% up to 25%.

Personal Protective Equipment (PPE):

 ***High Vis*** Worn at all times	 ***Work boots/ Gumboots*** Worn at all times	 ***Cut-Proof Gloves*** Must be worn when using knives

Equipment:

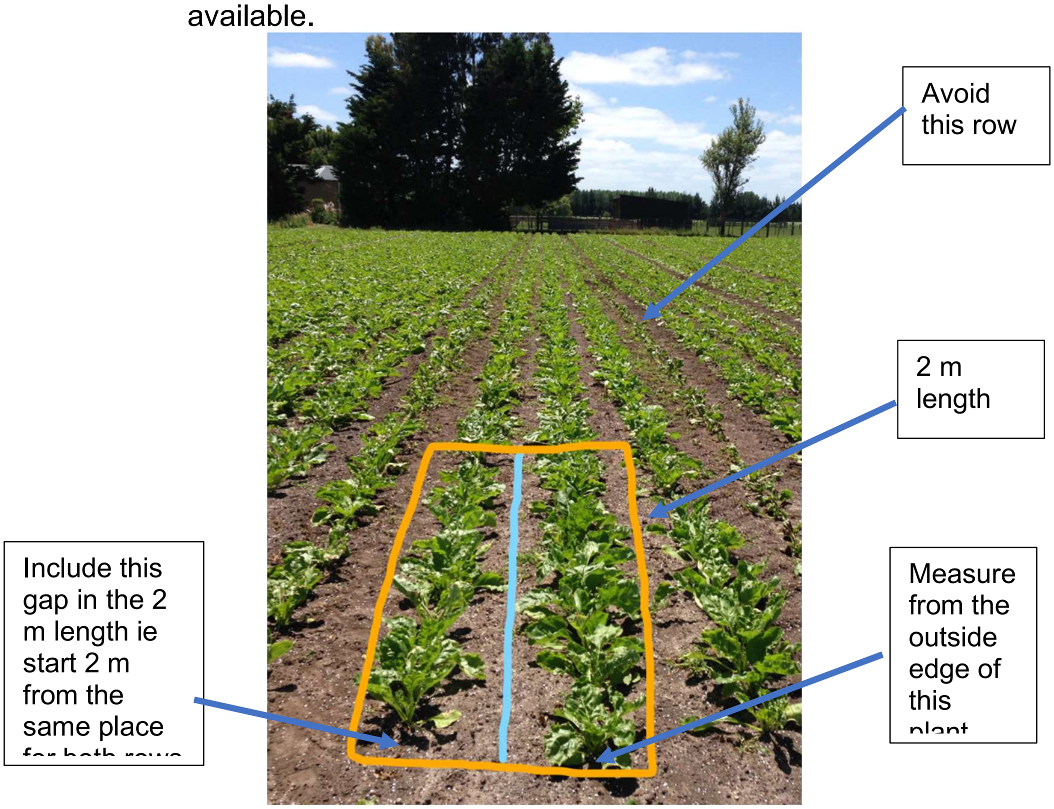
- Measuring tape
- Fence standards (if by yourself)
- Butchers knife (1 per person)
- Plastic bristle brush
- Weighing Sack
- Back pack
- Cut proof gloves
- Scales
- Sub sample sacks/bags
- Wet Weather Gear
- Recording sheet + clip board
- Water and food
- Spare batteries

Procedure:

1. **Select the area to be sampled**
   - **a.** Sample area should represent the next area to be grazed
   - **b.** Sample area should represent the whole paddock (depending on requirements)

2. **Three areas of 2 m x 2 adjacent rows will generally be sampled at each sampling but this may vary depending on time of year so please check exactly how many are required each time.**

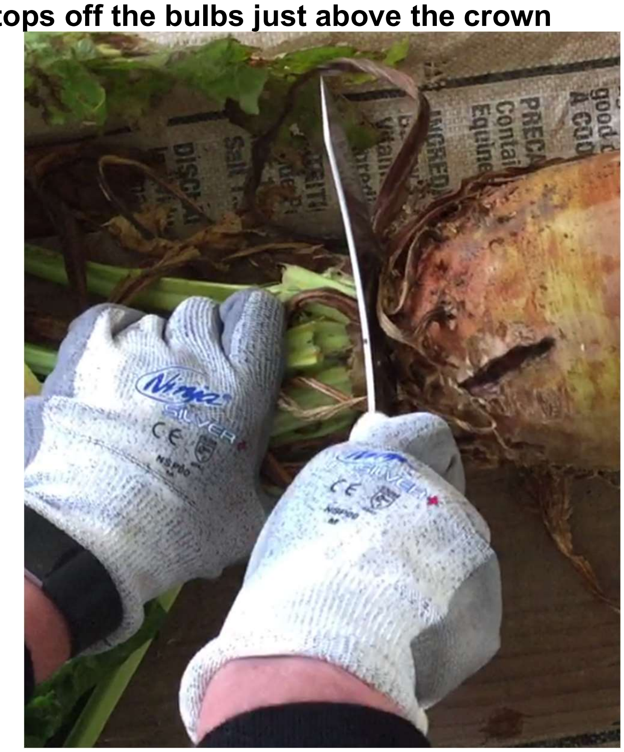
3. **Identify the two adjacent rows to be sampled and put a marker in the ground to identify where to start the 2 m measurement from**
   - a. Put the marker on the offside of a bulb and measure 2 m along the row from that point ensuring that whole plants are included in the 2 m.
   - b. Avoid non uniform areas unless they represent a large proportion of the area
   - c. Avoid any rows that have been damaged by spray or fertiliser crops and the rows adjacent to these as they may have had compensatory growth because there is more space and sunlight available.



4. **Pull all the beets from the 2 adjacent rows and clean any soil off the bulbs using the back side of the knife avoid chopping off any lateral roots**
   - a. For hard to remove soil you can brush off with the brush

b. Aim to remove as much soil as possible but they don't need to be absolutely clean

5. **Cut the tops off the bulbs just above the crown**



6. **When the leaves are cut off they should all be held together by a small section of the crown**
   NB the section in the photo below is slightly thicker than it needs to be

7. **Record the empty weight of the weighing bag on the recording sheet**
   NB if the crop is wet the bag will gain weight throughout the day so it is important that the weight is recorded at the start of each paddock
8. **Place all the harvested leaf into the weighing bag and record the weight on the recording sheet**
9. **Tip the leaves out of the bag and collect two representative leaves (as above)**
   a. put the leaves into the subsample bag/sack for that paddock.
10. **Place all the harvested bulbs into the weighing bag and record the weight on the recording sheet**
    a. Depending on the size of the bulbs and weight you might have to do this as 2 or 3 measurements so you are not lifting more than 20 kg at a time
11. **Weigh the full bag and record the weight (s) on the recording sheet.**
    NB when weighing the bag make sure it is held away from your body and is not touching the ground or surrounding crop.
    a. If weighing in more than one lot please remember to record all the weights
12. **Tip the bulbs out of the bag and collect two representative bulbs for the subsample**
    a. The 2 bulbs should represent most of the plants that were harvested ie. Don't just pick the biggest and the smallest
    b. put the bulbs into the subsample bag/sack for that paddock.
13. **Repeat steps 3-8 for the remaining samples in that paddock**
    a. The representative samples from one paddock all go into the same sack/bag
14. **Put the sub sample sack somewhere out of the sun and in an area that is not too hot.**
    a. If possible close the top of the subsample bag/sack to stop the plants wilting
15. **Take the crop back to the field lab as soon as sampling is finished and put into the fridge until it is processed (see walk in chiller SOP)**

Cleaning Equipment:
• **Rinse the bags out with warm water once finished with them**
• **Pull out the measuring tape, wipe down and allow to dry before retracting**
• **Carefully clean the knife (wear cut proof gloves as doing it)**
• **Sharpen the Sheers if required, wipe dry and spray with lanolin**
• **Wipe the scales down with a damp cloth (Do NOT wash directly under the tap)**

Emergency Procedures:
Severed appendage
1. **Wrap appendage in clean bandages from first aid kit located under seat in vehicle** • Put gloves on to keep environment as sterile as possible • If appendage is completely removed, place in a clean bag and put on ice as soon as possible (note: the wrapping of appendage and stopping blood flow is the priority)
2. **Elevate appendage and keep pressure on the wound**
3. **Depending on severity, dial 111 for an ambulance or drive patient to hospital immediately**
4. **Fill in an incident report form and give to your manager**

Activity	*Person*	*Date*
Created	Dawn Dalley	31/03/2020
Reviewed	Nicole Coulter	15/9/2021
Approved		

7.2 Kale yield assessment SOP

DairyNZ *Standard Operating Procedure:* **Kale Sampling**	**Site:** Southern Dairy Hub **Page:** 1 of 4 **SOP No.:** Kale **Last Reviewed:** **Persons Implementing:** Technicians

Background:

Kale is a part of the brassica family. It is grown mainly as a winter feed crop. It is grazed in situ and can have yields as high as 15 t/ha or more. It typically has a 3 t/ha maximum leaf yield with the rest being stem. It has an average energy content with less in the stem. The energy content of the stem is reduced as it begins to lignify and grow larger and thicker.

The advantage of kale is that it has a high nitrogen content which is corresponded with a high protein level. It is quite widely used in agriculture as a winter feed supplement.

Personal Protective Equipment (PPE):

 ***High Vis*** Worn at all times	 ***Work boots/ Gumboots*** Worn at all times	 ***Cut-Proof Gloves*** Must be worn when using knives

Equipment:

- Black 1m^2 hoop
- Loppers and butchers knife
- Weighing Sack
- Back pack
- Spare batteries
- Cut proof gloves
- Scales
- Sub sample sacks
- Wet Weather Gear
- Recording sheet + clip board
- Water and food

Procedure:

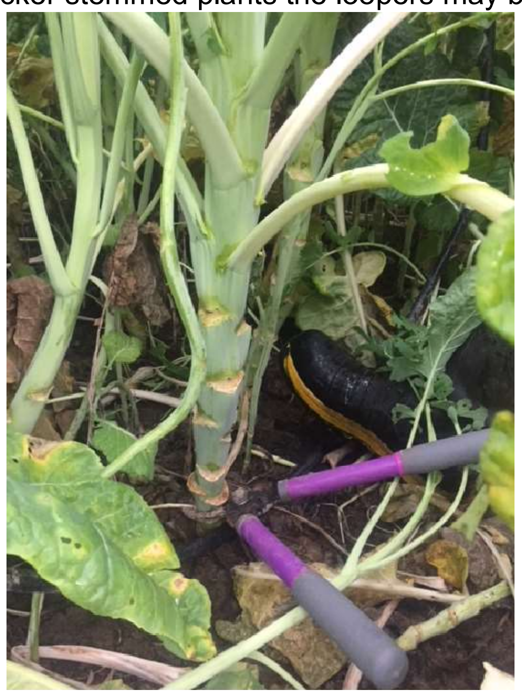
16. **Select the area to be sampled**
    - **a.** Sample area should represent the next area to be grazed
    - **b.** Sample area should represent the whole paddock (depending on requirements)

17. **Three areas of 1m^2 will need to be sampled**

18. **Throw the hoop out into the rough area that has been selected**
    - a. Make sure the area selected is representative of the surrounding area
    - b. Avoid non uniform areas unless they represent a large proportion of the area


19. **Slide the hoop down through the crop by gently positioning the kale either inside or out of the hoop**
    - a. If the base of the plant is within the hoop, make sure the whole plant is included in the sample
    - b. If outside move it away from the hoop to make it easier to sample the crop
    - c. Try not to flatten or destroy too much crop around the sample site

20. **Cut the kale that is within the hoop to 2-3 cm above ground level**
    a. Smaller stemmed plants can be carefully cut using the butchers knife and a slashing action with others standing well away
    b. For thicker stemmed plants the loopers may be required



21. **Record the empty weight of the weighing bag on the recording sheet**
    NB if the crop is wet the bag will gain weight throughout the day so it is important that the weight is recorded at the start of each paddock
22. **Place all the harvested kale from inside the hoop into the weighing bag**
23. **Weigh the full bag and record the weight on the recording sheet.**

NB when weighing the bag make sure it is held away from your body and is not touching the ground or surrounding crop.
24. Tip the kale out of the bag and collect two representative kale plants for the subsample a. put the plants into the subsample bag/sack for that paddock. This may require you folding them into thirds/half depending on size
25. Repeat steps 3-8 for the remaining samples in that paddock a. The representative samples from one paddock all go into the same sack/bag
26. Put the sub sample sack somewhere out of the sun and in an area that is not too hot. a. If possible close the top of the subsample bag/sack to stop the plants wilting
27. Take the crop back to the field lab as soon as sampling is finished and put into the fridge until it is processed (see walk in chiller SOP)

Cleaning Equipment:
• **Rinse the bags out with warm water once finished with them**
• **Carefully clean the loppers and knife (wear cut proof gloves)**
• **Sharpen the Sheers if required, wipe dry and spray with lanolin**
• **Wipe the scales down with a damp cloth (Do NOT wash directly under the tap)**

Emergency Procedures:
Severed appendage
5. Wrap appendage in clean bandages from first aid kit located under seat in vehicle • Put gloves on to keep environment as sterile as possible • If appendage is completely removed, place in a clean bag and put on ice as soon as possible (note: the wrapping of appendage and stopping blood flow is the priority)
6. Elevate appendage and keep pressure on the wound
7. Depending on severity, dial 111 for an ambulance or drive patient to hospital immediately
8. **Fill in an incident report form and give to your manager**

7.3 Crop Sampling Processing SOP

DairyNZ *Standard Operating Procedure:* **Processing Crop Samples**	**Site: Southern Dairy Hub** **Page:** 29 of 42 **SOP No.: Processing Crop Samples** **Last Reviewed:** **Persons Responsible for Implementing:** Technicians

Personal Protective Equipment (PPE):	
 ***Cut Proof Glove*** Worn on both hands	 ***Freezer Glove/s*** On left hand (required) or both (optional)

Procedure:

Background:

You will be chopping samples so they can be dried for a dry matter analysis. Samples are required to be cut into smaller pieces for drying.

Things you need:

- PPE-cut proof gloves
- A knife
- Cleaning brushes
- Large zip-lock bags
- Ensure you have the correct samples that need chopping

The processing procedure (Fodder Beet):

1. Pre label large zip-lock plastic bags with the correct paddock number and sample type
    a. Sample type could be either fodder beet bulb or fodder beet leaf
2. Brush as much soil off the sample as possible
3. Rinse the remaining soil off the sample in lukewarm water (Makes cleaning the samples easier) and dry off with paper towels to remove all surface moisture
   NOTE: Don't rinse if the sample has been cut open already as it can absorb the water and the wet weight will increase

4. Use the wooden chopping board that is in the wet lab

5. Being mindful of fingers carefully chop each fodder beet into quarters from top to bottom
    a. It is easiest to use the tip to penetrate the bulb (holding it steady with the other hand above the cutting point)
    b. Try to find a flatter edge for the bulb before starting to make this easier. Putting the chopping board in the sink may help

you apply more downward pressure and stop the bulb moving around so much

c. Once the knife is in the bulb carefully slice down towards the bottom of the bulb.

d. Each sub sample must be the same proportion of the bulb e.g most likely a quarter of a bulb. Don't take a bigger proportion of smaller bulbs by only cutting in half

6. Dispose of the unnecessary ¾ of the bulb into the green waste bin Waste FB can go to FB herds

7. Once all the bulbs from one paddock have been subsampled finely chop the bulb into thin slices ready for drying
    a. Thoroughly mix all the bulb pieces on the bench and then place into a labelled zip-lock bag

8. Follow the same procedure for the fodder beet tops sub-sampling ¼ of each of the tops that have been collected

9. Once each paddock has been processed seal the bags making sure you squeeze all the air out first and place in the fridge (only do this step if you think it will take more than a couple of hours to process all the samples)
10. After processing all the sampled paddocks take the samples into the weigh room
11. Ensure there are recording sheets in the template folder in the weigh room
12. Determine the number of trays required to split the sample over (3 trays= gold standard) and record the tray numbers in the spreadsheet
    a. For bulbs the pieces need to be in a single layer and for leaf material the tin should not be more than half full
13. Tare green weigh tub tray and place processed crop sample as per instructions in 13. and record the wet weight of each tray on recording sheet
14. Place the weighed trays onto the trolley
15. Once finished weighing the fresh weight of all the samples put them in the oven

a. Follow the Oven SOP for guidelines and Field Lab Duties SOP for weighing the samples out of the oven b. Crop samples are to be dried at 100°C unless being sent for wet chemistry or NIRS analysis which require to be dried at 60°C

The processing procedure (Kale):
1. Pre label large zip-lock plastic bags with the correct paddock number
2. Cut the leaves off the stalk towards the top and chop onto small pieces (5-8 cm in length) NOTE you do not have to chop all leaves off the stem like the photos below   
3. Place the cut kale into the corresponding labelled bag

4. Cut the stems in half and if they are bigger than your index finger cut them in half again

5. Chop the sliced stem into sections (4-5 cm in length) 
6. Place the chopped stem into the corresponding labelled bag with the leaves
7. Refer to step 9 in above SOP and follow the rest of the steps
Emergency Procedures:
Burns:
• Run all burns under cold water for **20 minutes**
• Notify the Senior Research Technician and fill in an accident form
• **If the burn is severe wrap the burn in glad wrap and get the person to the nearest medical centre as fast as you can**
Severed appendage:
9. Wrap appendage in clean bandages from first aid kit located under seat in vehicle • Put gloves on to keep environment as sterile as possible • If appendage is completely removed, place in a clean bag and put on ice as soon as possible (note: the wrapping of appendage and stopping blood flow is the priority)
10. Elevate appendage and keep pressure on the wound
11. Depending on severity, dial 111 for an ambulance or drive patient to hospital immediately
12. **Fill in an incident report form and give to your manager**

Activity	*Person*	*Date*
Created	Willis Ritchie	20/4/2018
Reviewed	Nicole Coulter	15/9/2021
Approved		

7.4 Post crop sampling SOP

The aim of post crop sampling is to measure the amount of crop being left behind in a break to determine the percentage of crop utilization. Only the current crop paddocks being grazed need post crop sampling

Equipment needed: quadrat square, cutters, hand shovel and one sack per paddock, an extra sack, recording sheet, pens, weigh scales and gloves

1. Once at the paddock, identify the previous break from 2 days prior, (e.g., if it is Wednesday, you sample Monday's area)

2. Make sure you tare/zero your weigh sack at the start of quadrat one and record the sack weight, then record cumulative weights at each quadrat.

3. Along the 2 days previous break, do 3 quadrats, evenly spaced out, of digging no more than 15 minutes. Try aim between 10-15 minutes per quadrat but if you are not finding anything move on. Any crop that you find while digging goes into the sack for weighing.
   In the kale paddocks if you come across stem with roots, cut the roots off. Any stem that is half in the quad and half out of the quad cut the stem at the outside edge of the quad and weigh the bit of stem that was placed inside the quad.

4. At the end of your 10-15 min per quad, weigh and record the weight.

5. Repeat steps 3 – 5 for all 3 quadrats

6. Once finished all 3 quadrats, mix crop sample thoroughly in the sack by shaking it around then tip the crop sample out onto the extra sack and give it another mix if required, sub sample approx 1 kg of the mixed sample for processing back at the lab. If the crop sample is smaller than 1 kg over the 3 quadrats, take all of it.

7. Back at the lab weigh out the dirty contents and record the dirty weight for each paddock.

8. Clean the crop thoroughly until next to no soil left on the crop. Reweigh and record the clean weight. *The aim of this is to get the percentage of soil for the quadrat weights.* Place clean crop into 3 (gold standard) recorded trays for the oven, FB bulb and leaf don't need to be separated. Use a baking paper liner. Cut up any bigger pieces of crop to help dry.

9. Place trays in the oven at 85 °C until dry.

10. Weigh out the samples and record dry weight on the recording sheet.

7.5 Infiltration

To be done in each treatment area

- Before grazing
- After grazing
- When returned to pasture (depending on re-cropping plan)

Measure the front half of the paddock prior to cows going onto crop and the back half just before they move into this area. Measurements need to be taken in undisturbed soil. If there is vegetation present (like the photo below), this needs to be cut off at ground level (not pulled out as this will disturb the soil surface) and removed from inside the ring

Use the medium-sized rings, 20 cm diameter (there are 5 of them)

Number of measurements per treatment

- Six – x3 between rows and x3 within a row
- may need to find gaps within the row in the conventionally cultivated area or get the ring as close to the row as possible.

Process

- Do a test run with one ring when you get to the paddock to determine whether you use a full disappearance or time based/measured height approach (full disappearance is preferred but if the test run is more than 15 minutes used the measured height approach
- Select the sites for the rings to be placed – ensure the measurements in the treatments are done in the same line across the paddock
- Push the rings into the soil so that the top is level (check with a spirit meter), there are no gaps around the bottom of the ring and the six rings are as close as possible to the same depth into the ground (this may require placing a board across the top of the ring and carefully tapping it into the ground with a hammer)
- Once the rings are all in place pour the same known volume of water – probably 400 mL based on the trial run (these could be pre-measured in containers to speed up the process) into the ring without disturbing the soil surface; i.e., pour down the back of a lid, the spade or onto a piece of wood
- Ideally we want the water at the same (measured) height in all the rings in case the infiltration is really slow and we need to use a timed approach (see below)
- Record the start time for each ring individually once all the water is in that ring
- Watch the water disappearance and record the time that all the water has disappeared
- If the water takes less than one minute to disappear, the measurement should be repeated until a consistent time (within ten seconds) is recorded for three runs (within reason). Alternatively, the volume of water could be increased. Ensure that any changes are noted on the recording sheet

- If infiltration in the test run is 1 to 15 min, then take three measurements at each site.
- If infiltration in the test run is longer than 15 minutes, then use the measured height approach. For this you need to fill the ring to a pre-defined height (top mark on the ring), let it soak in for 15 minutes and then measure the height of water remaining using a ruler
- Repeat process in all treatments

7.6 Penetrometer

To be done before and after grazing as per the infiltration measures

Ideally the same person would complete all measurements but if this is not physically possible then at least all measurements within a paddock need to be done by the same person

Attach cone two (medium) to the penetrometer and ensure both needles are together on zero. Perform some test probes to ensure that the readings are within the green zone on the dial. If the probe is too easy to push into the soil, then a larger cone will be needed. The same cone should be used across one treatment

Take 20 measurements in a line across the treatment

- For fodderbeet and swede paddocks take 10 measurements between the rows walking in one direction and 10 within the row as you return
- In kale paddocks take 20 measurements equally spaced across the treatment area

Push the penetrometer into the soil using consistent force to a pre-defined depth (see instructions below)

Remove the cone from the soil and record the pressure applied

Repeat across the paddock

HAND PENETROMETER EIJKELKAMP

Penetrometers are used to determine the resistance to penetration (bearing capacity) of a soil. The Eijkelkamp penetrometer is delivered in two different sets:

06.01.SA Hand penetrometer Eijkelkamp, set to a depth of 1 meter

06.01.SB Hand penetrometer Eijkelkamp, set to a depth of 3 meter

Both sets can be used for probing to a dept of between 1 and 3 meter. Both sets contain various cones, probing- and extension rods, a measuring instrument with a pressure gauge, tool set, a cone check, a calibration certificate and an instruction manual.

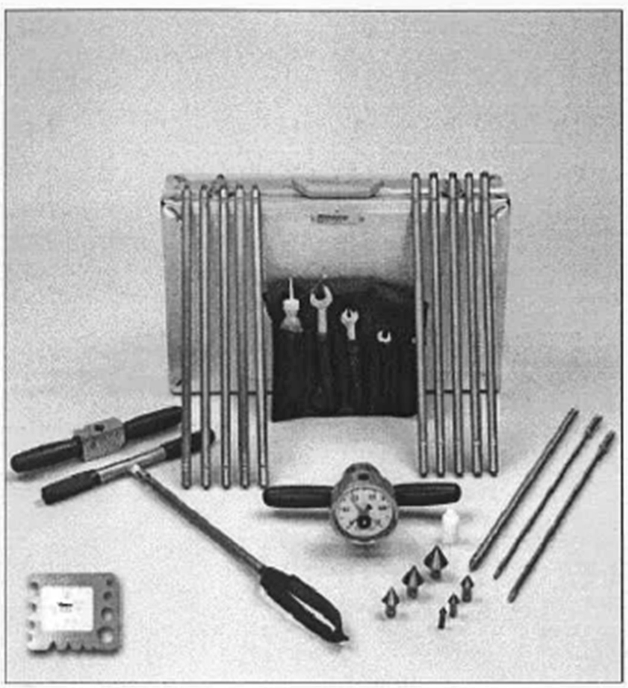
The measuring range of the pressure gauge is 10000 kN/m² (=10000 kPa).
The scale range runs from 0 up to 1.0 kPa. The accuracy is +/- 8% in the advised measuring range. The sets have been packed in compact aluminium carrying cases.

A hand operated auger is included in the set that reaches to a depth of 3 meter, which will enable you to execute research of a soil profile as well, or to penetrate a tougher layer in the soil.
The auger is also applied to drill-out the probing hole to avoid adhesion between the probing rods and the shaft wall.

Basically the penetrometer consists of a measuring instrument, a probing rod and a cone.

The device is pushed perpendicular into the soil by applying equal pressure on both grips. Jerking pushes yields values which are too high and which do not represent the soil.

The resistance measured by the cone can be read from the pressure gauge as indicated by the black pointer. The maximum resistance recorded during measurement is indicated by the red dragging pointer.



Hand penetrometer Eijkelkamp (SB)

P1.50

The penetrometer is pushed perpendicular into the soil at a speed of approximately 2 cm per sec. applying equal pressure on both grips.

To be able to determine the resistance to penetration of the lower layers in the soil the hole is pre-drilled using the Edelman auger.

Eijkelkamp
Agrisearch Equipment

www.eijkelkamp.com

P1.50.E

HAND PENETROMETER EIJKELKAMP

ISO 9001-CERTIFIED

P1.50

Applying the pull/push handle the extension- and probing rods can be extracted from the soil.

The resistance to penetration (kPa/cm²) of the soil can now be determined by dividing the reading value by the surface of the cone. The value of the resistance to penetration to be expected determines the surface of the cone to be used. For high values the small cone is used and for low values the larger cones are applied. The larger the cone the more accurate the value of the resistance to penetration can be determined.

Advantages

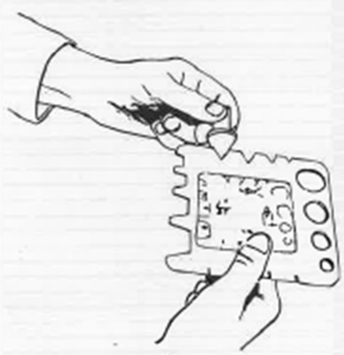
- Compact and complete.
- Easy to operate.
- Little maintenance.

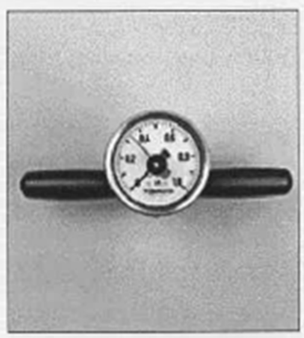
Applications

Because of their depth range the devices can be applied for the following:

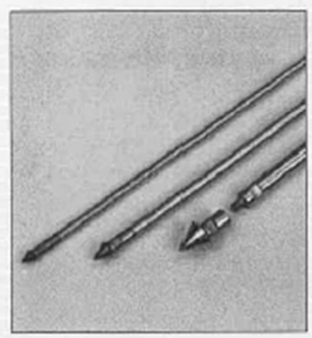
- General soil research.
- Basic advise for foundations
- Checking artificial compaction of the soil.
- Research of the growing circumstances (to be expected) of plants in the soil.
- Tracing compacted layers in the soil.

The cone check is used to inspect the wear of the cones.

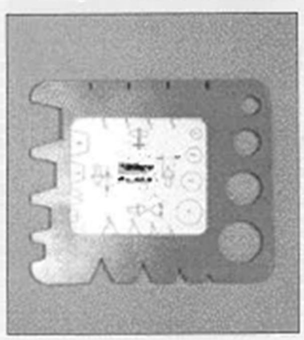




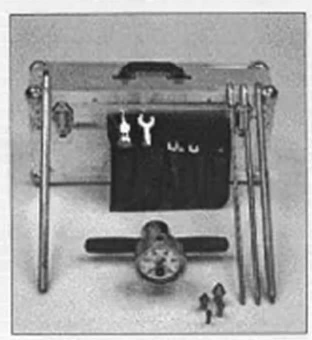
Measuring instrument with manometer



Cones and probing rods



Cone check



Hand penetrometer Eijkelkamp (SA)

Eijkelkamp
Agrisearch Equipment

P.O. Box 4, 6987 ZG Giesbeek
Nijverheidsstraat 30,
6987 EM Giesbeek
The Netherlands

T +31 313 880200
F +31 313 632167
E eijkelkamp@eijkelkamp.com

7.7 Soil moisture

- In each treatment area collect 10 soil cores to a consistent depth across the treatment area and place into a single bag. Seal and label the bag
- In the lab, break up and thoroughly mix the cores
- Split across 3 trays
- Record the wet weight of each tray
- Dry at 105°C for 48 hours or until a consistent weight is reached
- Record the dry weight of each tray

7.8 Soil profile

2 sites per treatment area

Easiest to do in the area where the crop yield has been taken

Dig a ‘trench’ approximately 30 cm wide, spade depth and across 2 rows keeping one edge as straight as possible. The other edge can be sloping provided there is sufficient width to easily photograph the face of the trench (see below)

Once the trench is complete, take one final slice off the straight face

Photograph the face and note anything of significance on the recording sheet


Strip till


Conventional


Direct drill

7.9 Soil visual assessment (VSA)

Perform an initial VSA in dry weather at the fenceline of the paddock. The soil is too wet to perform a VSA if you can shape a worm by rolling the soil between your hands. The initial VSA provides a benchmark for other VSAs performed in a treatment

The other 2 VSAs should be performed at the same sites as the soil profiles

For each VSA, dig up a representative sample with dimensions of 20x20x20 cm. Pick up the sample and drop from waist height into a tub (which can contain a board to provide a solid flat surface to help break up the sample). Drop the sample twice more from waist height into the tub

Arrange the pieces of sample from large to small on a tarp

Complete the Visual Score column on the ‘SOIL INDICATORS’ score card while referring to the laminated book ‘Visual Soil Assessment’. Take a photograph of the score card for each VSA