FOUNDATION FOR ARABLE RESEARCH

FAR®

Cover crops x maize establishment & soil quality review

Tuesday 12 December

Te Awamutu & Ohaupo

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In case of emergency notify a FAR staff member or call 111 and provide the address of the event:

- Courtesy of Colin Jackson, 448 Te Mawhai Rd, Tokanui, Te Awamutu
- Courtesy of Alan Henderson, 1221 - 1287 Paterangi Rd, Ohaupo

Contents:

Colin Jackson site

The trial layout includes four winter cover crops and three maize establishment systems (***Figure 1***). All winter crops are harvested mechanically prior to planting maize. This research project is now into its third year, and prior to establishing the research trial the field where the research site is located had more than 50 years of monoculture maize production using traditional cultivation practices.

On farm research site trial plan

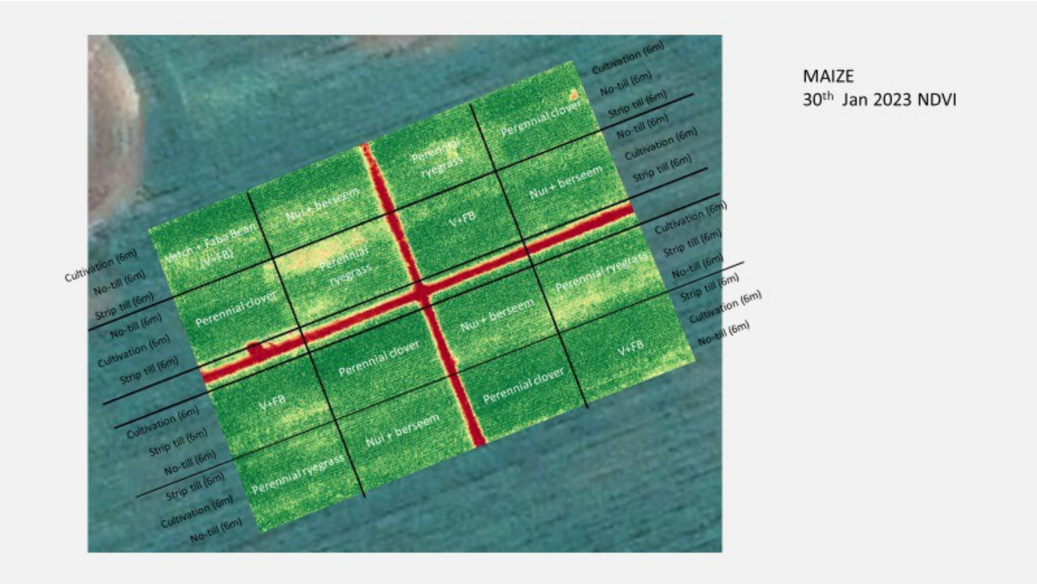

Figure 1. Cover crop and maize establishment system plan and OSAVI 3rd January 2022 at Colin Jackson's.

Alan Henderson site

The trial layout includes four winter cover crops and three maize establishment systems (***Figure 2***). All winter crops are initially grazed over the winter and the harvested mechanically prior to planting maize. This research project is now into its second year at this location, and prior to establishing the research trial the field where the research site is located had more than 10 years of monoculture maize production using traditional cultivation practices.

On farm research site trial plan

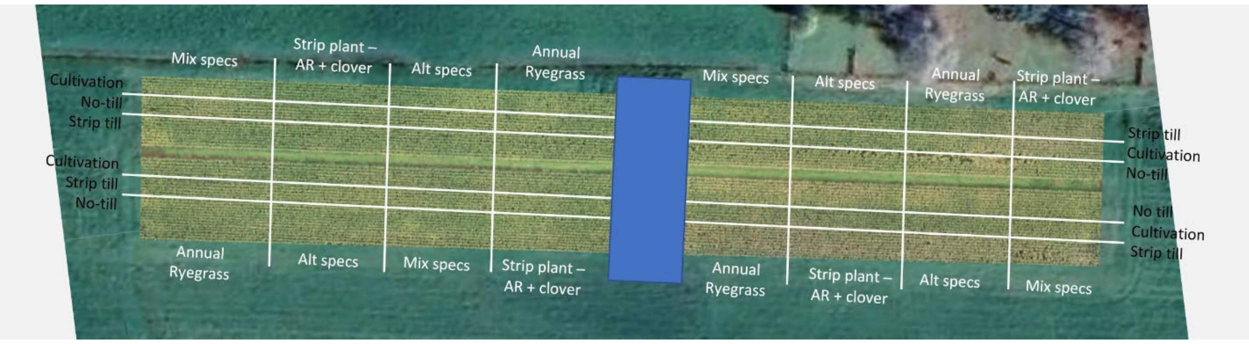

Figure 2. Cover crop and maize establishment system plan at Alan Henderson's.

Several observations and measurements are taken at both sites within a production cycle including yield and gross margins, soil density, plant emergence and plant spacing uniformity and changes in soil quality attributes. One interesting observation during the 2022/23 season was the influence the maize establishment system had on standability following a significant weather event caused by Cyclone Gabrielle. ***Figure 3*** provides a very good visual of the lodging that occurred within the cultivation and strip till plots, and the standability within the no-till plots.

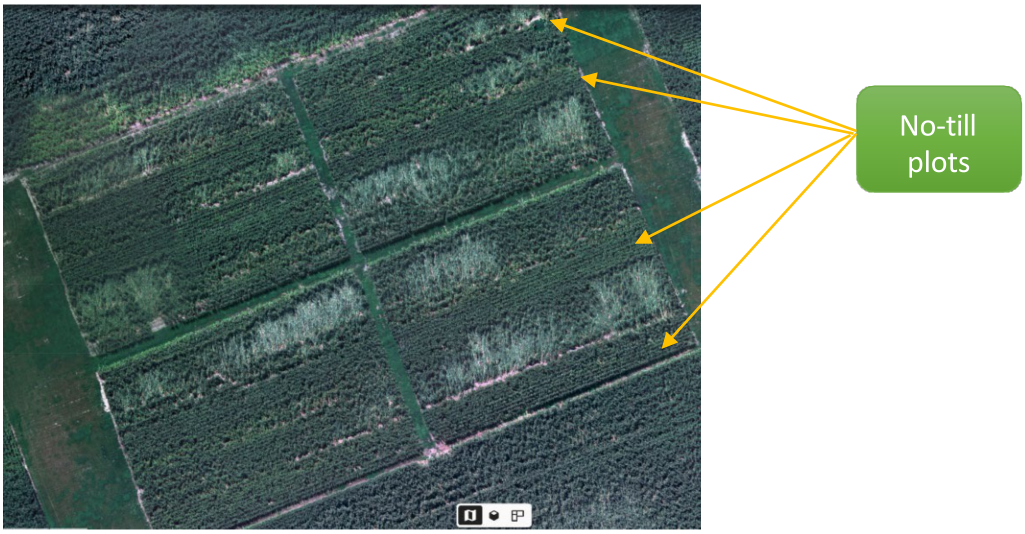

Figure 3. Impact of Cyclone Gabrielle on standability across maize establishment system treatments at Colin Jacksons.

A summary of the lodging assessments is shown in *Table 1*.

Table 1. Maize plant lodging score by maize establishment system following Cyclone Gabrielle

	Cultivation	**Strip Till**	**No-till**
	Maize establishment system (MES) Average Lodging Score		
	1.375	0.625	0.375
Cover crop x MES Average Lodging Score			
Perennial clover	2.0	0.5	1.0
Perennial ryegrass	1.5	0.5	0.3
Perennial ryegrass + clover	1.0	0.5	0.3
Woolly pod vetch + faba bean	1.0	1.0	0.0

Lodging score
0 = nil
1 = semi lodged
2 = lodged
3 = very lodged

Soil N contribution and winter legumes

Key points

- The mineralisation of soil organic matter can supply a significant amount of N to summer crops like maize.
- Proceeding legume crops also contribute to the amount of N in the soil.
- The FAR on-farm cover crop by maize establishment systems research project has shown soil MinN levels of between 86 to 264 kg/ha of N (Tables 2 and 3).

Biological N in the Waikato on-farm trials

Prior to maize side-dressing soil Mineral N (MinN) and Potentially Mineralisable Nitrogen (PMN) are measured at the Jackson, Henderson and Corson Maize FAR on-farm research sites. These on-farm research sites include four different winter cover crops and three different maize establishment systems.

Soil samples were collected from the different treatments at the V3 maize growth stage and between the maize rows, with MinN samples collected to a depth of 60 cm and PMN samples collected to a depth of 15 cm. Prior to planting YaraMila Complex fertiliser (12:5:15) was applied at 400 kg/ha.

Soil MinN values ranged between 86 to 264 kg/ha, with the lowest soil MinN value coming from the ryegrass plots, and the highest soil MinN values from the rape and legume-based winter cover crops. Soil PMN values, the amount of soil N potentially mineralised over the maize growing period, ranged between 45 to 68 kg N/ha.

Table 2. Soil MinN and PMN values at the Colin Jackson FAR on-farm research site near Te Awamutu in November 2023.

Winter cover crop	Min N (mg/kg)	Min N (kg/ha)	PMN (mg/kg)	PMN (kg/ha)
Perennial ryegrass (PR)	12	86	64	45
PR + annual clover strip plant[1]	12	86	89	62
Woolly pod vetch + faba bean	25	180	87	61
Perennial clover	21	151	80	56

Table 3. Soil MinN and PMN values at the Alan Henderson FAR on-farm research site at Paterangi in November 2023.

Winter cover crop	Min N (mg/kg)	Min N (kg/ha)	PMN (mg/kg)	PMN (kg/ha)
Annual ryegrass	24	144	117	68
Annual ryegrass + clover strip planted[1]	19	114	94	55
Mixed species (triticale + rape + tick beans)	30	180	109	63
Rape	44	264	112	65

Soil density and soil compaction

Key points

- Soil compaction is often referred to as the 'silent yield thief' because compaction is sometimes less obvious, but its effects can have significant implications on yield, yield stability and quality.
- Soils are most vulnerable to compaction when they are at or near field capacity.
- Soil compaction above 2,000 kPa can impact maize yield.
- As soil density increases water infiltration rates decrease, plant root development is impeded, and nutrient and water uptake reduced.
- A penetrometer can be used to determine if and where soil compaction exists in the soil profile.

At each FAR research site and on most research projects, soil density is measured across treatments following maize planting. A FieldScout SC900 is used to determine soil density, and to identify if field limiting soil compaction is present in within a treatment. For each plot soil density is measured in the planter row on four rows to a depth of 45 cm. Soil density is measured at 2.5 cm increments to determine soil density throughout the profile, and to identify the presence of yield-limiting soil compaction. At the Henderson and Jackson cover crop by maize establishment system on-farm

research sites, the influence of cover crops and maize establishment system on soil density is being measured over time. The Henderson site is a typical Waikato ash soil and has been in maize

[1] Soil samples collected in the ryegrass strips

production for more than 10 years. The soil type on the Jackson site is a clay soil and has been in maize production for more than 50 years. ***Figure 4*** shows the soil density after two years of research at the Henderson site (A), and three years at the Jackson site (B).

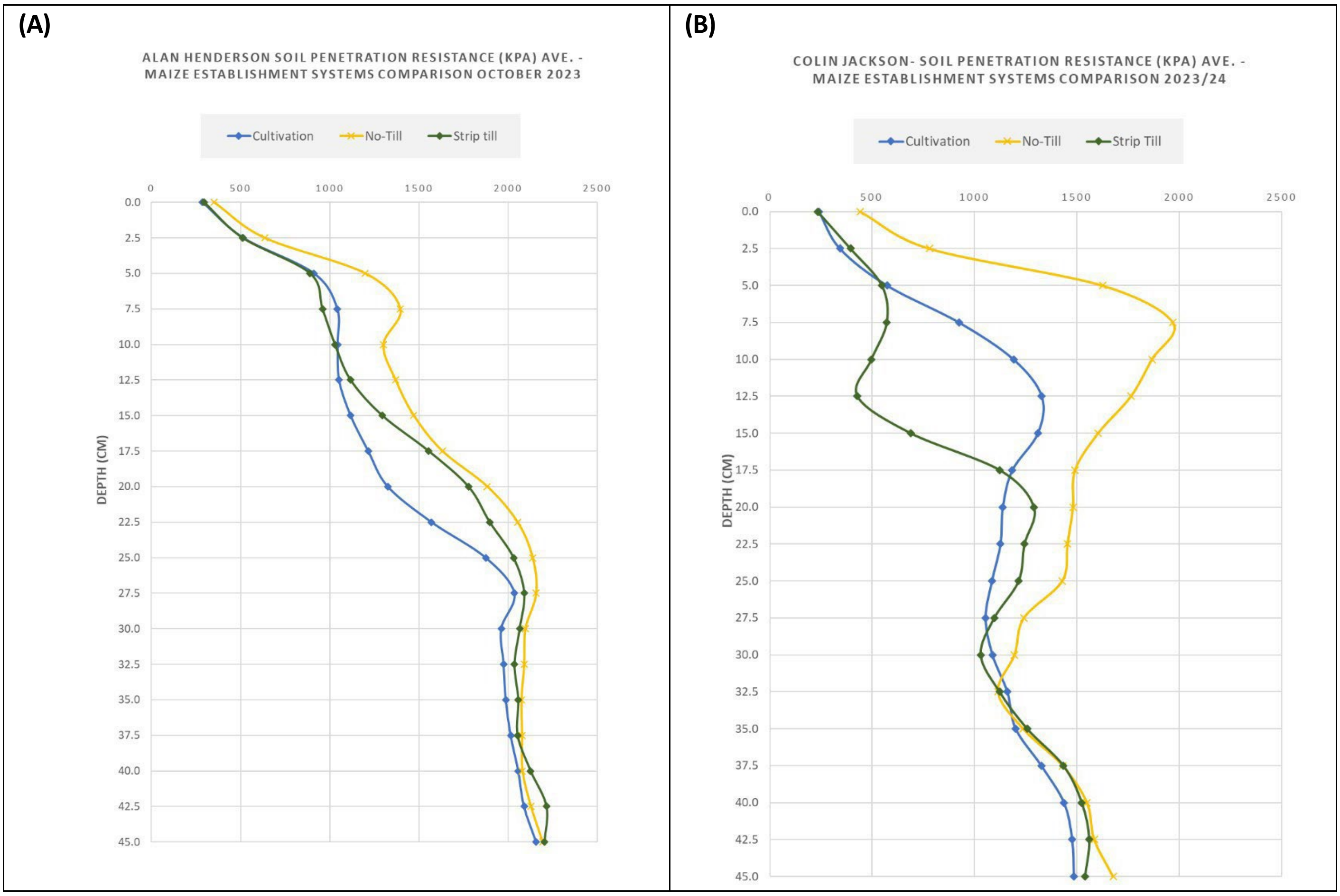

Figure 4 Soil compaction assessments at Alan Henderson's (A) and Colin Jackson's (B) as measured in the maize planter row following maize planting.

The cultivation practice on the cultivation plots at the Henderson site included two passes with the disc rippers. The strip-till unit has a shank and coulter system.
Cultivation practice on the cultivation plots at the Jackson site included a James aerator, two passes with the disks, and one pass with the power harrow to a 20 cm depth. The strip-till unit is a powered rotary unit with a shank set to a depth of 20cm.

Maize emergence uniformity

Key points

- Within row uniformity of plant emergence is considered important to maximise yield potential in maize.
- Many factors influence within row plant emergence uniformity including seed quality and seedling vigour, soil type, moisture and temperature variability, production system, and planter settings and performance.
- On the ash soils at the Henderson site, for the cultivation and strip-till plots on average around 90% emergence occurred within plots by Day 2, whereas on the no-till 90% emergence occurred around Day 3.
- Maize emergence uniformity was more variable on the heavier clay soils at the Jackson site, with strip-till on average having slightly better within plot emergence uniformity than the cultivation plots.

Emergence uniformity assessment methodology

Little research has been undertaken in New Zealand on maize yield reduction due to uneven within-row emergence. However, several studies in North American have shown the impact of within row non-uniform emergence. One study showed a 1.5-week delay between early and late emergence causes a 6-9% decrease in overall maize grain yield (Carter 1989). A multi-year day of emergence study by Precision Planting showed a grain yield reduction of 90% in maize plants that emerge more than 48 hours later than their neighbouring plants.

Uniformity of emergence is assessed when the first seedlings appear and reach a height of less than ≈10 mm. Different coloured stakes are placed next to seedlings that appear each day. ***Figure 5*** shows the emergence uniformity by maize establishment system by year for the Henderson and Jackson on farm research sites (Blue, Day 1; Orange Day 2; Grey, Day 3; Yellow, Day 4; Light Blue, Day 5).

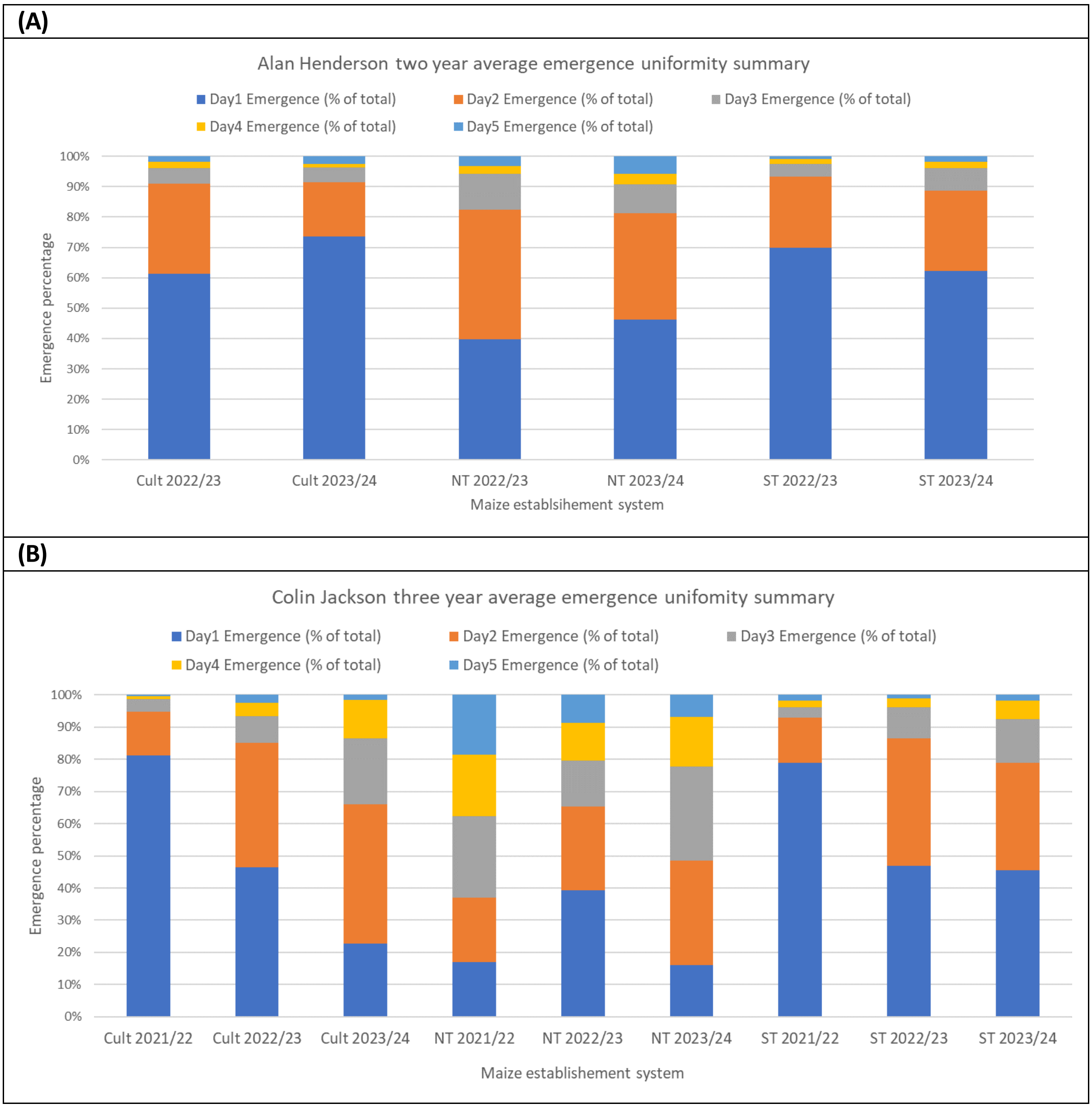

Figure 5. Two-year maize emergence uniformity summary for the Henderson site (A) and three-year maize emergence summary for the Jackson site (B).

Table 4. Average planting, emergence, and silage yield measurements for maize silage crops in the cover crop by establishment trial at the FAR on-farm site at Colin Jackson's, Waikato after planting with either cultivation, strip-till or no-till in 2021-22 and 2022-23 (i.e. a two-year average).

Cover crop		Plant spacing (st dev cm)			Plant population (plants/ha)			Dry matter (%)			Silage yield (DM t/ha)		
	Maize establishment	Cultivation	No-till	Strip-till	Cultivation	No-till	Strip-till	Cultivation	No-till	Strip-till	Cultivation	No-till	Strip-till
Perennial Clover		3.98	5.79	3.88	95268	89686	97244	0.4031	0.3697	0.3965	23.97	19.59	22.04
Perennial ryegrass		3.77	7.38	3.62	97571	80814	97900	0.4103	0.3877	0.4344	24.25	19.63	22.74
Perennial ryegrass + clovers		4.12	7.89	3.32	97570	85413	96582	0.4178	0.4005	0.4162	25.05	23.24	23.96
Woollypod Vetch + faba bean		3.94	7.82	3.57	97568	86728	95608	0.4294	0.3873	0.4105	24.71	23.08	24.49
P value (establishment)		<.001			<.001			<.001			0.002		
P value (cover crop)		0.652			0.691			0.122			0.063		
P value (establishment x cover crop)		0.213			0.094			0.021			0.179		
LSD (p=0.05) (establishment)		0.957			2818			0.0089			1.191		
LSD (p=0.05) (cover crop)		ND			ND			ND			ND		
LSD (p=0.05) (establishment x cover crop)		ND			ND			0.0236			ND		

Note. Cells highlighted yellow indicate where establishment, cover crop or a combination of both had an effect on a planting, emergence or silage yield parameter.

Table 5. Average maize silage gross margin and annualized gross margin for different treatments in the cover crop by establishment trial at the FAR on-farm site at Colin Jackson's, Waikato after sowing with different winter crops and planting maize with either cultivation, strip-till or no-till in 2021-22 and 2022-23 (i.e. a two-year average)[2].

Cover crop		Maize silage gross margin ($/ha)			Annualised gross margin ($/ha)		
	Maize establishment	Cultivation	No-till	Strip-till	Cultivation	No-till	Strip-till
Perennial Clover		3309	2459	2871	3105	2290	2676
Perennial ryegrass		3320	2211	2898	3691	2515	3144
Perennial ryegrass + clovers		3491	3359	3243	3799	3702	3506
Woollypod Vetch + faba bean		3391	3299	3420	3288	3293	3399
P value (establishment)		0.020			0.031		
P value (cover crop)		0.115			0.067		
P value (establishment x cover crop)		0.137			0.088		
LSD (p=0.05) (establishment)		334			353		
LSD (p=0.05) (cover crop)		ND			ND		
LSD (p=0.05) (establishment x cover crop)		ND			ND		

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Table 6. Average planting, emergence, and silage yield measurements for maize silage crops in the cover crop by establishment trial at the FAR on-farm site at Alan Henderson's, Waikato after planting with either cultivation, strip-till or no-till in 2022-23.

Cover crop	Plant spacing (st dev cm)			Plant population (plants/ha)			Dry matter (%)			Silage yield (DM t/ha)			Starch + sugar (t DM/ha)			Milksolids/ha		
	Maize establishment																	
	Cultivation	No-till	Strip-till	Cultivation	No-till	Strip-till	Cultivation	No-till	Strip-till	Cultivation	No-till	Strip-till	Cultivation	No-till	Strip-till	Cultivation	No-till	Strip-till
Alternating species	4.62	3.89	6.07	93177	92521	95145	0.3298	0.3490	0.3383	22.44	22.24	19.93	7.48	8.08	7.65	1879	1935	1786
Annual ryegrass	4.06	6.33	4.18	96458	91865	95802	0.3298	0.3305	0.3393	24.20	20.00	20.67	8.29	6.82	7.01	2044	1718	1770
Annual ryegrass + clovers	5.52	5.34	4.98	91208	92521	95145	0.3418	0.3390	0.3283	23.13	23.13	19.84	8.47	8.45	7.26	2018	2050	1728
Mixed species	5.68	5.67	5.83	97114	92521	96458	0.3435	0.3420	0.3298	25.06	22.56	21.09	8.58	8.20	7.57	2116	1977	1880
P value (establishment)	0.862			**0.043**			0.626			**0.042**			0.338			0.191		
P value (cover crop)	0.595			0.605			0.798			0.611			0.344			0.389		
P value (establishment x cover crop)	0.433			0.685			0.451			0.263			0.566			0.248		
LSD (p=0.05) (establishment)	1.32			**1999**			0.01			**1.98**			1.04			213.06		
LSD (p=0.05) (cover crop)	1.44			3797			0.01			2.22			0.87			177.34		
LSD (p=0.05) (establishment x cover crop	2.63			5524			0.02			3.26			1.66			300.46		

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Table 7. Average maize silage gross margin and annualized gross margin for different treatments in the cover crop by establishment trial at the FAR on-farm site at Alan Henderson's, Waikato after sowing with different winter crops and planting maize with either cultivation, strip-till or no-till in 2022-23 season[3].

Cover crop	Maize silage gross margin ($/ha)		
	Maize establishment		
	Cultivation	No-till	Strip-till
Alternating species	3955	4148	3161
Annual ryegrass	4555	3385	3414
Annual ryegrass + clovers	4190	4451	3132
Mixed species	4848	4257	3557
P value (establishment)	**0.047**		
P value (cover crop)	0.611		
P value (establishment x cover crop)	0.263		
LSD (p=0.05) (establishment)	**675**		
LSD (p=0.05) (cover crop)	756		
LSD (p=0.05) (establishment x cover crop	1109		

Soil quality update – on-farm trials

Key points

- Good soil quality contributes to farm production system resilience.
- Baseline soil results from the Henderson trial show that soil quality is generally good and soil carbon stocks are high. There is room for soil structure to be improved.
- We are measuring increases in soil structure in the no tillage plots at both the Jackson and Henderson trials compared with cultivation plots.

Introduction

A quality soil can be defined as a soil that works for you. Every farm system is different and therefore a quality soil for growing grapes will be different to a quality soil for growing maize. Soil quality is strongly associated with soil organic carbon (SOC) and intensive cropping rotations come with a risk of degrading soils through depleting SOC.

There are six basic principles outlined in "Good soil is good business" (FAR Focus Issue 15) that cropping farmers can apply to influence soil quality for the better. New Zealand arable farms and farmers are diverse, but most employ at least some of these six principles as a matter of course.

The six principles for improving soil quality:

1. Avoid bare soil (with living plants or residues).
2. Maximise below ground returns of organic matter.
3. Minimise soil disturbance.
4. Integrate livestock and cropping*.
5. Increase plant biodiversity (across and within the rotation).
6. Increase or retain soil fertility through biological means.

* Not all principles apply to all systems e.g. integrating livestock into a maize system with heavy soils may be damaging to soil quality due to grazing taking place in winter.

Managing soil quality is a long-term game that provides some easy wins

Understanding how your particular soil can function at its best has many benefits. Not only does good soil quality contribute to production system resilience and increase crop yield potential, poor soil quality is often linked to poor environmental outcomes.

Soil Structure and Compaction

One indicator of soil physical quality is soil structure. Plant roots, earthworms, bacteria, fungi and other microorganisms release organic compounds which act like glue binding soil particles together and helping to stabilise aggregates. Stable aggregates create pore spaces for root growth, air and water movement and they hold nutrients for plant uptake. Compaction occurs when the pore spaces between aggregates are crushed. Compacted soils lose their structure, do not drain freely, can limit root growth and are vulnerable to surface water pooling and overland flow. In a Hawke's Bay soil compaction trial, the compaction treatments had silage maize yields 6.1 t/ha lower than the uncompacted treatments decreasing returns by $1500/ha.

Work in Southland showed that every 10% reduction in soil structure, came with an average yield loss of 8% (Figure 6). Although this work was carried out in wheat, in the maize system using silage yield from the Henderson trial in 2021/22 of 22 t DM/ha (with a silage price of $0.3/kg DM), a 10% reduction of aggregate stability could result in a potential loss of $530/ha. Long-term monitoring is required to validate this.

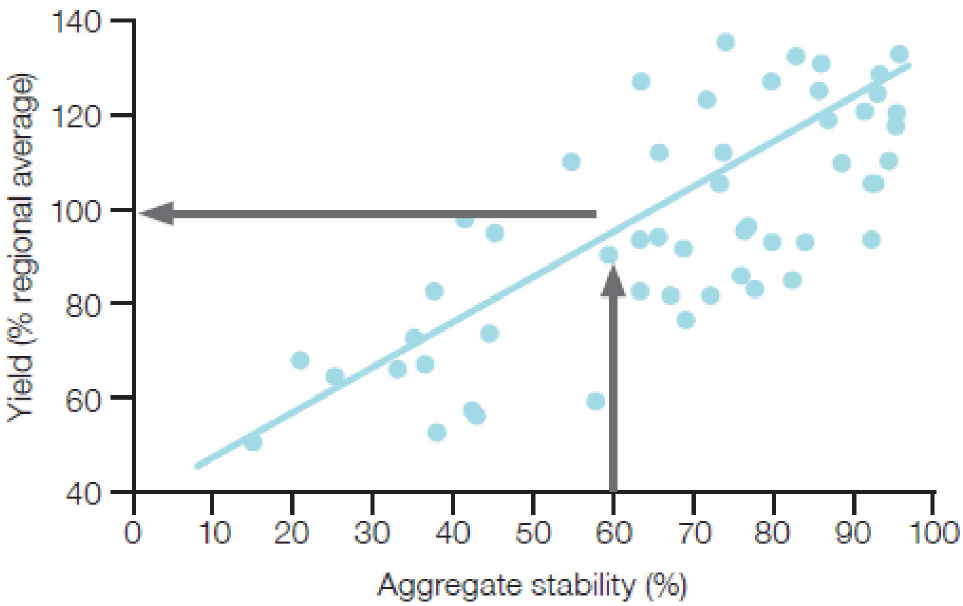

Figure 6. Relationship between aggregate stability (soil quality indicator) and relative crop yields, 2004, Southland. Grey arrows show yield averages for the region.

Soil organic matter and Soil carbon

Soil organic matter (SOM) consists of approximately 58% carbon (C). Optimal amounts of SOM and soil C vary depending on soil type, climate and management (Table 8).

Table 8. Total carbon target ranges for New Zealand soils (%w/w) as reported in Hill & Sparling (2009).

	Very depleted	Depleted	Normal	Ample	
Allophanic	0.5	3	4	9	12
Semi-arid, Pumice and Recent	0	2	3	5	12
All other soils	0.5	2.5	3.5	7	12

Average soil C stocks in New Zealand's agricultural soils are about 100 t/ha in the top 30 cm (Mudge, 2019). Pastures in New Zealand have soil C stocks as high as 109 to 138 t/ha (NZ Ministry for the Environment, 2018). Although cropping soils generally have less, as they are impacted by non-continuous production, disturbance and C removal at harvest, they can still have soil C stocks around 90 t/ha to 30 cm depth (compared to rates as low as 10 t/ha in some overseas cropping systems).

Results

The hypothesis around soil quality at the on-farm trials is:
Compared to conventional cultivation, well managed no tillage or strip till maize establishment systems, combined with the strategic integration of cover crops, results in improved soil quality, production systems resilience, and profitability over time, and provides beneficial environmental outcomes.

What have we learnt so far?

A full baseline assessment was carried out at the Henderson trial in October 2022 (Table 9).

Table 9. Average baseline soil quality measurements from 48 plots at Alan Henderson's trial before planting in Spring, October 2022. Range of results is presented in parentheses ().

	Aggregate stability, mean weight diameter (mm)	Bulk density (g/cm^3)	Carbon stocks, (t/ha)	Carbon (%)	Organic matter (%)
0-7.5	1.29 (0.9-1.72)	0.71 (0.62-0.78)	38.2 (32.2-45.4)	7.2 (5.8-8.4	12.5 (10.1-14.4)
7.5-15		0.70 (0.62-0.77)	38.5 (30.7-45.9)	7.3 (6.2-8.5)	12.7 (10.7-14.6)
15-30		0.64 (0.56-0.72)	46.7 (29.7-75.6)	4.9 (3.3-7.1)	8.4 (5.7-12.3)
30-60		0.60 (0.52-0.67)	32.7 (23.4-55.4)	1.8 (1.4-3.3)	3.1 (2.5-5.7)
60-90		0.67 (0.58-0.75)	26.1 (20.1-33.7)	1.3 (1.1-1.7)	2.3 (1.8-2.9)
90-120		0.66 (0.56-1.15)	24.2 (16.5-85.3)	1.3 (0.6-4.9)	2.2 (1.1-8.5)

Putting these results into context

Soil carbon concentrations are well within the target ranges for allophanic soil at the upper end of 'normal' (Table 8). Carbon stocks to 30 cm are high for cropping soil at 170 t/ha which is comparative with pastoral soil in New Zealand. Although the aggregate stability result was lower than the recommended target, it is in line with cropping averages from Waikato assessed during extensive monitoring that took place in Waikato between 2002 and 2007 as part of the Land management Index monitoring programme (Figure 7).

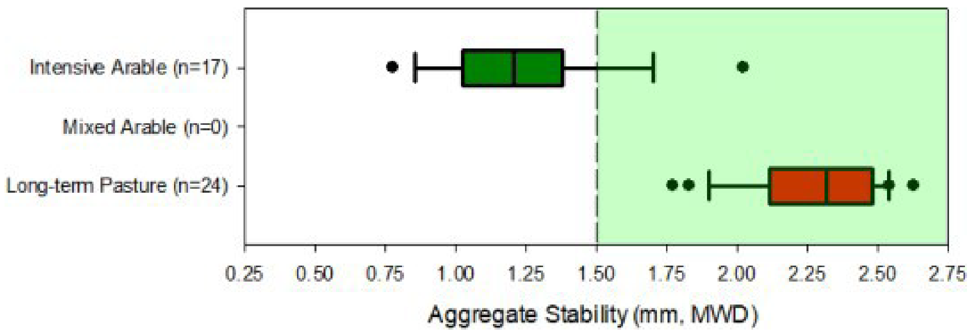

Figure 7. Aggregate stability for Waikato sites sampled between 2002 and 2007. The line inside each box is the median value for this land use. The recommended target value to be above is the vertical dashed line.

Using the Landcare Research soil qulaity tool indicator (SINDI), macroporosity was low on the target range (Figure 8). This could be improved by management practices that increase soil structure such as those suggested in the introduction.

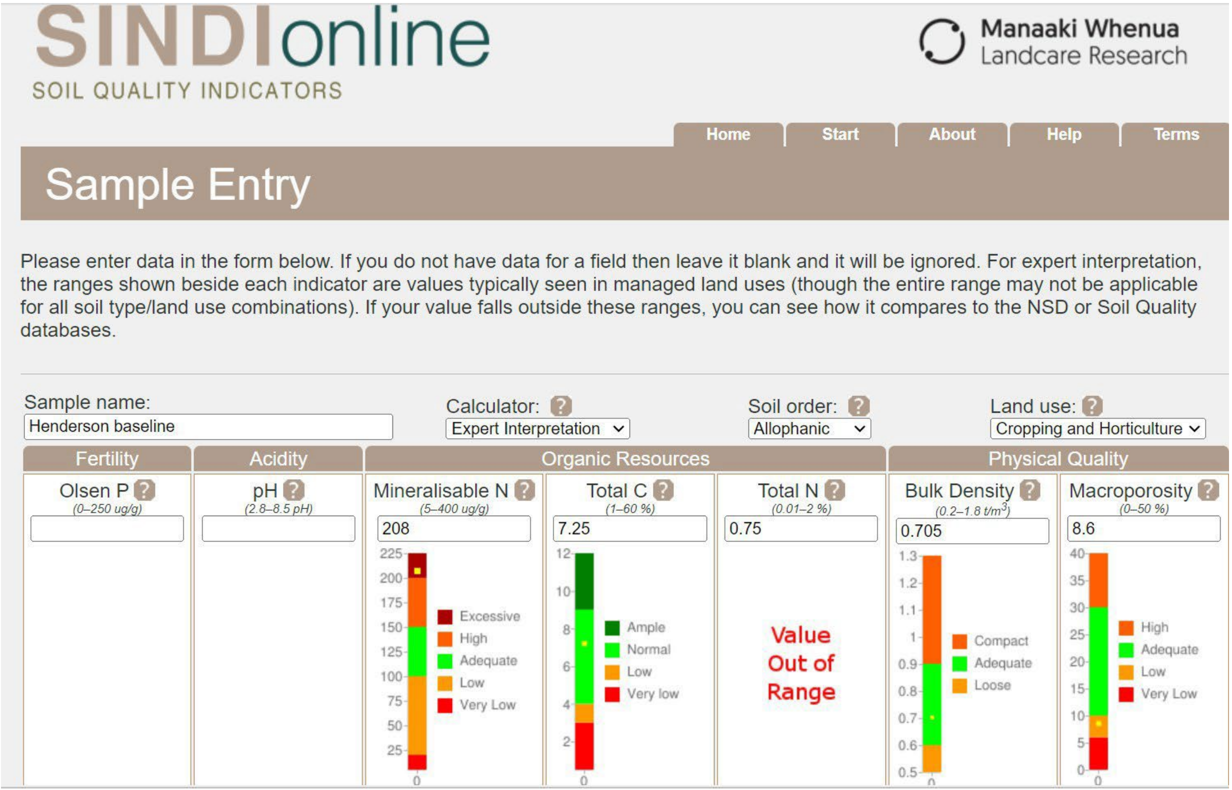

Figure 8. Landcare Research soil quality indicator calculator. Henderson baseline values, October 2022.

Soil quality sampling a year into trial

Aggregate stability assessments were carried out October 2023. Samples were either analysed by Landcare Research using the same baseline method where results are presented as a mean weight diameter (MWD) or assessed using a plunger method where results are presented as wet stable aggregates (WSA). For both measures a higher value means greater structural stability and quality. As already mentioned, stable aggregates create pore spaces for root growth, air and water movement and they hold nutrients for plant uptake. At the Jackson trial these were carried out in the woolly pod vetch, perennial clover and perennial ryegrass winter crop treatments for no tillage and cultivation. At the Henderson trial these were carried out in the annual ryegrass, rape and mix (triticale, rape, tick bean) for no tillage and cultivation.

Jackson site

At the Jackson site we have measured an increase in aggregate stability and therefore soil structure in the no tillage plots (Figure 9a). We have also measured an effect of winter crop selection on soil aggregate stability, with woolly pod vetch plots having lower values than perennial ryegrass or clover plots (Figure 9b). We have not measured an interaction between establishment practice and winter crop on soil aggregate stability.

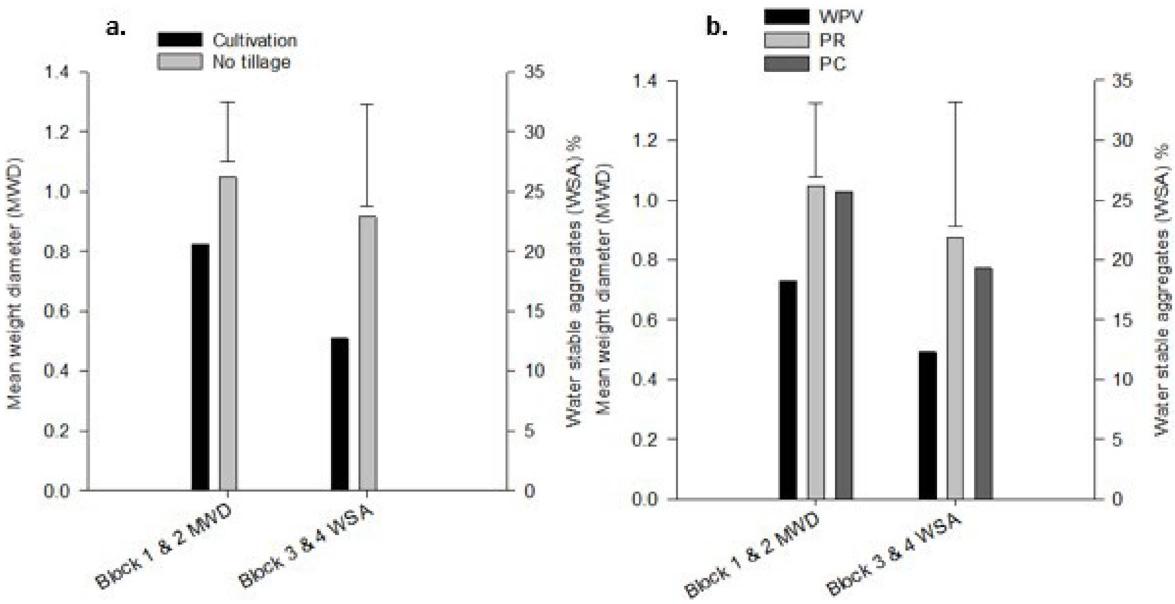

Figure 9. Aggregate stability (MWD; mean weight diameter left axis and water stable aggregates right axis), October 2023, Jackson trial site; **a)** for cultivation and no tillage treatments, and **b)** for woolly pod vetch (WPV), perennial ryegrass (PR) and perennial clover (PR). Error bars represent the LSD (5%) for the main effect of tillage.

Henderson site

At the Henderson site, a smaller number of samples were analysed with the MWD method (n=8) and there were no differences between cultivation and no tillage (Figure 5a). There was, however, a trend for the no tillage plots to have greater structure than with cultivation using the WSA method (n=12) (Figure 5a). There were no differences between the winter crops using either method (Figure 5b). We have not measured an interaction between establishment practice and winter crop on soil aggregate stability.

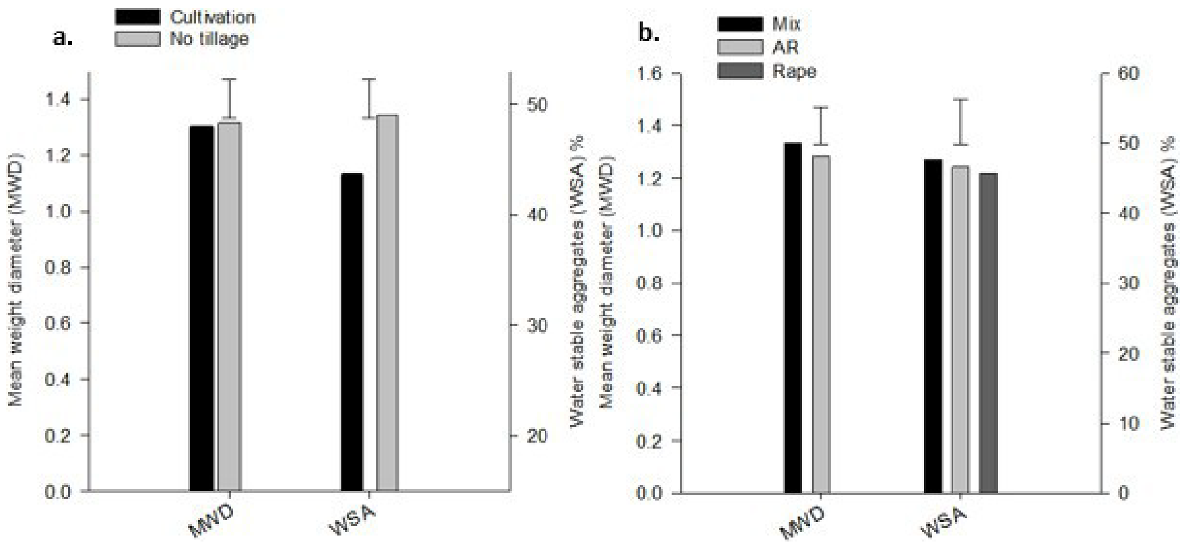

Figure 10. Aggregate stability (MWD; mean weight diameter left axis and water stable aggregates right axis), October 2023, Henderson trial site; a) for cultivation and no tillage treatments, and b) for annual ryegrass (AR), rape and mix (triticale, rape, tick bean). Error bars represent the LSD (5%) for the main effect of tillage.

Conclusion

A full baseline assessment at the Henderson trial show that soil quality is already good although there are areas where improvements can be made (e.g. aggregate stability and macroporosity). On-going measurements will inform if implementing management practices such as reducing tillage and winter sequences using crops with high returns of below ground organic matter will benefit soil structure.

References

Mudge, P (2019). A national soil carbon monitoring system for agricultural land in New Zealand. Published 10 August 2019 in Manaaki Whenua newsletter, Soil Horizons.

Hill, R and Sparling, G (2009). Soil quality monitoring. In Land and soil monitoring: A guide for SoE and regional council reporting. Land Monitoring Forum, New Zealand Pp. 48.

Across planter soil density assessment

Key points

- Internationally, the increasing use of strip till units with fertiliser hoppers and centre filled maize planters has resulted in an increasing incidence of soil compaction from equipment tyres.
- This research has shown that in some circumstances maize yield within the rows adjoining tractor and equipment tyre rows is reduced because of an increased level of soil compaction.
- This occurrence of compaction is known as the 'pinch rows' effect.
- At the Richard Strang site there was a significant difference in soil density (kPa) between the equipment tyre row (between planter rows), the middle of the planter row (mid row), and planter row at every sample depth to 25cm. There was a significant difference between the tyre row and mid row at 25cm on both sample sites (5% lsd = 406.6 and 436, respectively).
- At the Paul Hunter site there was a significant difference in soil density between the equipment tyre row, the middle of the planter row, and planter row at 0 and 5cm at both sample sites (p=0.003, <0.001, 0.023, and <0.001 at 2.5cm and 5.0cm at Site 1 and Site 2, respectively).

Both Richard Strang and Paul Hunter operate an 8 row strip till unit and maize planter, with fertiliser hoppers attached to the strip till units. Richard operates an Orthman strip till unit, which includes a shank. The fertiliser hopper is located on a caddy, which is towed between the tractor and strip till unit. With this strip till system both the tractor and fertiliser caddy tyres are contributing to tyre row soil compaction.

Paul's strip till unit is a Soil Warrior, which utilises wavy coulters to create a seed bed. The fertiliser hopper sits on top of the strip till unit, and when the strip till unit is in the ground the down force of the coulters lifts the tyres carrying the strip till frame and fertiliser hopper off the ground. Therefore, the only potential cause of tyre row soil compaction is from the tractor.

To measure soil density differences and to determine if soil compaction was occurring in the tractor and strip till unit tyre rows at both strip-till system, FAR undertook a soil density assessment across the 8-row strip-till width both in the maize row and between the maize row. A FieldScout SC900 Soil Compaction Metre was used to assess soil density to a depth of 45 cm, at 2.5 cm increments in spring when soils were at field capacity. At both farm locations, four strip-till passes were assessed on two different soil types with the soil density values for the tyre rows, between planter rows, and the planter rows shown in ***Figure 11***.

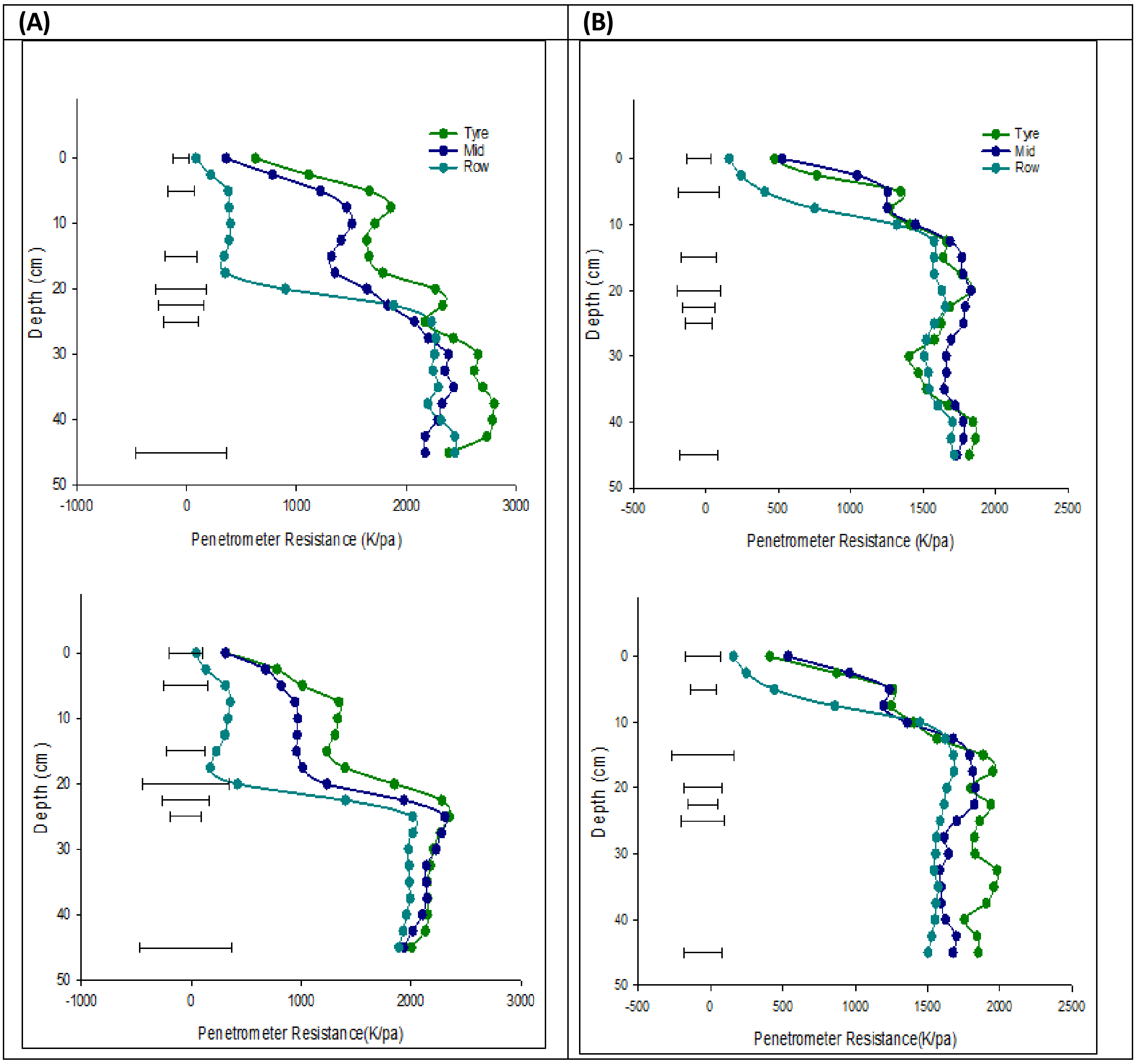

Figure 11. Across planter soil density assessment at 2.5cm increments to a depth of 45cm at Richard Strang's (A) (two soil types) and Paul Hunter's (B) (two soil types). Bar = LSD (p=0.05).

The influence of winter crop options on soil temperature and water content within the maize crop

Key points

- TDR (time-domain reflectometry) units have been installed within various research projects at the FAR NCRS site at Tamahere to measure Volumetric Water Content (%) and soil temperature.
- TDR instruments are used to track temporal changes in soil moisture and temperature across treatments and to assist with interpreting research outcomes.
- Volumetric Water Content (VWC) percentage is the volume of water contained within a volume of soil.
- In the at-planting N application research project, the plots with a winter fallow have approximately 8% to 10% less VWC compared to the plots with previous winter plant stover that remains in situ.
- At this same research site, where stover remains soil temperatures in November are approximately 5.0 to 7.5C cooler compared to the bare sites.

One of the research projects at NCRS is the *at-planting nitrogen application and availability for maize following various winter crop treatments*. This study includes plots with no winter crop (fallow), oats removed prior to maize planting, and oats rolled before planting and left in situ (**Figure *12***).

Figure 12. At planting nitrogen application and availability for maize following various winter crop treatments research project showing 'plant stover removed' (foreground), no winter crop (centre plot), and winter plant stover (oats) in situ (background).

The TDR units were installed once the maize research plot had been planted. Probes were installed at the 5 to 10cm depth for measuring soil temperature, and 10 to 20cm for measuring VWC.

As can be seen in ***13*** (next page), VWC% remains higher in the plant stover in situ plots compared to the fallow (no winter crop) and the plant stover removed treatments. This difference has remained over the last six weeks following maize planting. As might be expected, VWC% is higher in the mid maize row winter stover crop plots compared to the maize plant row. It will be interesting to see if and when this difference disappears which, if it does, would indicate that maize roots are pulling water from the centre of the maize row.

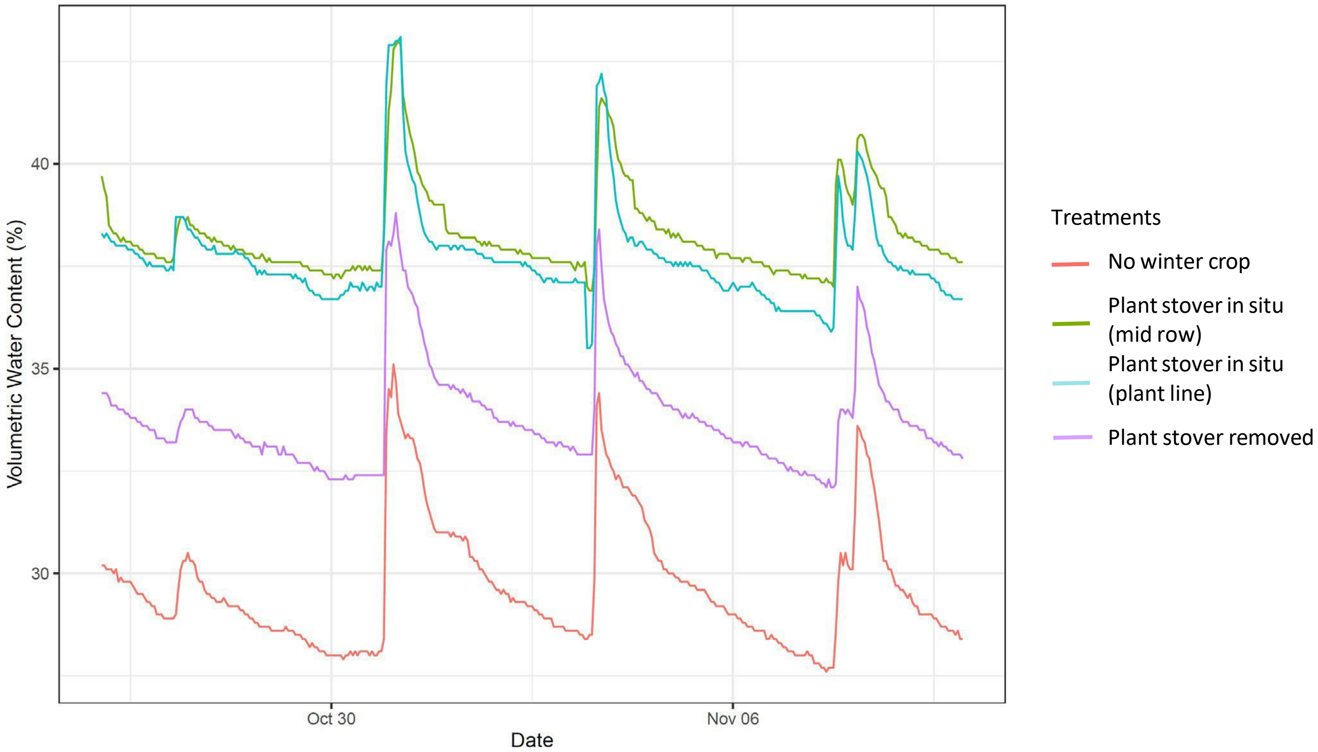

Figure 13. VMC % across different treatments within the at-planting N study at NCRS.

At the beginning soil temperatures across the various treatments were similar. However, over time soil temperatures on the fallow and winter crop removed plots have increased more than the plots where winter crop stover remains (***Figure 14***).

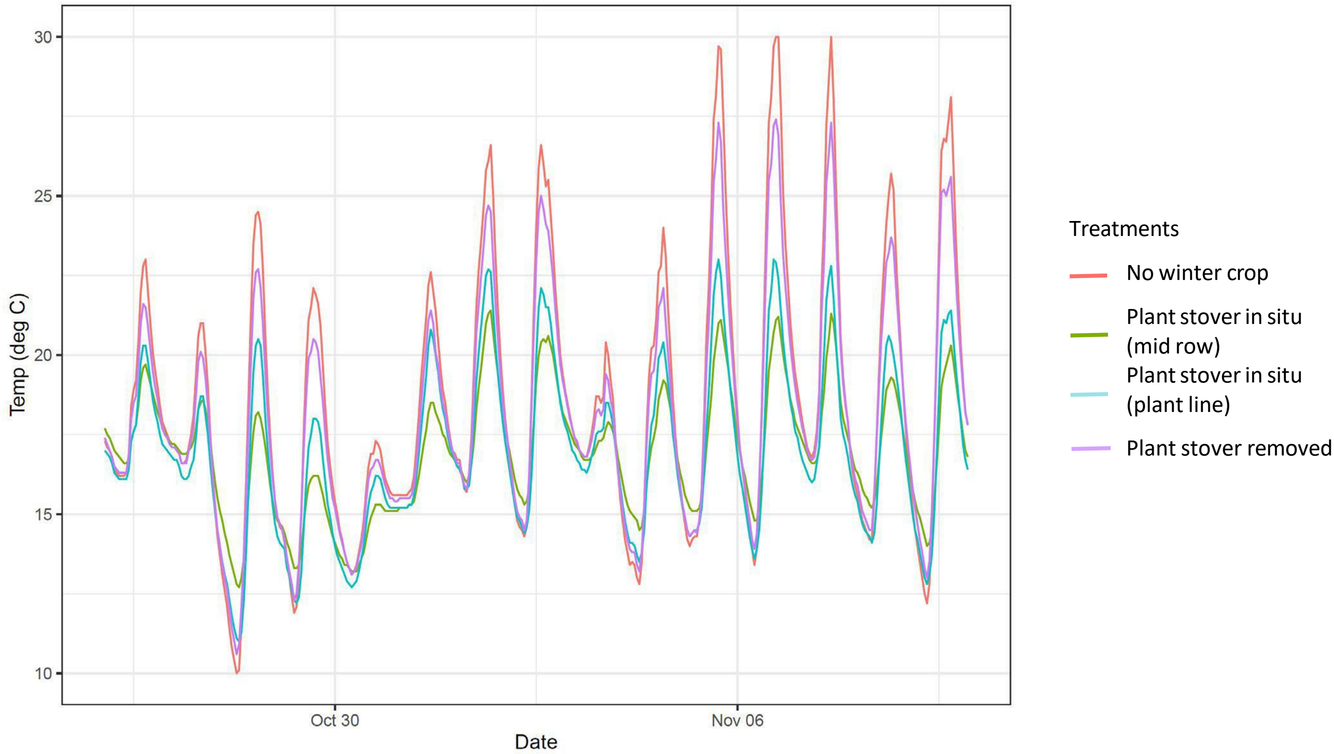

Figure 14. Soil Temperature across different treatments within the at-planting N study at NCRS.

Cover Crop Information from the Spring 2023 field day

Cover crops

Jackson site (Year 3)

Cover crop use description: cut once for silage, approximately 1 October.

Seeding rates and treatment descriptions

Table 10. Seeding rates and treatment descriptions for the 2023-24 season

Cover crop treatment	Cultivar	Seeding rate (kg/ha)	Treatment description
Perennial ryegrass	Nui	25	Colin's standard (initially)
Strip plant			
Perennial ryegrass	Nui	15	Annual clovers drilled in strip where maize will be planted, annual ryegrass drilled in strip between maize rows
Berseem clover	Alex	4	
Crimson clover	W3129	4	
Other legumes			
Tick bean +	unknown	35	
Woollypod vetch	RM4	15	High biomass legumes
Perennial clover			
White clover	Mantra	4	Attempt to maintain living clover year-round
Red clover	Reaper	6	

Cover crop establishment and management information for 2023-24 season

Cultivation: Due to hard soil conditions the whole trial area was sub-soiled, and run over with the drill without seed to loosen the drill rows, 19 May 2023.

Drilling: 19 April 2023, Great Plains triple disk.

Slugbait: 11 and 26 May 2023, 3 kg/ha Metarex® Inov.

Fertiliser: 1 June 2023, 100 kg/ha SustaiN® applied to perennial ryegrass treatment only.

14 August 2023, 100 kg/ha SustaiN® applied to perennial ryegrass treatment only.

Herbicide: 17 May 2023; Perennial ryegrass and strip plant, 2.5 L/ha Troy® (480 g/L Bentazone) in 500 L/ha water; Tick bean + woollypod vetch and Perennial clover, 2.5 L/ha Troy®, 0.5 L/ha Sequence™ (240 g/L clethodim) and 1 L/100 L Bonza® (471 g/L heavy paraffinic petroleum distillate) in 500 L/ha water.

Anticipated harvest date 1 October 2023.

Cover crop yields for the 2021-22 and 2022-23 seasons

- Winter cover crops have been planted in the trial over the previous two years.
- Perennial ryegrass yield ranged from approximately 3 - 4.5 t DM/ha. Strip planting provided a more consistent yield, while yield legume-based cover crops were more variable.

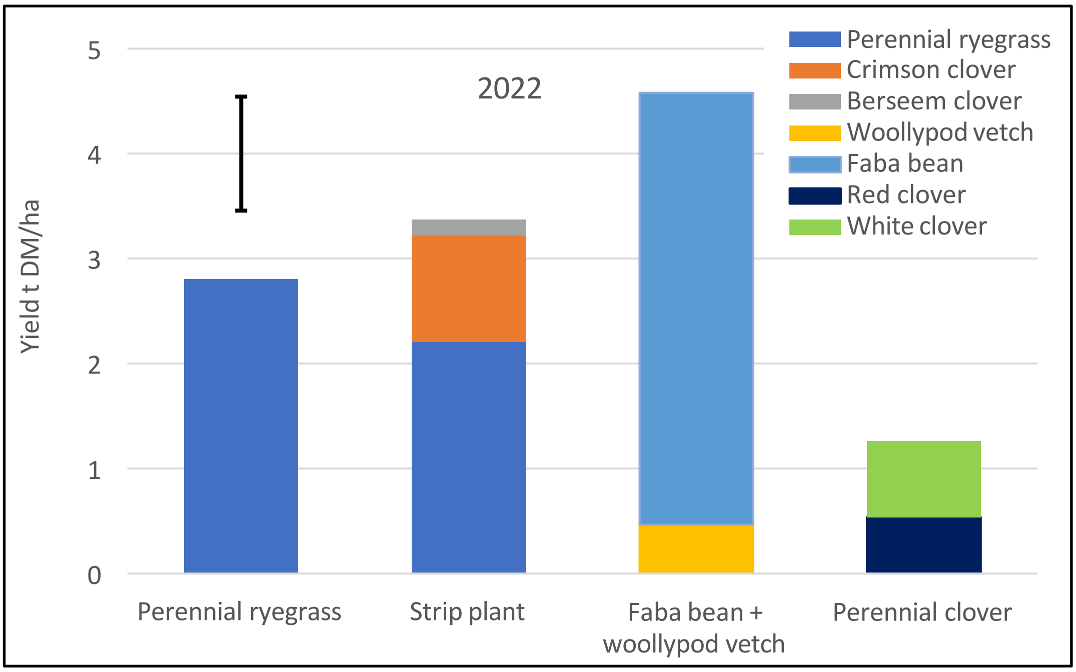

Figure 15. Jackson site, 2022 cover crop dry matter yields. Drilled 10 May 2022, harvested 4 October 2023. Bar = LSD (p=0.05).

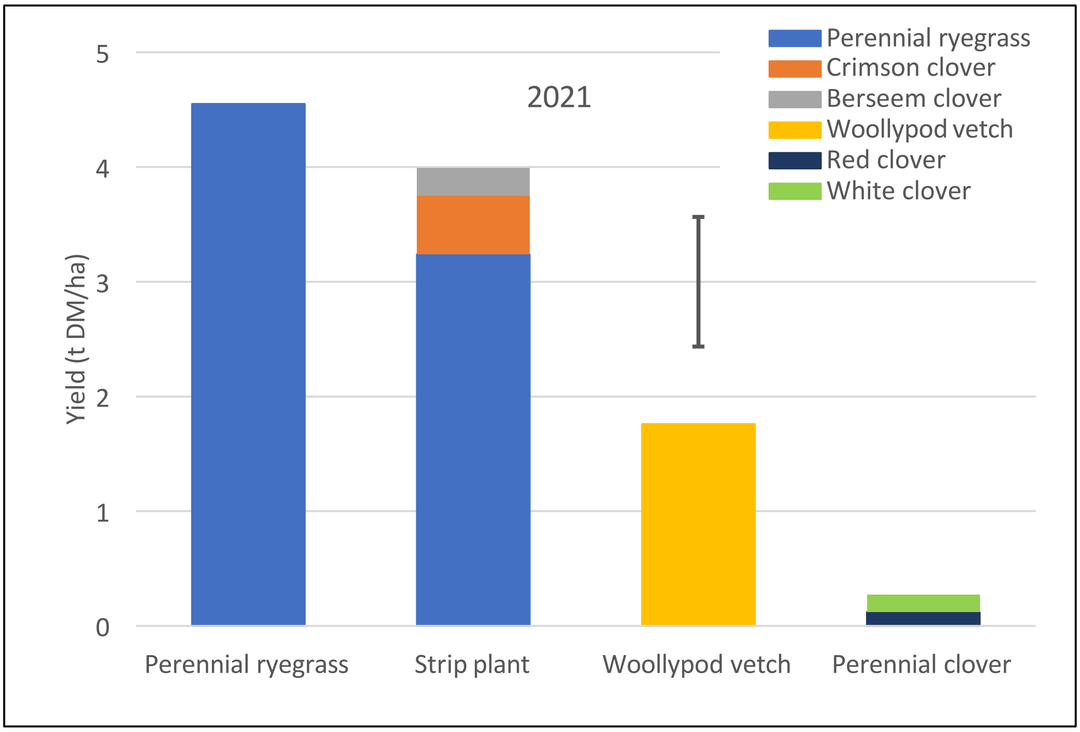

Figure 16. Jackson site, 2021 cover crop dry matter yields. Drilled 19 April 2021, harvested 28 September 2021. Bar = LSD (p=0.05).

- The forage quality of the individual cover crop species was measured.

Table 11. Jackson site, 2022 cover crop harvest feed test results.

	Crude Protein (%DM)	Acid Detergent Fibre (%DM)	Neutral Detergent Fibre (%DM)	Lignin (%DM)	Soluble Sugars (%DM)	Starch (%DM)	Metabolisable Energy (MJ/kg DM)
Faba Bean	30.4	27.2	38.4	11.2	9.9	< 0.5	12
Crimson Clover	22.1	24.1	33.9	7.3	9.6	2.8	11.4
Berseem Clover	24.3	19.9	29.6	9.3	10.4	1.6	11.4
Triticale	13.6	30.4	56.8	4.4	10.1	1.6	8.8
Perennial Clover	25.8	20	30.7	7.1	7.7	0.8	11.8
Vetch	24.9	29	39.7	7.5	2	2.2	10.5
Perennial Ryegrass	N/A	23.6	41.8	2.6	17.1	< 0.5	11.7

Combined analysis of cover crop yields and gross margins for the 2021-22 and 2022-23 seasons

- Combining data from the 2021-22 and 2022-23 season, maize establishment technique had no effect on cover crop yield or gross margin (Table 12).
- On average over the two years, cover crop species had an effect on both cover crop yield and gross margin (Table 12). All cover crops provided similar yield except perennial clovers.
- The cost of the woollypod vetch and faba bean mix, meant that despite producing good biomass, the gross margin for this treatment was not as high as for those including perennial ryegrass (Table 12).
- Despite the lower yield and/or gross margin of cover crops including clovers, these legumes may provide other benefits (e.g. soil remediation and nitrogen fixation, higher quality forage).
- Cover crop yield and gross margin were not affected by any interaction between cover crop species and maize establishment technique (Table 12).

Table 12. Average dry matter yield and gross margins for cover crop treatments in the cover crop by establishment trial at the FAR on-farm trial at Colin Jackson's, Waikato after planting with either cultivation, strip-till or no-till in 2021-22 and 2022-23 (i.e. a two-year average).

Cover crop		Dry matter yield (t/ha)			Gross Margin ($/ha)		
	Maize establishment	Cultivation	No-till	Strip-till	Cultivation	No-till	Strip-till
Perennial Clover		0.71	0.85	0.75	-204	-169	-196
Perennial ryegrass		3.93	3.66	3.43	372	304	246
Perennial ryegrass + clovers		3.70	3.84	3.52	307	343	263
Woollypod Vetch + faba bean		2.95	3.25	3.32	-103	-6	-21
P value (establishment)		0.738			0.575		
P value (cover crop)		<.001			<.001		
P value (establishment x cover crop)		0.338			0.445		
LSD (p=0.05) (cover crop)		0.976			236.6		

Note. Treatments highlighted yellow were amongst those with the greatest cover crop yield or gross margin. The perennial clover treatment included a mix of red and white clover while the mix of perennial ryegrass and clovers included a mix of Crimson and Berseem clovers.

Henderson site (Year 1)

Cover crop use description: grazed once (27 June), and cut for silage, approximately 1 October.

Seeding rates and treatment descriptions

Table 13. Seeding rates and treatment descriptions for the 2023-24 season

Cover crop treatment and species	Cultivar	Seeding rate (kg/ha)	Treatment description
Annual ryegrass	Jivet	25	Industry standard
Strip plant			
Annual ryegrass	Jivet	15	Annual clovers drilled in strip where maize will be planted, annual ryegrass drilled in strip between maize rows.
Berseem clover	Alex	4	
Crimson clover	W3129	4	
Mixed species			
Tick bean	unknown	25	High biomass species
Rape	Titan	1.3	
Triticale	Kudos	50	
Rape (alternating mixed species)	Titan	4	Each of the mixed species will be rotated through as a monoculture. Introduced to contrast the Mixed species treatment.

Cover crop establishment and management information for 2023

Drilling 28 March 2023, Great Plains triple disk.

Slugbait 6 April 2023, 1 kg/ha Metarex® Inov.

Fertiliser 1 June 2023; SustaiN® applied to Annual ryegrass, Mixed species and Rape at 100 kg/ha.

15 August 2023; SustaiN® applied to Annual ryegrass, Mixed species and Rape at 100 kg/ha.

Rhizobia Tick bean rhizobia applied by knapsack 19 June 2023. Rhizobia applied to crimson clover at drilling.

Cover crop sampling 27 June 2023

Grazing 5 and 6 July 2023, dry milking herd.

Herbicide 23 August 2023; Rape, 0.5 L/ha Sequence™ (240 g/L clethodim) and 1 L/100 \L Bonza® (471 g/L heavy paraffinic petroleum distillate) in 200 L/ha water.

Anticipated harvest date 1 October.

Early assessment cover crop yield for 2023

- Strong early growth of cover crops.

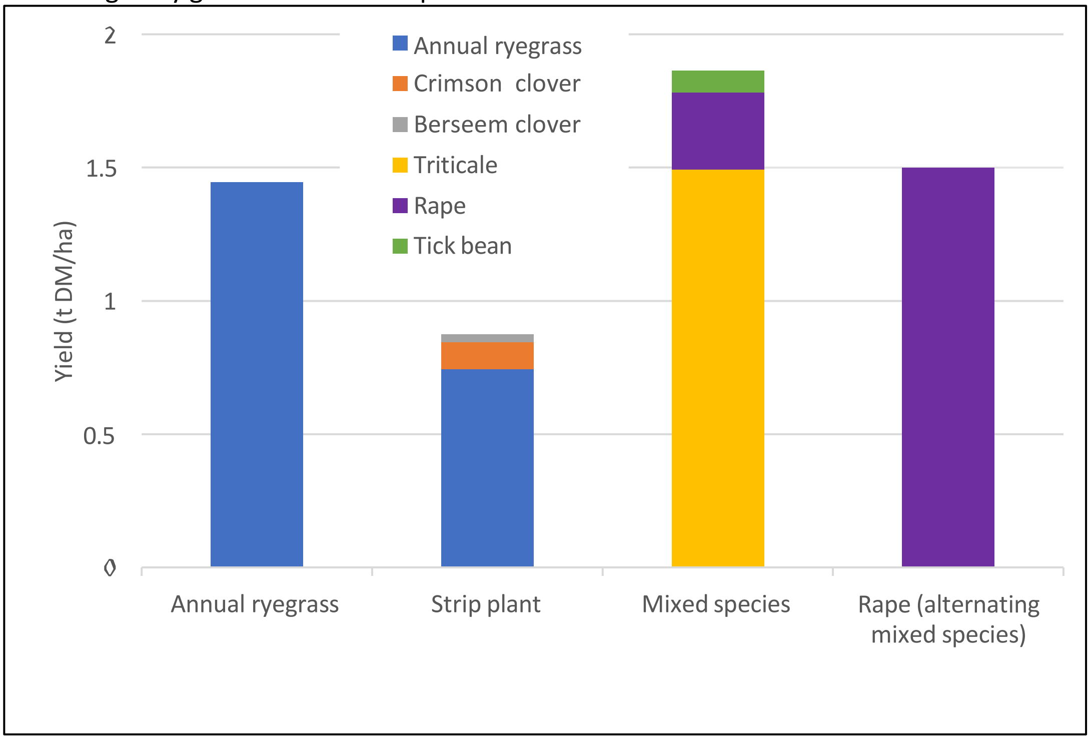

Figure 17. Henderson site, first assessment (27 June 2023) cover crop dry matter yields. Drilled 28 March 2023, harvested 27 June 2023. Statistical analysis yet to be done.

Table 14. Henderson site, first assessment (27 June 2023) cover crop feed test results

	Crude Protein (%DM)	Acid Detergent Fibre (%DM)	Neutral Detergent Fibre (%DM)	Lignin (%DM)	Soluble Sugars (%DM)	Starch (%DM)	Metabolisable Energy (MJ/kg DM)
Triticale	20.3	23.7	43.9	3.8	10.4	<0.5	11.1
Tick bean	22.2	24	31.3	8.2	15.2	< 0.5	11.8
Annual Ryegrass	25.4	20.2	37.9	6	11.4	< 0.5	12.1
Rape	25.4	11.7	18	4.2	20.2	1.1	14
Berseem clover	26.8	21.5	31.7	7.8	6	< 0.5	11.4
Crimson clover	26.6	19.8	25.2	5.3	13.5	1.4	12.6

Resources:

Carter, Paul, and Emerson Nafziger. 1989. Uneven Emergence in Corn. NCR-344.
http://corn.agronomy.wisc.edu/Pubs/UWEX/NCR344.pdf
2022 Precision Technology Farm Research Summary (pg. 25)
https://www.precisionagriservices.com/PDFs/InsidePTI-Results/2022%20PTI%20Yield%20Summary%20Report%20Final%202.4.23.pdf
FAR Cover crops and maize establishment update booklet September 19 2023
https://www.far.org.nz/resources/cover-crops-and-maize-establishment-update-booklet
FAR Corson Maize cover crops and maize establishment system booklet February 28 2023
https://www.far.org.nz/resources/corson-maize-demonstration-site-field-day-booklet
FAR On-farm maize research booklet February 15 2023, The use of NDVI and OSAVI in maize production page 9 https://www.far.org.nz/resources/on-farm-maize-research-booklet-february-15-2023
FAR On farm maize research booklet December 14 2022 https://www.far.org.nz/resources/on-farm-maize-research-booklet
FAR On-farm cover crop & maize establishment systems booklet December 10 2021
https://www.far.org.nz/resources/on-farm-cover-crop-maize-establishment-systems
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FAR

MAIZE PROFIT & PRODUCTIVITY

12-13 FEBRUARY 2024, CLAUDELANDS EVENTS CENTRE

DAY 1: Monday 12 February

Session 1: Global issues and considerations for New Zealand

9.00am Welcome

Reducing emissions to net zero by 2050.
Nestlé

What's driving change on North Island dairy farms?
Raewyn Densley, AgFirst

Financing rural sustainability.
Turi McFarlane, ASB

10.50am Morning tea and sponsors

Compliance update – what do we know and how will it affect maize?
Dirk Wallace, FAR

A farmer perspective on the diverse role of maize and maize production systems.
Grower panel

12.30am Lunch and sponsors

Session 2: NCRS field tour: Research delivering sustainability and profitability into maize production systems

i. N indicators trial, *Dirk Wallace, FAR*

ii. Long Term Establishment Trial, *Abie Horrocks, FAR*

iii. Multi hybrid plantings, *David Densley, FAR*

iv. Maize, time of planting, *Sam McDougall and Steve Payne, FAR*

5.30pm Drinks and dinner at Claudelands

DAY 2: Tuesday 13 February

Session 3: Preparing for the future – what might it look like for the maize industry?

8.30am Welcome

Risk and resilience, preparing for future.
Alison Stewart, FAR

Biological options – current and future role in resilient maize systems.
Connor Sible, University of Illinois

Improving yield, resilience and profit through improving soil quality and agronomic practice.
David Densley, FAR

The quest for profitability, production resilience, and environmental good practice.
Grower panel

10.30am Morning tea and sponsors

Session 4: The role of precision agriculture in future maize systems

The current and future role of precision ag in US maize systems.
Scott Shearer, Ohio State

The current and future role of precision ag in New Zealand maize systems.
Chris Smith, FAR

The role of precision ag in building a more profitable maize production system.
Grower panel

12.45 pm Lunch and informal opportunity to speak with:

- *Sponsors*
- *Compliance experts*
- *Conference speakers*
- *Biosecurity staff*

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