FAR

ADDING VALUE TO THE BUSINESS OF CROPPING

Northern Crop Research Site 2016/17
978-0-9941286-1-4 (Print)
978-0-9941286-2-1(Electronic)

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Northern Crop Research Site

Research Summary 2017

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Northern Crop Research Site 2016/17

This publication provides a summary of trials undertaken at the Northern Crop Research Site over the 2016/17 season, and their results. Key points are provided for each trial.

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2016/17 Summary

FAR's Northern Crop Research Site is located at 82 Oaklea Lane, Tamahere, near Hamilton.

At the Northern Crop Research Site FAR runs research trials and demonstration plots to provide quality research and extension activities for New Zealand, and particularly North Island, cropping farmers. During the 2016/17 season FAR undertook nearly twenty different trials at the Northern Crop Research Site (NCRS).

The 2016/17 maize season was climatically difficult. A very cold and wet spring resulted in slow early crop growth and delayed canopy closure. This was followed by a dry late December and January, resulting in maize plants exhibiting some leaf rolling and other symptoms of drought stress, while February onwards was wet. For the Waikato district maize yields this season were below average by between 1 and 2 t/ha for grain and averaged around 10 t/ha.

Site changes

In autumn 2016, we established a winter crop rotation trial, a variation on the classic maize rotation of maize one year, followed by soybeans the next. This rotation gives multiple advantages, including the ease of controlling grass weeds in broadleaf crops and broadleaf weeds in maize; and nitrogen (N) fixation by the soybean reducing applied N required by the maize crop. We plan to have maize-ryegrass-maize plots and treatments where faba bean and clovers are grown for a complete season, and then maize will be grown again. This will allow us to measure the yield difference between continuous maize and maize/legume rotations.

Personnel changes

Mike Parker has reduced the number of days he works for FAR each week, and we have employed a new Field Research Officer, Steve Payne.

Field days

On 4 December 2017 FAR held its third annual Northern Crop Research Field Day, an event that saw nearly 130 growers visit the site and listen to nine speakers. This successful annual event will be repeated on 13 December 2018.

Soil conditions

The soil at the site is predominantly a well-drained Horotiu silt loam. Typical results from a soil test are provided in Table 1.

Figure 1. NCRS 2017.

Table 1. Background soil fertility at planting at NCRS (0–15 cm depth).

Fertility indicator	Average site value	Optimum range[1]
pH	7.1	5.7 – 6.2
Olsen P (mg/l)	74	20 – 30
Exchangeable K (me/100 g)	1.4	0.30 – 0.60
Exchangeable Ca (me/100 g)	16.2	5.0 – 12
Exchangeable Mg (me/100 g)	1.4	0.60 – 1.2
Exchangeable Na (me/100 g)	0.08	0.0 – 0.50
CEC (me/100 g)	20.6	12 – 25
Anaerobically Mineralisable N (AMN, kg/ha)	89	100 – 150
Total C (%)	4.5	n/a
Total N (%)	0.48	n/a

[1] Based on values provided by RJ Hill Laboratories for oats and ryegrass.

Weather station

In spring 2015, a new weather station was installed at the NCRS site. This station records air and soil temperature, rainfall, soil moisture and leaf wetness every thirty minutes. This data will be valuable for use interpreting trial results from the site in the context of the weather conditions experienced.

Figure 2. The weather station at NCRS records air temperature and relative humidity, rainfall, soil moisture and temperature, leaf wetness and solar radiation.

2016-17 weather

Rainfall for July 2016 – June 2017 at NCRS was 1654 mm as compared to the 30-year average at Hamilton of 1108 mm, an additional 546 mm (+49%). NCRS has free draining soils and didn't suffer from the flooding and ponding seen elsewhere around the Waikato. However the high rainfall may have affected nutrient availability to the crops. December and January were cooler than the 30-year average.

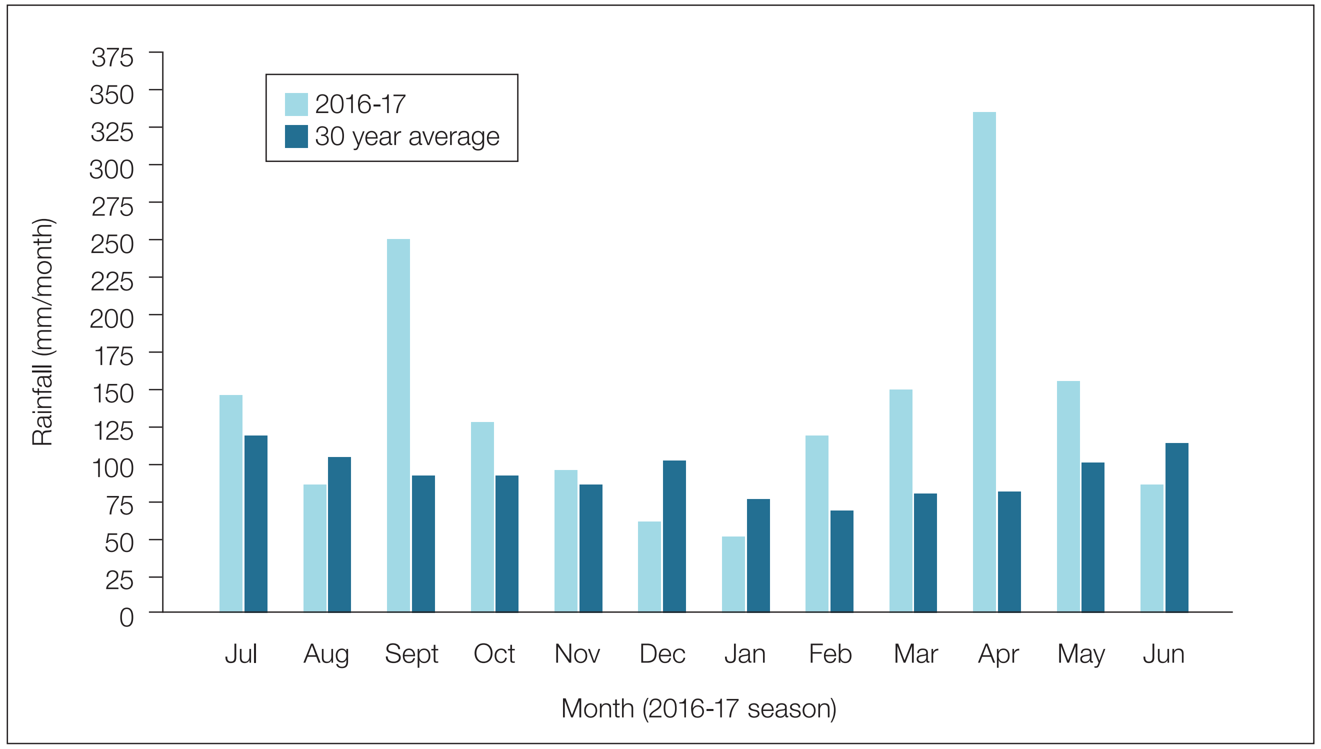

Figure 3. Monthly rainfall at NCRS for 2016-17.

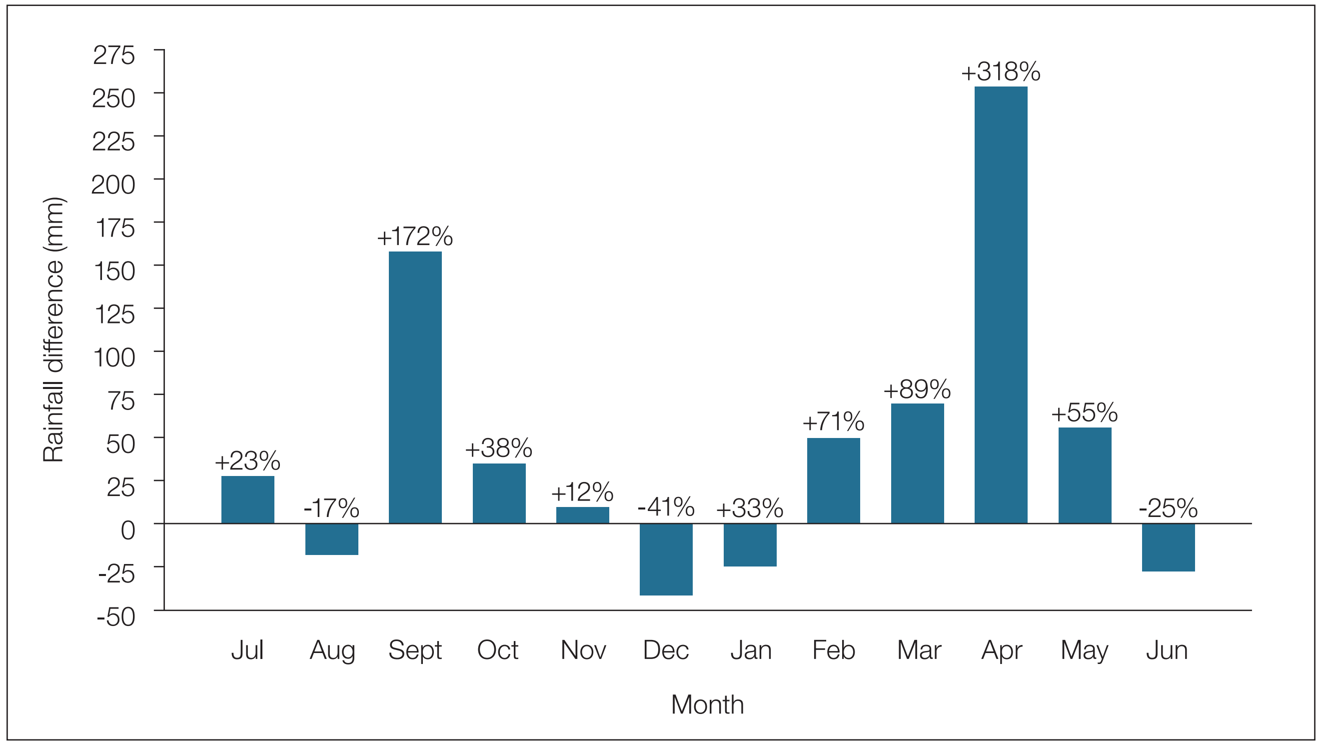

Figure 4. Comparison of rainfall at NCRS 2016-17 to 30-year average (Hamilton Airport).

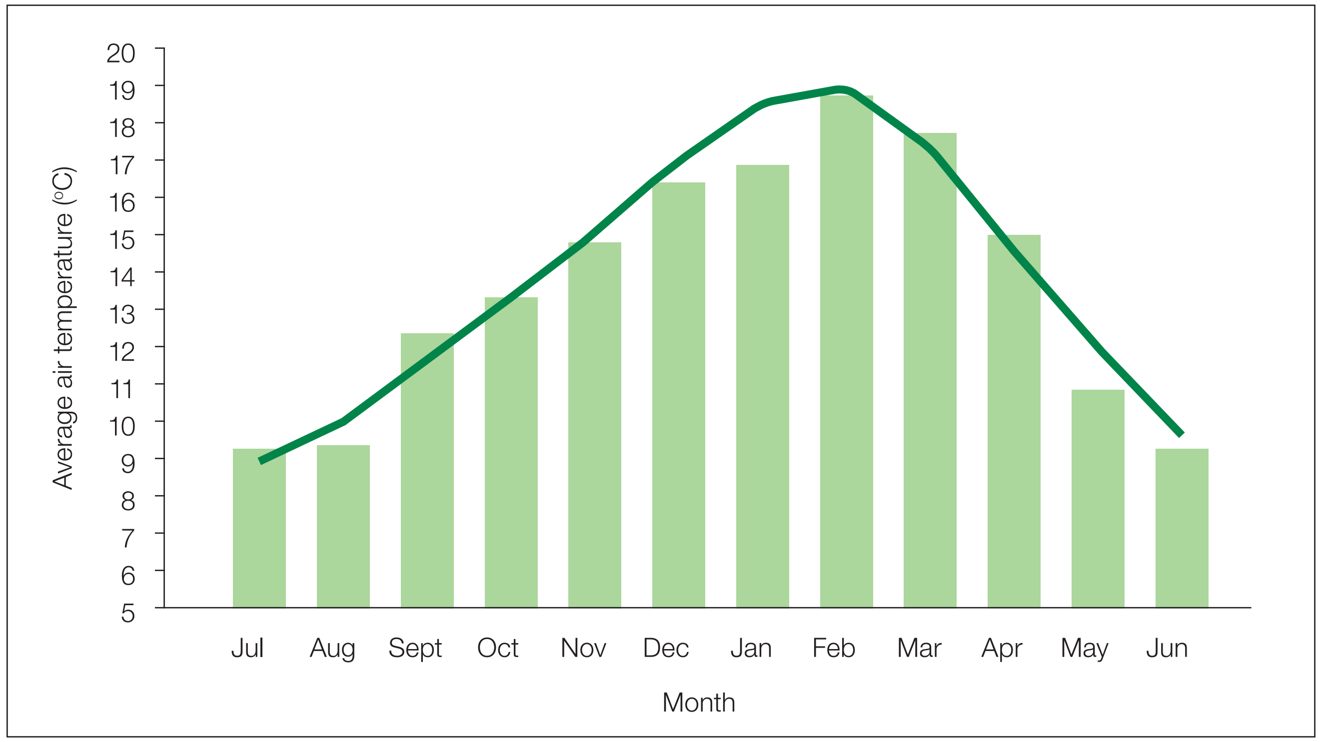

Figure 5. Average air temperature for 2016-17. Green bars are measured air temperature at NCRS, green line is 30-year average from Hamilton Airport.

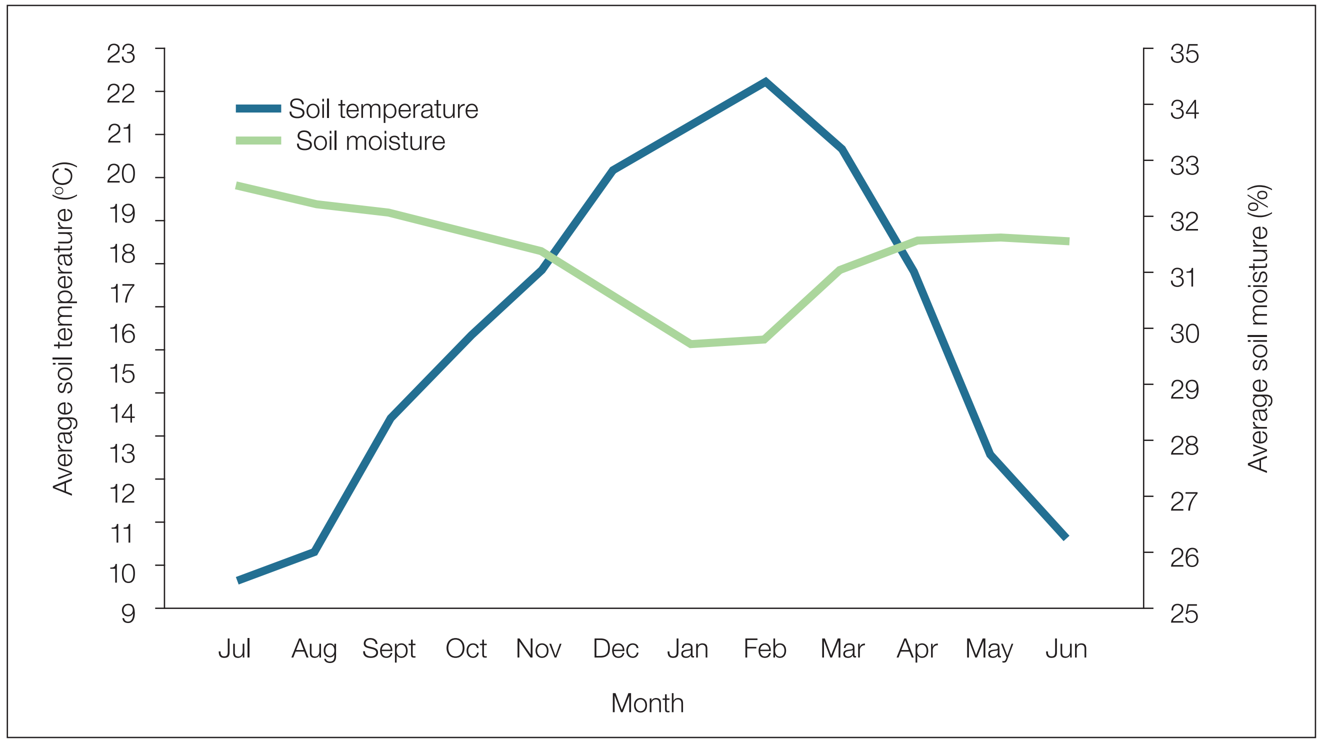

Figure 6. Average soil temperature and moisture at NCRS in 2016-17.

Winter cover crops to reduce herbicide inputs in maize crops

Key points

- No differences were found in maize silage or grain yields between the untreated control and any of the different herbicide treatments.
- Winter cover crops were effective in reducing assessed weed ground cover levels.
- Maize establishment and growth was slower in plots with residues of oats and ryegrass than in plots with residues of clover and faba beans.
- Maize silage yields were significantly higher in plots with residues of clover and faba bean compared to plots with residues of oats and ryegrass. Yields from the fallow plots were intermediate.
- Maize grain yields were significantly higher in clover and faba bean residue plots than in the oat and ryegrass residue plots.

Background

This is the second season of evaluating the use of winter cover crops to improve weed control and reduce the use of herbicides in maize cropping. Previous trials have shown that cover crops can be effective in suppressing weed incursion and reducing yield loss due to competition.

Objectives

- To understand the effect of different winter cover crop residues on weed establishment and the growth or yield of the spring planted maize crop.
- To understand the efficacy of weed management of the winter cover crop residues with and without subsequent pre- and/or post-emergent herbicide programmes compared to winter fallow followed by a pre-emergence and/or a post-emergence weed control programme, and to an untreated control.

Methods

A field trial was established in June 2016. The site had been used to grow maize the previous season and was harvested for grain in May 2016. The ground was then left fallow for about three weeks before cover crops were planted.

Winter cover crops

Four winter cover crops: gland clover (*Trifolium glanduliferum*) cv. Prima; faba bean (*Vicia faba*) cv. Ben; oats (*Avena sativa*) cv. Milton; and ryegrass (*Lolium multiflorum*) cv. Tama were drilled on 2 June 2016 in 6 m wide x 36 m long plots at rates of 6.6, 300, 100 and 25 kg/ha respectively (Treatments 1–4). The plots were orientated east-west (columns) and replicated four times in a randomised block design. A winter fallow plot of the same dimensions (Treatment 5) was also included in the layout. On 24 October 2016, winter cover crop dry matter (DM) cuts were taken before the cover crops were pushed over by roller and then sprayed with herbicide treatments to terminate the cover crop growth (Table 2).

Maize planting and treatments

Three days after applying the cover-crop-destruction herbicide, maize hybrid Pioneer® 9911 was no-till planted on 27 October 2016 aligning north-south (rows) at a seeding rate of 90,000 seeds/ha, with YaraMila™ starter fertiliser applied at 150 kg/ha. Each of the 20 main plots were then divided into five sub plots of 6 x 6 m, containing the remains of one cover crop and eight rows of maize, giving a total of 100 plots.

Metaldehyde (SlugOut®) was broadcast at a rate of 216 g ai/ha three days after emergence to kill slugs and snails, and alpha-cypermethrin (Sheriff® 100) plus 70 ml/ha Contact™ Xcel at 20 g ai/ha was used on 18 December 2016 to control armyworm. A stabilised urea fertiliser (SustaiN) was broadcast at a rate corresponding to 92 kg nitrogen per hectare, 18 days after maize emergence.

Table 2. Winter cover crops and herbicides used for cover-crop-destruction and weed control in the spring sown maize; including rate and timing.

Winter crop	Cover crop		Herbicide	Pre-emergence (maize)		Post-emergence (maize)		Time
	Product	Rate (prod/ha)	Treatment	Product	Rate (prod/ha)	Product	Rate (prod/ha)	(DAE)[1]
None	Weedmaster® 540[2]	2.7 l	1	nil	-	nil	-	-
			2	Roustabout®/Sharpen®	3 l / 150 g	nil	-	-9
			3	Roustabout®/Sharpen®	3 l / 150 g	Arietta® mix[3]	200 ml	-9; 40
			4	nil	-	Arietta® mix[3]	200 ml	26
			5	nil	-	Callisto® mix[4]; Astound® Ultra	200 ml; 1.5 l	18; 40
Faba bean	Gramoxone®	4 l	1	nil	-	nil	-	-
			2	Roustabout®/Sharpen®	3 l / 150 g	nil	-	-9
			3	Roustabout®/Sharpen®	3 l / 150 g	Arietta® mix[3]	200 ml	-9; 40
			4	nil	-	Arietta® mix[3]	200 ml	26
			5	nil	-	Callisto® mix[4]; Astound® Ultra	200 ml; 1.5 l	18; 40
Gland clover	Weedmaster®[2] + Granstar®	2.7 l + 40 g	1	nil	-	nil	-	-
			2	Roustabout®/Sharpen®	3 l / 150 g	nil	-	-9
			3	Roustabout®/Sharpen®	3 l / 150 g	Arietta® mix[3]	200 ml	-9; 40
			4	nil	-	Arietta® mix[3]	200 ml	26
			5	nil	-	Callisto® mix[4]; Astound® Ultra	200 ml; 1.5 l	18; 40
Oats	Weedmaster® 540[2]	2.7 l	1	nil	-	nil	-	-
			2	Roustabout®/Sharpen®	3 l / 150 g	nil	-	-9
			3	Roustabout®/Sharpen®	3 l / 150 g	Arietta® mix[3]	200 ml	-9; 40
			4	nil	-	Arietta® mix[3]	200 ml	26
			5	nil	-	Callisto® mix[4]; Astound® Ultra	200 ml; 1.5 l	18; 40
Ryegrass	Weedmaster® 540[2]	2.7 l	1	nil	-	nil	-	-
			2	Roustabout®/Sharpen®	3 l / 150 g	nil	-	-9
			3	Roustabout®/Sharpen®	3 l / 150 g	Arietta® mix[3]	200 ml	-9; 40
			4	nil	-	Arietta® mix[3]	200 ml	26
			5	nil	-	Callisto® mix[4] (early); Astound® Ultra (late)	200 ml; 1.5 l	18; 40

[1] DAE = days after emergence. A –ve sign means the herbicide was applied prior to maize crop emergence.
[2] Applied with Pulse Penetrant® 0.1% v/v.
[3] Applied with Hasten™ 0.5% v/v.
[4] Applied with Synoil™ 1% v/v.

Results and discussion

Winter cover crops emerged about 15 days after planting and established well, except for gland clover which was slow. Cover crop yields prior to maize planting were 1.2 t DM/ha, 4.0 t DM/ha, 6.7 t DM/ha and 4.6 t DM/ha for gland clover, faba bean, oats and annual ryegrass respectively.

Winter cover crop kill by herbicides prior to planting the maize was effective, although some perennial white clover, ryegrass and multi-crowned broadleaved dock survived in faba bean plots treated with paraquat. The percent ground coverage of the cover crop residues after rolling and spraying of plots was assessed on 24 October 2016 and were 35% for clover, 43% for faba beans, 79% for oats and 80% for ryegrass. Fallow plots had 15% cover from dead weeds. Rapid breakdown of gland clover residue was observed in the first week following maize planting, with 11% of its residue remaining (Figure 8). Breakdown thereafter was gradual with 6% remaining at maize canopy closure 11 weeks after emergence (WAE). Oat and ryegrass cover crops showed little degradation, with the residue still providing a high level of physical cover over the soil (>70%) at maize canopy closure. Faba bean residues provided intermediate cover and the fallow treatment showed rapid breakdown of winter herbaceous weeds following spraying.

Maize emergence appeared to be complete by 10 days after planting in the fallow, clover and faba bean winter treatments; but emergence in the oat and ryegrass plots took a further five days.

Weed ingress was reduced, both by the presence of winter cover crop residues and by the herbicides used in the maize crop. Weed cover percentage of the fallow untreated plots (control) was variable, but showed a steady increase, reaching a mean of 51% ground cover at maize canopy closure. Average faba bean residue percentages across all herbicide treatments reduced both weed establishment and weed growth rates, with final weed covers around 22% by canopy closure. Ryegrass, oat and clover residues reduced weed ingress to only about 8-10% weed cover, compared to 85% in the fallow.

Weed counts in fallow untreated plots during the early establishment of the maize crop indicated that this site had low to moderate weed density (45 – 200/m^2) with the majority (86%) being broadleaf species. The main annual weeds present included prostrate amaranth (*Amaranthus deflexus*), redroot (*Amaranthus powellii*), wireweed (*Polygonum aviculare*), summer grass (*Digitaria sanguinalis*) and smooth witchgrass (*Panicum dichotomiflorum*).

All herbicide treatments used in the maize crop provided excellent weed control throughout the season with ≥98% control at maize canopy closure. No significant differences in rates of armyworm or slug damage, percentage weed control, silage yield or grain yield were found between herbicide treatments.

Observations of the number of emerged maize leaves and crop height showed that maize plants grown following the legume cover crops (gland clover and faba bean) generally had one or two more leaves and were slightly taller than those grown following oats and ryegrass, while maize grown in fallow land was intermediate.

Maize plants within plots of oat and ryegrass residues had significantly smaller leaf-7 areas than those in faba bean residue or fallow plots (Table 3). While a significantly higher level of slug damage was measured in the oat and ryegrass cover crop plots at V5 stage, this was not apparent by V11 stage.

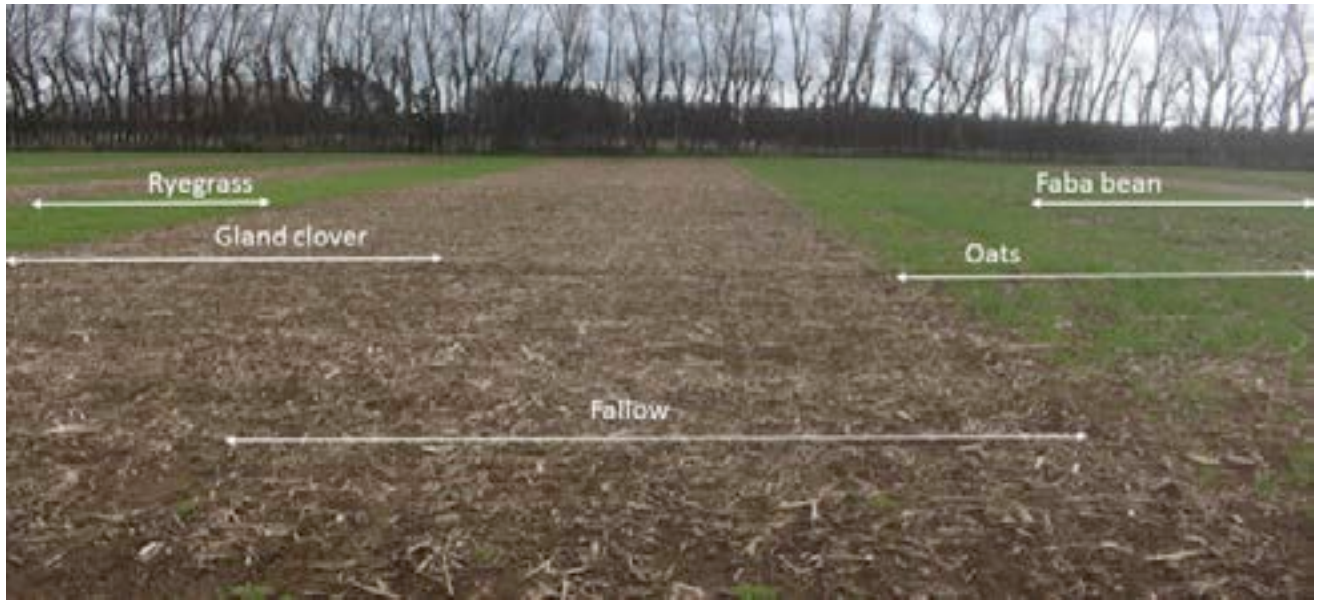

Figure 7. Established winter cover crop strips and fallow (12 August 2016) into which maize was subsequently sown (in spring 2016).

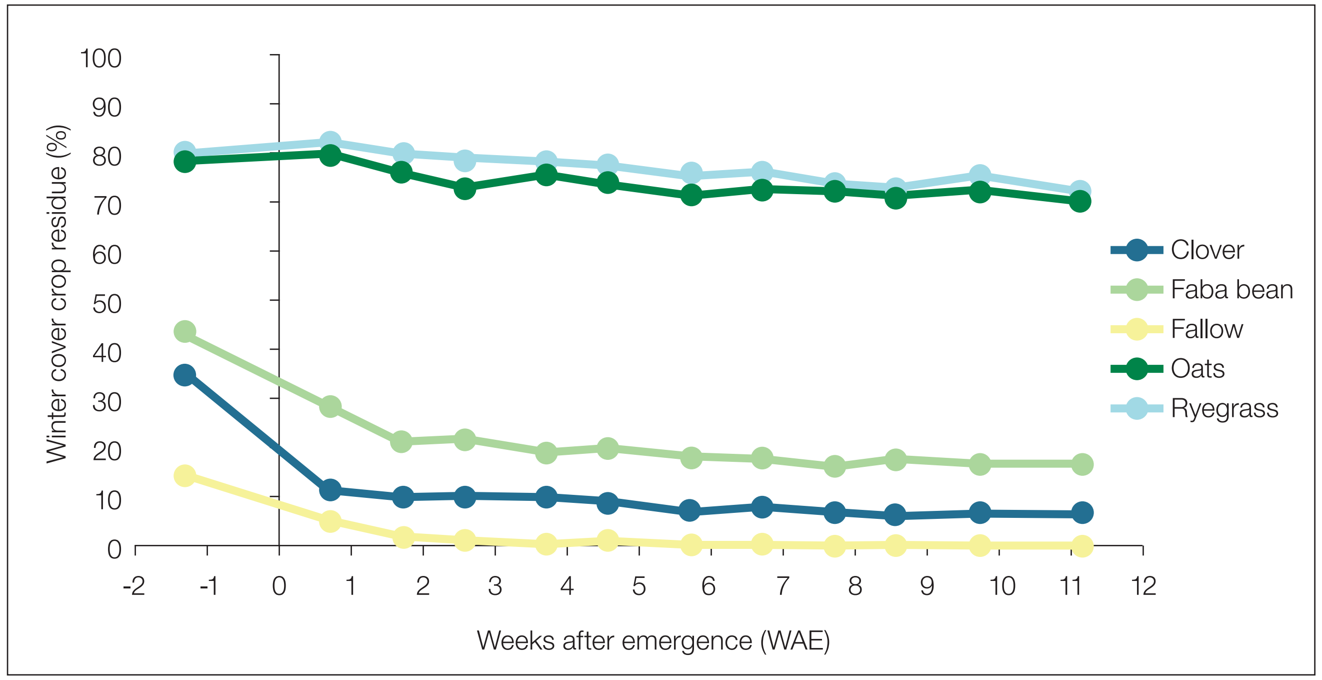

Figure 8. Weekly average winter cover crop residue ground covers (%), from maize planting to maize canopy closure (11 WAE). Maize emergence date was 6 November 2016.

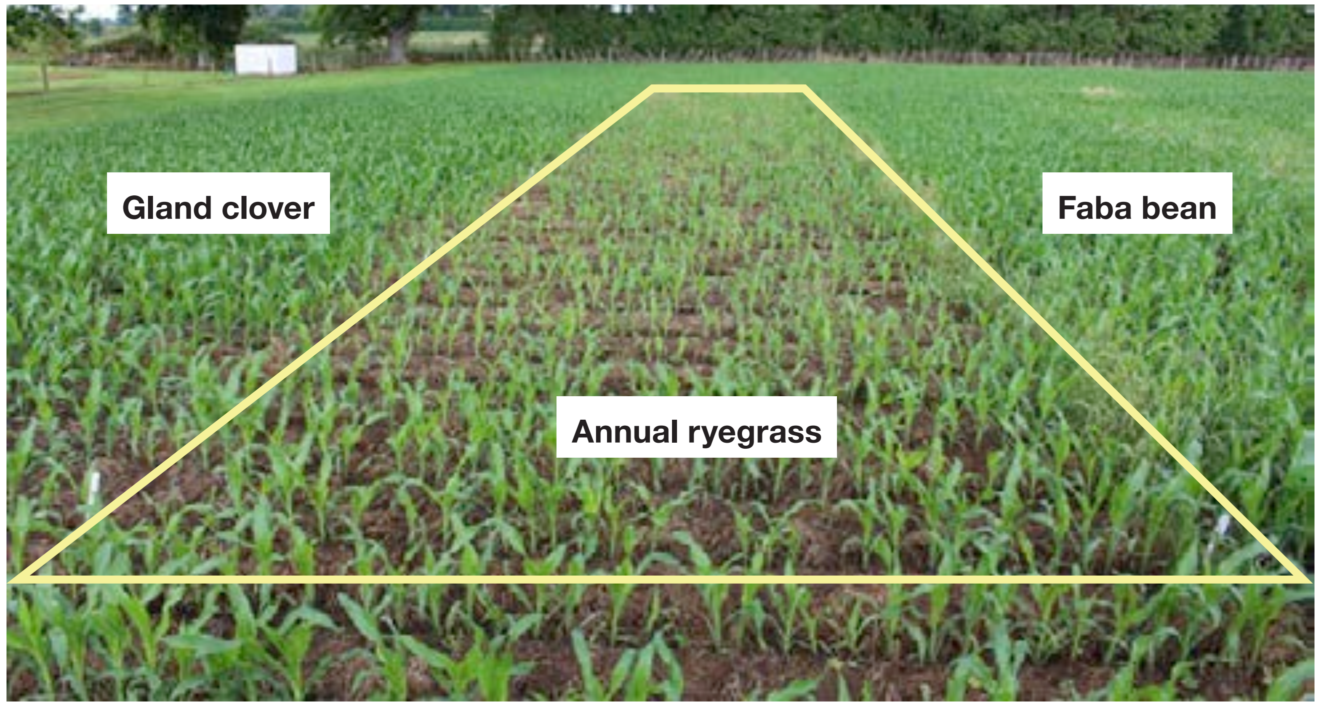

Figure 9. Maize growing through ryegrass residue (centre), compared to maize growing through clover residue (left) and faba bean residue (right). (9 December 2016, 5 WAE).

Table 3. Summary of cover crop effect on maize silage and grain production.

Cover crop	Leaf-7 area (cm^2)	Armyworm/ slug damage (%)	Silage population (plants/ha)	Silage DM (%)	Silage yield (t/ha DM)	Grain population (plants/ha)	Cob number /ha	Grain yield (t/ha)
Clover	301 ab	1.7 b	88 087 a	35.1 a	24.7 a	89071 bc	89508 ab	12.5 ab
Faba	312 a	4.1 b	87 650 a	33.6 ab	23.2 a	93989 a	93443 a	12.8 a
Fallow	309 a	1.2 b	86 120 ab	34.0 ab	21.5 ab	89399 b	87104 b	11.2 b
Oats	276 bc	14.5 a	84 153 ab	33.1 b	19.2 bc	83279 d	81421 c	9.4 c
Ryegrass	252 c	13.1 a	82 623 b	33.1 b	17.6 c	85246 cd	80656 c	8.3 c

Treatments followed by the same letter are not significantly different from each other (P<0.05).

Both silage and grain yield was influenced by cover crops, but not by herbicide treatment. Maize yielded significantly more DM and grain when grown in cover crop residues of legumes compared to residue from oats or ryegrass (Table 3). Maize following gland clover and faba beans produced the highest DM and grain yield, while maize following ryegrass the least, with the fallow treatment being intermediate.

In the fallow control plots with no pre- or post-emergent herbicide applied, silage and grain yield was unaffected by weeds. Maize plant populations were generally higher in the legume cover crop plots and plants also showed a potential to stay green longer. The plant population difference between treatments is not enough to account for the variation in yield. The number of cobs was significantly higher in legume cover crop plots compared to the oat and ryegrass plots, with fallow plots being intermediate.

Conclusions

Winter cover crops were effective in reducing weed ground cover in the maize plots, with 81-85% less at canopy closure in plots with residues of ryegrass, oats or gland clover than in the winter fallow plots. The plots with residues of faba bean had 57% less weed cover than the winter fallow plots.

Maize establishment and growth was slower in plots with residues of oats and ryegrass than in residues of gland clover and faba beans. Maize silage yields were significantly higher in plots with residues of gland clover and faba bean compared to oats and ryegrass, with fallow plots being intermediate. Similarly, gland clover and faba bean plots yielded significantly more maize grain than the oat and ryegrass plots. There was no difference in maize silage or grain yields between different herbicide treatments used in the maize crop, including the untreated plots.

Although the residues of gland clover had only 6% ground cover at maize canopy closure (compared to >70% in the case of oats and ryegrass), they provided the same amount of weed suppression. This could be due to allelopathic inhibition of some weeds by the clover. The slower development and lower yields of maize in the oat and ryegrass residue plots, could be due to low soil nitrogen availability (high C:N ratio of the residues); but also could be due to the slug damaged plants having delayed development (see page 34).

It is important to note that this trial was carried out at a site with low weed pressure, and the trial received adequate summer rainfall. We are repeating the trial in the 2017/18 season to see the effect of the treatments over multiple years, and with increased weed seed bank.

Clover cover crops under maize

Key points

- Managing established cover crops using herbicide application prior to no-till maize planting suppresses summer growth of the cover crop.
- Gland clover provided nitrogen to the subsequent maize crop.
- Yields from maize following gland clover with only 12 kg N/ha applied, and fully fertilised maize following ryegrass adjacent to the trial (110 kg N/ha applied) did not differ significantly.

Background

Direct drilling annual ryegrass into paddocks immediately after maize silage harvest is a regularly used practice in New Zealand. Annual and perennial clovers can also be used to follow maize, providing nitrogen and weed suppression for the following maize crop.

Objectives

Following a maize silage crop harvest in early March 2016, a cover crop trial was established to:

- Demonstrate maize establishment into different crop covers, after knock-down herbicide application.
- Evaluate weed suppression under different cover crops and knock-down herbicides.
- Demonstrate and measure reduced nitrogen input to maize following the use of clover cover crops.

Methods

On 10 May 2016, 12 m wide strips of five clover species were sown using a 3 m wide power-harrow, drill and roller. The clover species were:

- Annual ryegrass cv. Tama (25 kg/ha)
- Red perennial clover cv. Rubitas
- White perennial clover cv. Legacy
- Strawberry perennial clover cv. Palestine
- Gland clover cv. Prima

All clovers were sown at 6 kg/ha. No clover inoculants were applied, as they were not considered necessary for these varieties. The sowing date was later than anticipated due to the late arrival of seed from Australia.

On 7 September 2016, the clovers were sprayed with 3 l/ha Thistrol® Plus (MCPA and MCPB) to control broad leaf weeds that were starting to compete with the cover crops. On 20 September 2016, the gland clover began flowering and all species began to grow more rapidly with the warmer spring weather.

Figure 10. Gland clover at flowering.

On 25 October 2016, single quadrats from each of the clover and ryegrass plots were harvested, weighed and a dry matter sample taken for analysis. Soil samples for deep mineral nitrogen analysis (0-60 cm) were also taken from each plot (3 samples and combined).

Alternating 12 m wide strips of glyphosate (Weedmaster® TS 540 @ 3 l/ha + 100 mls/100 l Pulse) or Preeglone® Extra (@ 4 l/ha) were sprayed in 220 l/ha water at right angles to the cover crop strips on 26 October 2016, to try and suppress cover crop growth while the maize was establishing. Three replicates of each treatment were applied.

Figure 11. Gland clover treatment immediately after maize no-till planting.

On 27 October 2016, a John Deere MaxEmerge 2 planter was used to no-till plant maize, hybrid P9911 treated with Poncho® Plus, at 90,000 seeds per hectare. 100 kg/ha of YaraMila 12:5:14 starter fertiliser was the only fertiliser applied throughout the trial season to the cover crop plots.

At growth stage V3 (29 November 2016), two rows measuring 2.5 m were marked within each cover crop and replicate, maize plant populations were counted and plant damage (slug) noted. No slug bait was applied.

On 9 December 2016, the three outside rows of each 16-row plot were sprayed with post-emergence herbicides Arietta® (topramezone) @ 200 mls/ha + Atraflow™ (atrazine) @ 1l/ha, plus Hasten™ oil @ 100 mls/100 l to control some clover regrowth, as well as some weed emergence.

Observations continued throughout the season. Following black layer and dry-down, the 2 x 2.5 m row lengths previously marked were harvested for grain, shelled and weighed. Results were calculated to 14% moisture, and are given in Table 4. Immediately following harvest, the plots were soil sampled to 60 cm deep and mineral nitrogen levels were ascertained by Hill Laboratories.

Results

Table 4. Maize grain yield (t/ha @ 14% moisture) following different cover crops.

Treatment	Cover crop harvest 25 Oct 2016		Maize grain yield (t/ha)
	Dry matter (%)	Yield (t DM/ha)	
Annual ryegrass	19.8	5.0	4.6[1] 10.9[2]
Gland clover	22.2	1.7	10.1
Red clover	12.7	1.7	6.2
Strawberry clover	16.1	0.9	7.7
White clover	15.0	1.7	6.0

[1] no fertiliser
[2] full fertiliser

Population counts at growth stage V3 were very similar, at 87,000 to 89,500 plants/ha across all treatments and replicates, but the maize in the ryegrass plots was a growth stage behind and had fewer leaves with more slug damage present than on any of the other cover crops. All the clover cover crops showed no or very little slug damage, except for the white clover plots which recorded minor slug damage from V3 to V6 growth stages. No other pest damage was seen.

Table 5 compares maize yields from the two herbicide treatments, and the different cover crops. There was a difference between the two herbicides on the grain yield of the maize planted into the red a strawberry clovers, and the annual ryegrass, but not in the gland and white clovers. This yield difference was due to the difference in competition between the clover and the maize.

The application of Preeglone® or glyphosate was intended to knock back the cover crop sufficiently to allow the maize to flourish, and then the cover crops to slowly recover as maize senescence and dry-down occurred. However, this season, knock-down only occured in the gland clover, which was killed by both herbicide treatments. Being a contact herbicide, Preeglone® did not kill the annual ryegrass, which quickly recovered and then competed with the maize. The use of glyphosate to suppress the cover crops resulted in significantly higher maize yields than the use of Preeglone®, but the use of a post-emergent herbicide application as well as the glyphosate application resulted in no significant difference in subsequent maize yield (Table 6).

Table 5. Yield (t/ha @ 14 % moisture) of maize grain by herbicide treatment and cover crop.

Crop	Herbicide	
	Glyphosate	Preeglone
Annual ryegrass	7.2	2.0
Gland clover	9.7	10.6
Red clover	7.2	2.0
Strawberry clover	10.0	5.3
White clover	7.1	4.8

LSD 5% between herbicides, within each crop = 2.4.

Table 6. Maize grain yield (t/ha @ 14% moisture) with and without post-emergence herbicide applications across all cover crops.

Treatment	Grain yield (t/ha)
Glyphosate + post- emergence	8.3
Glyphosate alone	8.1
Preeglone® + post-emergence	6.0
Preeglone® alone	4.0
LSD 5%	1.3
CV%	10.0

Figure 12. Glyphosate treatment on the left and Preeglone® treatment on the right (note the recovery of the annual ryegrass in the foreground).

Discussion and conclusions

The fully fertilised maize following ryegrass plots yielded 10.9 t/ha, compared to 4.6 t/ha from maize with no fertiliser following the ryegrass plots. However, nil-fertiliser maize following gland clover yielded 10.1 t/ha, which is not significantly different from the fully fertilised maize following ryegrass. Therefore, we conclude that when terminated, gland clover can release sufficient nitrogen to grow a successful maize crop. Soil deep mineral nitrogen test results were inconclusive, with measurements ranging from 6-17 mg/kg across the treatments.

From observation and yield data, in this season, glyphosate was the most effective knock-down herbicide and being systemic, gave excellent termination of the annual ryegrass. Also note that the gland clover was completely terminated by both glyphosate and paraquat-diquat formulations. Had the spring been warmer, the maize canopy may have smothered the red and white clover treatments more successfully, but the conclusion is that these species are likely not to be the best options for a cover crop under maize.

Dry matter production from the clover treatments was poor compared to the annual ryegrass harvested just prior to maize planting on 25 October 2016 (Table 4). However, due to the late arrival of seed, planting was delayed until the cooler month of May 2016. Had planting occurred earlier, dry matter production is likely to have been much higher.

No slug baits were used on this trial, and it appears as though all the clovers had some suppressive effect on slugs when compared with ryegrass. The white clover however, exhibited less suppression than the other clover species.

All cover crop species provided excellent weed control, due to their mulch effect, but as stated earlier, the ryegrass, red and white clovers competed with the maize plants. Some dock and Californian thistles (both perennial weeds) survived.

Also of interest was that topramezone and atrazine herbicides only had a slight effect on clover species when applied post-emergence. More work is required to see what effect other herbicides have on cover crop species when applied post–emergence to maize crops.

The gland clover was the best performing winter cover crop of the species trialled, providing adequate nitrogen to the subsequent maize crop. There was no significant difference in maize yields between the gland clover plots and the fully fertilised maize crop following annual ryegrass.

Work is continuing on other species and further trials are currently being undertaken in the Waikato and Northland regions.

Annual clovers under maize observation plots

Key points

- No-till planting maize into unsprayed early maturing annual clovers appeared to have little effect on maize vigour.
- To get annual clover to re-establish in the second year without intervention, further research is needed.

Background

Research at NCRS has investigated a range of approaches to establishing cover crops in maize systems. This work is particularly important to situations where post-harvest drilling is difficult. One approach which may be worthwhile, is no-till planting maize directly into unsprayed annual clovers. Some annual clovers go to seed early in the summer season, which should limit competition with the maize. It is hoped that the clovers will re-establish without intervention the following autumn/winter.

Objective

To measure the vigour of maize no-till planted into various living annual clover stands, and observe whether annual clovers can regenerate independently within a maize-on-maize rotation.

Method

In mid-May (2016) three annual clover species were direct-drilled into non-replicated strips. Two herbicide applications were made to the clovers, MCPA/MCPB (Thistrol® Plus @ 3 l/ha) 7 September, and MCPA/MCPB (Thistrol® Plus @ 2 l/ha) and flumetsulam (Valdo® @ 130 gm/ha) 10 October. Maize was no-till planted into the clovers on 3 November. Due to high weed pressure, the trial was hand weeded 8 December.

Results and discussion

Gland clover and subterranean clover had moved into the reproductive phase by the time of maize sowing, and consequently provided little competition with the maize. While the gland clover produced a lot of seed, none was observed emerging the following autumn/winter. However, in another gland clover planting at NCRS, mature plants mown in early December resulted in a thick stand establishing over the following months.

Subterranean clover produced some seedlings in February 2017, following a January rain event, but few seedlings emerged subsequently. Visually, subterranean clover did not appear to be as vigorous as the two other clovers, however the dry matter yield does not reflect this (Table 7).

Arrowleaf clover was later (late October, November) than the other species to produce large quantities of biomass, which led to a very high level of competition with the maize crop. By the time the clover had finished flowering in mid-December the maize was very stunted. Despite shedding large quantities of seed, no seed germination or plant establishment of arrowleaf seedlings was observed.

Conclusions

No-till planting maize into living clover stands had little effect on maize vigour in the gland clover and subterranean clover plots, and there is the possibility that other annual clovers with early summer reproduction could be compatible with the approach.

However, clover seedling emergence was limited to a small number of subterranean clover seedlings. For this no-till planting in to living crops approach to work it is important for this issue to be understood.

Table 7. Clover dry matter yields before maize sowing.

Species	Sowing rate (kg/ha)	Yield (kg DM/ha)
Arrowleaf clover cv. Cefalu	5	2460
Gland clover cv. Prima	4	1970
Subterranean clover cv. Monti	8	1990

Sampled 28 October using 1 m x 1 m quadrat.

Figure 13. Maize seedlings in gland clover plot (photo taken 19 November).

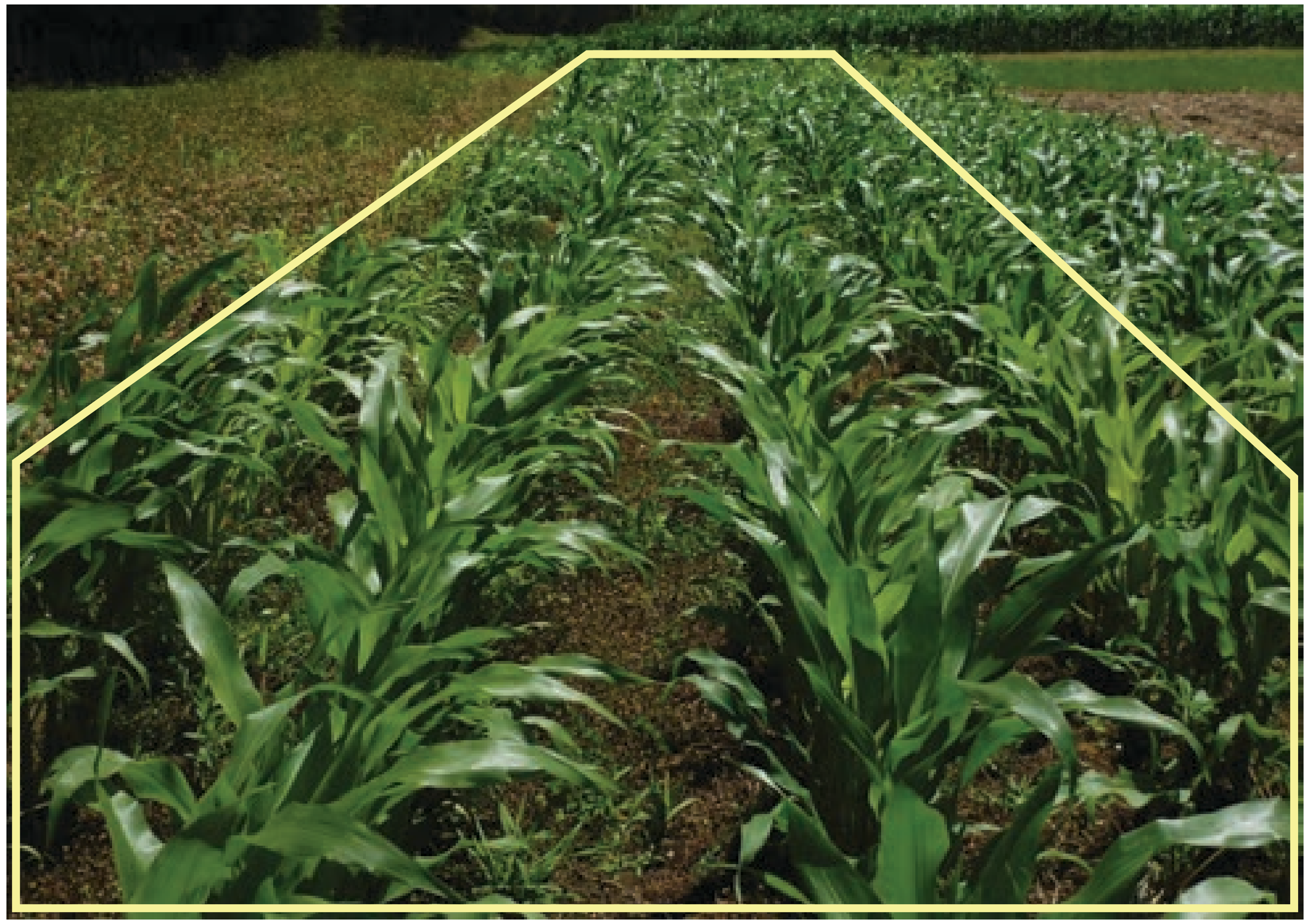

Figure 14. Difference in maize establishment in three annual clover plots (photo taken 24 December). (LHS) arrowleaf clover; Centre 4 rows, sub clover; (RHS) 4 rows, gland clover.

Inter-seeded cover crops and herbicides

Key points

- It is essential to understand different cover crop species and their interactions with herbicides.
- Existing seed drills can be easily modified to be used as inter-row seeders

Background

A range of winter cover crop options in maize systems are being investigated at NCRS. An important aspect of this work is to understand the interactions between inter-seeded cover crops and herbicides, especially for cover crops which are planted before maize canopy closure, for example around the maize V5 stage. In most situations cover crops are sown into paddocks which have been treated with pre- and/or post-emergence herbicides, therefore it is likely herbicide residues will still be present at sowing time.

Objectives

In most situations cover crops are sown into paddocks which have been treated with pre- and/or post-emergence herbicides, therefore it is likely herbicide residues will still be present at sowing time. A clearer understanding of the interactions between herbicides and cover crops could allow cover crop species selections to be based on the herbicide programme.

Methods

Two trials were undertaken involving inter-seeded cover crops. One focused on crop species and the other on herbicides. The species trial received pre-emergence only herbicide application of saflufenacil and acetochlor, while the herbicide trial included four pre-emergence herbicides trialed with five cover crop species. Results were not consistent and we hope to carry out further work to develop a greater understanding of the topic before sharing with growers.

Future work

A further herbicide and cover crop trial is planned for 2017. The trial has been altered to address some of the variables that affected last season's work.

We have recently acquired a drill which has now been set up for inter-seeding, providing the opportunity to carry out this work on a larger scale. This should allow greater consistency in establishment and more robust results.

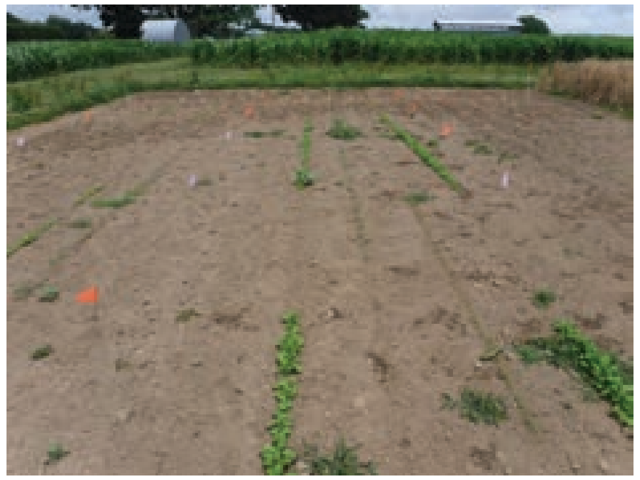

Figure 15. Cover crops and herbicides trial, where cover crops were planted in continuous strip through the herbicide treatments. Photo taken 9 January 2017.

Figure 16. Cover crop species trial, species in this mix include; common vetch, cv. unknown; chicory cv. Choice; and tillage radish cv. Lunch. Photo taken 30 May 2016.

Cool season cover crop performance trial

Key points

- In nitrogen limiting conditions, oats generated the greatest dry matter, while annual ryegrass produced considerably less.
- Compared to other species, the clovers produced limited quantities of dry matter, however their high feed quality could increase their value.

Background

Cool season cover crops have the potential to provide a range of benefits on cropping farms. These include: winter grazing, baleage/silage production, reduced nutrient and sediment losses, and improved soil quality. The range of potential cool season cover crop species is increasing, but there is a lack of knowledge about the performance of some species in New Zealand conditions. More information is required on dry matter production of new species such as annual clovers.

Objective

To generate cool growing season dry matter accumulation data for a range of current and newer cover crop species based on mid-April and mid-May sowing dates.

Methods

On 15 April and 12 May 2016 eleven monoculture and one polyculture species treatment were hand sown with a rake. Treatments were replicated four times, dry matter (DM) harvests were taken on three dates using a 0.5 m x 0.5 m quadrat (sampling was carried out in a different place each time) over the duration of the trial, with the trial ending 30 September 2016.

Table 8. Species and sowing rates.

Species		Sowing rate (kg/ha)
Subterranean clover cv. Monti		12
Persian clover cv. Lusa		6
Alsike clover cv. Hytas		6
Red clover cv. Rubitas		8
Gland clover cv. Prima		6
Crimson clover cv. Blaza		10
White lupin cv. Promore		90
Faba bean cv. Ben		240
Oats cv. Milton		100
Annual ryegrass cv. Tama		22
Arrowleaf clover cv. Cefalu		6
Mix	Oats cv. Milton	50
	Faba beans cv. Ben	110
	Red clover cv. Rubitas	3

April and early May provided dry conditions at NCRS, causing delayed germination of some species, and affecting establishment.

Soil testing in April 2016 revealed nitrogen (N) levels were relatively low, with 22 kg N/ha present in the top 15 cm of soil in plant-available forms. No N applications were made in this trial, therefore nitrogen fixing species should have had an advantage over non-nitrogen fixing species.

Rhizobia inoculum was not applied, as a range of clover species have been grown successfully at NCRS in the past.

Results and discussion

Due to the dry conditions around the April sowing germination was uneven. Drilling may have led to improved establishment, particularly of the large seeded species. As an indication of effect this had on establishment, ten out of the fourteen species (including three species within the mix) had greater rates of establishment in the second sowing than in the first.

Many clover plants struggled during winter, exhibiting purple and red discolouration, and ultimately many died. The clovers were very small coming into winter, increasing the risk of them being killed by pests, disease or adverse soil conditions.

Overall, a large amount of dry matter was accumulated between the second and third dry matter harvest, particularly from the May sown plots. The April sown plots had established before growth slowed over winter and did not suffer as badly from winter purpling and plant loss.

In the April sown plots, the mix treatment produced the greatest yield at 9.2 t DM/ha. Of this, 91% consisted of oats, followed by faba beans at 8% and red clover at 1% (Figure 17). In the final cut from the May sown plots, the oat treatment produced the greatest yield (6.4 t DM/ha), followed by the mix treatment (5.6 t DM/ha). Again, the bulk of the dry matter in the mix treatment was produced by oats (89%), followed by faba beans (7%) and red clover (4%) (Figure 18).

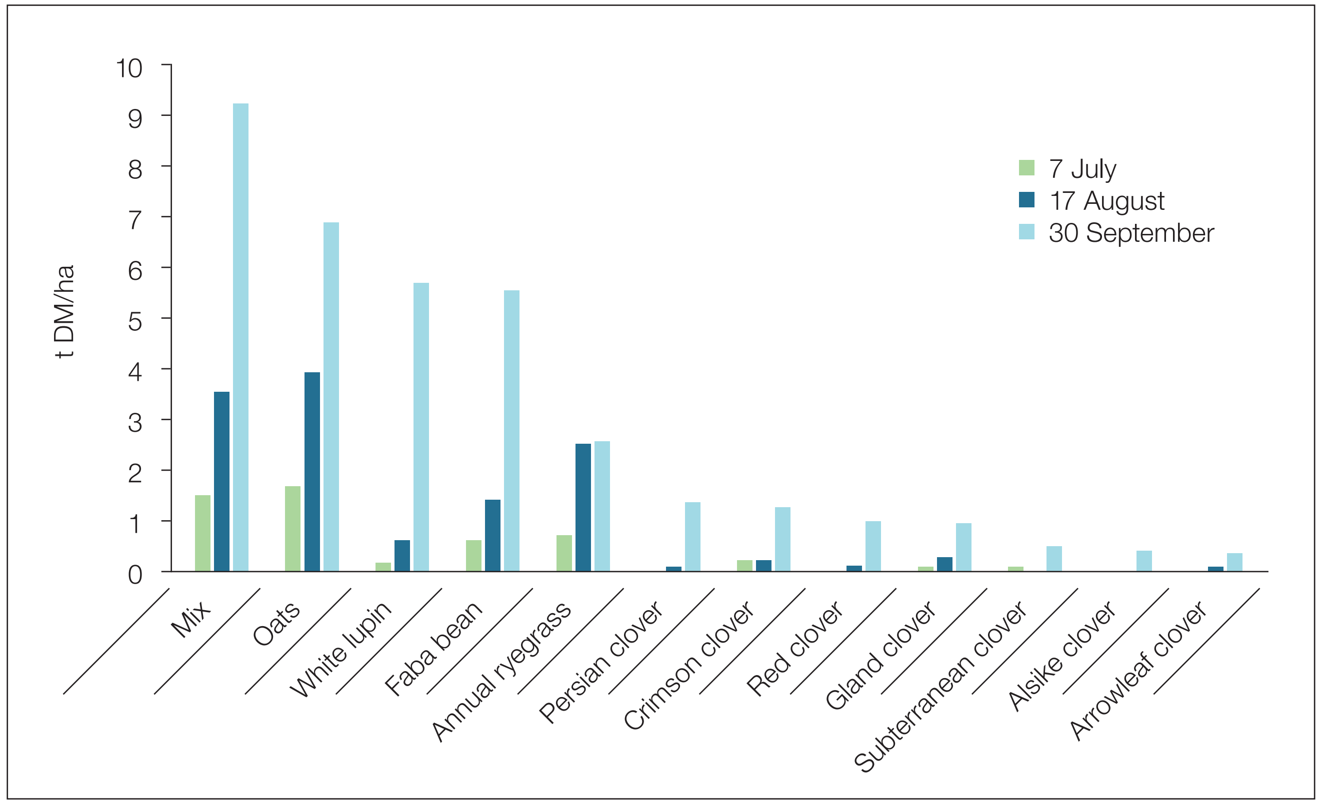

Figure 17. Dry matter yields from cover crop sowing one (15 April 2016). Least significant difference (0.05) DM cut 1, 0.59; DM cut 2, 1.9; and DM cut 3, 4.44.

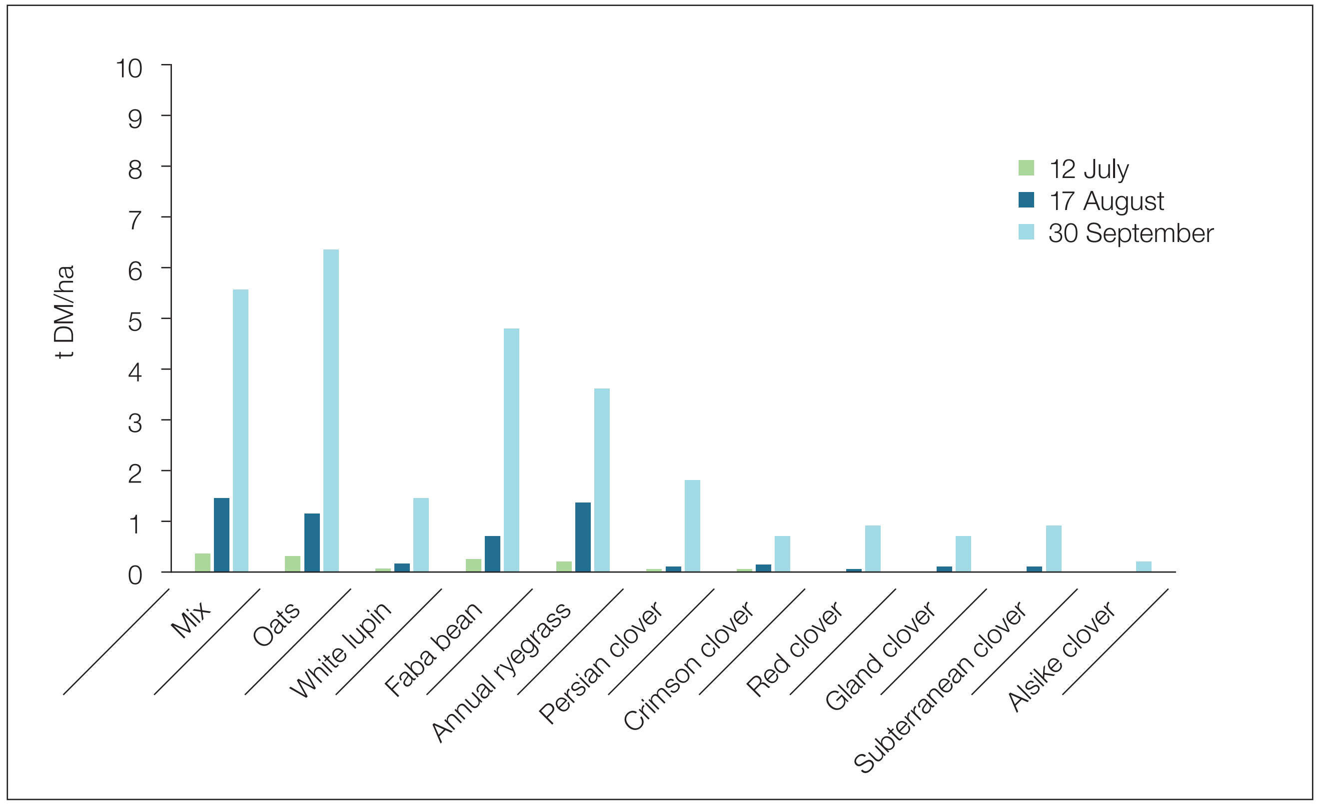

Figure 18. Dry matter yields from cover crop sowing two (12 May 2016). Least significant difference (0.05) DM cut 1, 0.24; DM cut 2, 0.94; and DM cut 3, 3.13.

Annual ryegrass exhibited chlorosis (leaf yellowing) and did not yield well, probably due to low soil N levels. The 2017 cover crop performance trial has received nitrogen which should benefit non-nitrogen fixing species, and provide a contrast to the trial discussed in this report.

Overall, clover yields were less than the large seeded legumes, oats and annual ryegrass. However, as clovers produce a high-quality feed, and fix N which will be available for the next crop, this may compensate for the reduced yield from a grower perspective.

Several annual clover species are available and for the 2017 trial, clovers which exhibit early season growth or high dry matter production have been selected.

Oats produced the greatest quantity of dry matter in the mixture. In the future, sowing rates could be adjusted to allow greater legume production. In this trial, faba beans may have established better if they had been sown with a drill rather than raked in. Dry weather around the April sowing could also have contributed to a reduced faba bean establishment. Red clover was largely outcompeted by the two other species in this mixture. Reducing the oats and faba bean sowing rates would have improved red clover establishment, also further work (not reported here) indicates red clover (cv. Rubitas) produced greater dry matter in October/early November in Waiuku.

Conclusions

Based on these results, many changes have been made to the 2017 cover crop performance trial:

- Fewer clover species.
- Vetch, ryecorn, turnip and balansa clover have been added.
- The mix plot was changed to include oats, faba beans, vetch and tillage radish.
- Nitrogen fertiliser was added.
- Three sowing dates (March, April and May).

In the future, it is likely that research will be more focused on species for specific uses. Areas of interest could include species for high feed values, no till situations and reducing N leaching.

The area of species mixtures is attracting a lot of interest and it is likely this work will increase. Topics of particular interest include establishment and sowing rates, C:N ratios of cover crop residue in no-till systems and cover crop termination.

Figure 19. Example of a mixed plot, April sowing. Photo taken 29 September 2016.

Figure 20. Cover crop performance trial. Photo taken 29 September 16.

Long term maize cultivation/crop establishment trial

Key points

- No significant difference in yields of maize between treatments using full cultivation, strip till and no-till techniques.
- The no-till established maize generated significantly more profit than the full cultivation treatment.

Background

Cultivation practices can strongly influence important soil processes, which in turn can affect the sustainability and profitability of arable cropping systems in both the short and longer term. There are many reasons to decrease cultivation, including reduced establishment costs, retention of soil moisture, improved soil structure, less carbon loss, reduced soil erosion and the limiting of soil compaction. While the benefits of reduced cultivation are generally well accepted, such approaches have been applied with varying success and limited uptake by maize farmers in New Zealand.

In 2008, FAR established a long-term crop establishment trial at the Northern Crop Research Site (NCRS) to support the development and adoption of reduced cultivation and establishment practices for successful maize production. Three cultivation practices were being considered in this ongoing trial, including full conventional cultivation (FC) and two forms of reduced cultivation, strip till (ST) and no-till planting. Each year incremental improvements have been made to the technologies associated with ST and NT, and key agronomic issues have been resolved. In 2014, a new expressway was built which resulted in the loss of two replicates of this long-term trial and this trial was abandoned in 2015. A new long-term crop establishment trial comprising of four replicates of the three treatments was established in 2014. This report will examine the findings of the new LTC trial but still consider the findings from the old LTC trial.

Objective

The aim of the trial is to compare the effectiveness of conventional tillage, strip tillage and no-till planting on the establishment and subsequent crop performance and profitability of maize each year, and their long-term effects on soil quality.

Method

The entire trial area (approximately 1 ha) was sprayed with 2.5 l/ha of Glyphosate 540 in September 2016. This killed the annual ryegrass cv. Tama that was planted following the previous maize harvest, and any weeds present. Strip-tilling was carried out with two passes of a SoilWarrior® cultivator in mid-September 2016. In late September, the conventional cultivated plots were disc ripped and just prior to planting, power harrowed. The trial was planted on 18 October 2016 with an 8 row John Deere MaxEmerge planter equipped with residue removers and reduced inside diameter gauge wheels suited to both no-till planting and planting into cultivated soil.

The trial comprised four replicates each of eight row strips of maize with the three cultivation treatments. These strips were 97 metres long, arranged in a random order, with eight rows at the edge of the block as buffers. Row spacing is the standard 762 mm (30 inches).

At planting, 150 kgs/ha of Nitrophoska® Extra (12:5:14 +Mg + trace elements) starter fertiliser was placed 50 mm to the side and below the maize seed (Pioneer hybrid P9911, Poncho® Plus treated) at a population of 90,000 seeds/ha. On 19 October 2016, pre-emergence herbicides saflufenacil (Sharpen® at 150 gm/ha) and acetochlor (Roustabout® at 3 l/ha) were applied using a 12 m boom equipped with AI nozzles and calibrated to 220 l water rate/ha.

Plant counts were undertaken following maize seedling emergence. Prior to harvest soil bulk density samples were taken from the surface 5 cm, dried, weighed and results recorded.

Following grain black layer and plant dry down, the strips were harvested and weighed into a weigh wagon. Samples were analysed using a Dickey John GAC 2100 Agri moisture meter.

Results

Table 9. Final maize emergence counts on 10 November 2016 (means of all replicates).

Full cultivation	92,000 plants/ha
Strip tilled	92,500 plants/ha
No-till planting	90,000 plants/ha

Planter population was set at 90,000.

Table 10. 0-10 cm depth soil bulk density on 2 June 2016 (means of all replicates).

Cultivated	0.81 kg/l
Strip tilled	0.88 kg/l
No-till planting	0.90 kg/l

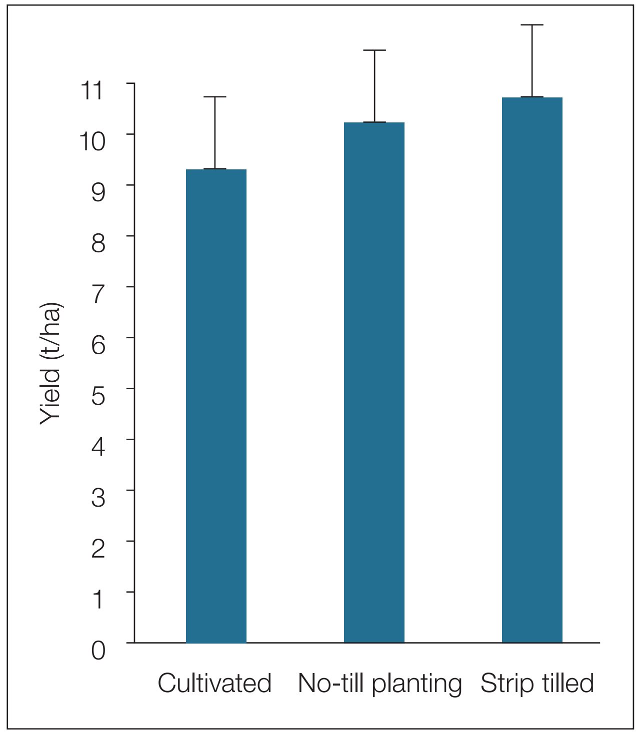

Figure 21. 2016/17 maize yields at NCRS LTC trial. Note the bar in cultivated plots showing the variation in yield within the replicates.

Figure 22. 2016/17 maize yields at NCRS LTC trial. The mean was 10.06 t/ha. LSD 5% = 1.76. CV% = 10.1. There was no significant difference due to the high CV.

Table 11. Grain yield from different crop establishment treatments (t/ha @14% moisture) from previous and current seasons.

	Cultivation and planting costs 2016/17 ($/ha)	New trial 2016/17	New trial 2015/16	New trial 2014/15	Old trial 2008-2015
Full cultivation	$500	9.3	12.1	10.5	11.8
Strip till	$370 (2 pass)	10.7	12.4	10.3	11.2
No-till planting	$150	10.2	10.9 (2 reps)	9.4	12.0

Discussion and conclusions

Before 2014/15 the new trial site had been cultivated for 15 years. Overseas research suggests at least a four-year period for no-till crop establishment to create a new equilibrium in soil state. This may explain some of the lower yields recorded in this treatment in the previous seasons. However, in 2016/17, yields from both the no-till planting and strip till treatments were trending higher than the cultivated treatments (note a high coefficient of variation (CV) shows no significant difference). Rainfall was below average in December and January (see front of booklet for data) and we know from previous research that by not cultivating there is a 3% saving in soil moisture compared to cultivating at the NCRS site. This is likely to have been another contributing factor to the higher yields of the non-cultivation treatments.

Although the start and finish of the season were very wet, most of the growing season was dry. In seasons like this, variations in soil texture and water-holding capacity across a paddock may be highlighted. This, coupled with some variation in weed infestation, may help to explain the large variation between replicates (8.34 - 9.96 t/ha cultivated replicates and 8.54 - 11.83 t/ha for no-till planting replicates) and the high CV% of 10.1.

Cost wise, no-till planting saves at least $300/ha (including the cost of slug baiting) while maintaining yields.

Figure 23. Maize no-till planted into annual ryegrass.

Fungicide use in maize

Key points

- There was no significant difference in yields between the treatments with or without fungicide.
- Growers should choose a maize hybrid that is known to have resistance to leaf diseases.
- Fungicide application at VT reduced leaf disease but did not increase yield.

Background

Significant benefits in maize grain yields were obtained using fungicides in the previous two seasons in trials at NCRS, despite very low disease pressure from Northern Corn Leaf Blight (NCLB) and common rust.

Objectives

1. Gather further data on fungicide efficacy on maize in New Zealand conditions.
2. Evaluate the effect of ThermoPhos on disease pressure and fungicide efficacy.
3. Evaluate the effect of fungicide applications on a range of maize hybrids with different disease susceptibilities.

Methods

The trial paddock was previously harvested for maize silage. Potassium levels were low (0.3 me/100 g) and 700 kg/ha serpentine potassic super was applied on 12 September 2016. The trial paddock was then ploughed and in mid-October cultivated by a spring-tine cultivator. On 20 October, 10 m long plots were marked out, denoting the four randomised replicates of the five treatments:

1. No spray (control).
2. Spray at V7 growth stage.
3. Spray at VTassel (VT) growth stage.
4. ThermoPhos soil treatment.
5. Spray fungicide at both growth stages.

ThermoPhos contains 8% phosphorous and high levels of silica, which is known to improve plant defence mechanisms against disease in other plant species. Following marking out, the ThermoPhos was applied at 500 kg/ha, and the whole trial area was spring-tine cultivated again. On 28 October four rows of maize hybrids with varying disease resistance (Table 12) were planted using a four row John Deere MaxEmerge 2 precision planter @ 90,000 seeds/ha.

Starter fertiliser of 150 kg/ha YaraMila™ 12:5:14 was applied at planting and pre-emergence herbicides saflufenacil (Sharpen® @150 g/ha) and acetochlor (Roustabout® @3 l/ha) were applied by 12 m boom the following day. 200 kg/ha of Sustain® was broadcast on 6 December 2016, at growth stage V3 to V4.

The growth stage V7 fungicide treatments were applied on 20 December 2016 using a boom sprayer fitted with air induction nozzles and calibrated to 220l/ha water rate. The growth stage VT spray was applied on 17 January 2017 just prior to tassel for most hybrids, using a CO_2 powered backpack with an air induction nozzle high clearance mini-boom. For each spray treatment, the spray applied was a combination of the fungicides pyraclostrobin (Comet® at 1 l/ha) and epoxiconazole (Opus® at 1 l/ha).

The 2016/17 season was wet until mid December, dry through January and very wet again in late February.

On 13 February 2017, 10 adjacent plants in each of the treatment plots were scored for leaf disease by examining the leaves above and below the cob.

Table 12. Disease ratings of hybrids planted at NCRS trial site on 28 October 2016.

Hybrid	Source	CRM	NCLB rating[1]	Rust rating[1]
P0791	Genetic Technologies	107	5	7
39T45	Genetic Technologies	84	6	4
P9911	Genetic Technologies	99	5	5
PAC230	Pacific Seed	98	7	5
N51-N4	Corson Maize Seed	104	7	7
Afinity	Corson Maize Seed	100	6	6

[1] Disease resistance ratings range from 1 (low) to 9 (high). All companies use their own ranking systems.

Following black layer and dry down, 2 x 2.5 m central rows in each plot were hand harvested, shelled, weighed and moisture content determined in a Dickey John GAC2100 Agri moisture meter.

Results

The main leaf disease was common rust (*Puccinia sorghi*), and there was no clear difference between the percentage of leaf disease shown on the leaf above and below the cob, and therefore the results were combined prior to analysis. Disease scores are shown in Figure 24. The control and ThermoPhos treatments had similarly higher levels of leaf disease compared to the VT and both timings applications. There was a rapid increase in leaf disease in late February, however, by this time, many of the hybrids with shorter CRMs were almost at physiological maturity, black layer. After this point any leaf disease would not affect yield.

Table 13 shows maize grain yield (t/ha at 14% moisture) for each hybrid and treatment in the trial.

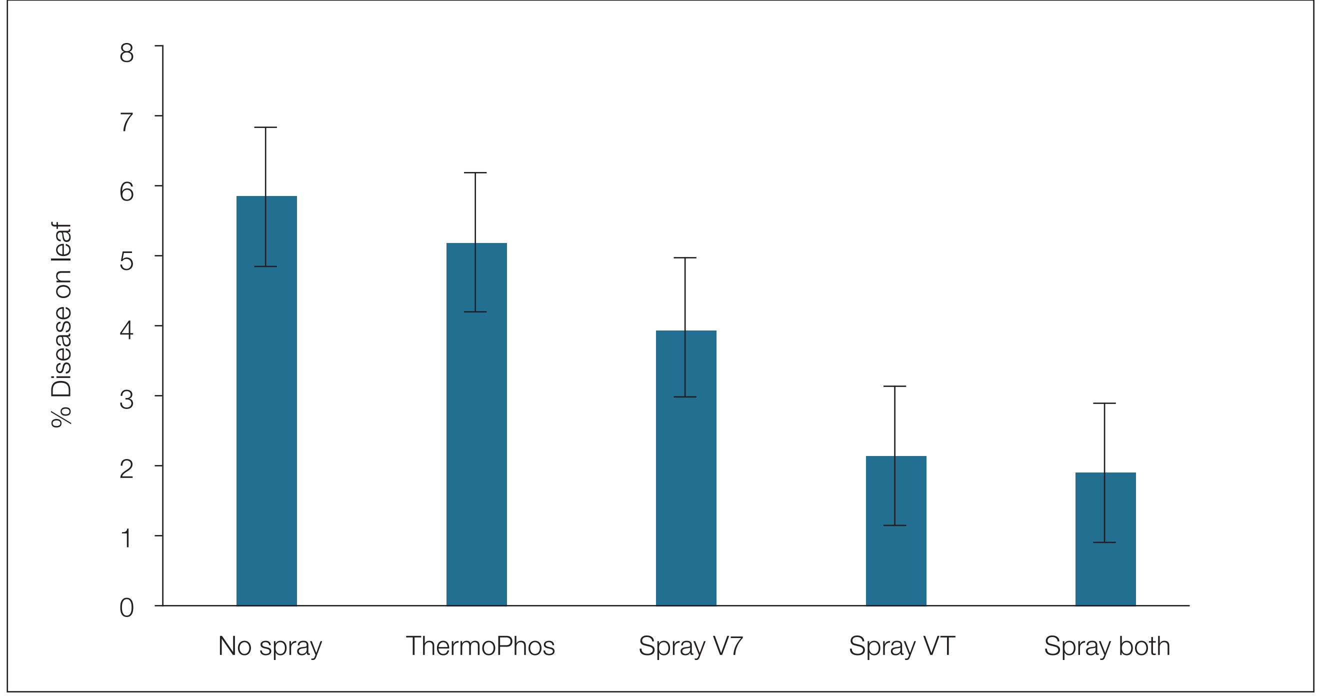

Figure 24. Percentage of leaf disease scores for all hybrids by treatment. Bar shows LSD @ 5%.

Table 13. Maize grain yield by hybrid and treatment (t/ha at 14% moisture).

Treatment	Hybrid					
	PAC230	39T45	Afinity	N51-N4	P0791	P9911
No Spray (Control)	11.8	10.3	11.3	12.1	12.3	8.6
ThermoPhos	9.7	10.0	10.4	11.5	11.3	9.0
V7	10.5	9.4	11.1	12.7	11.7	10.3
VT	11.6	10.7	11.0	12.0	11.9	10.8
Both	11.2	10.6	11.2	12.7	12.6	9.4
Mean	**11.0**	**10.2**	**11.0**	**12.2**	**11.9**	**9.6**
LSD 5%	**1.65**	**1.41**	**1.87**	**1.83**	**2.76**	**2.46**

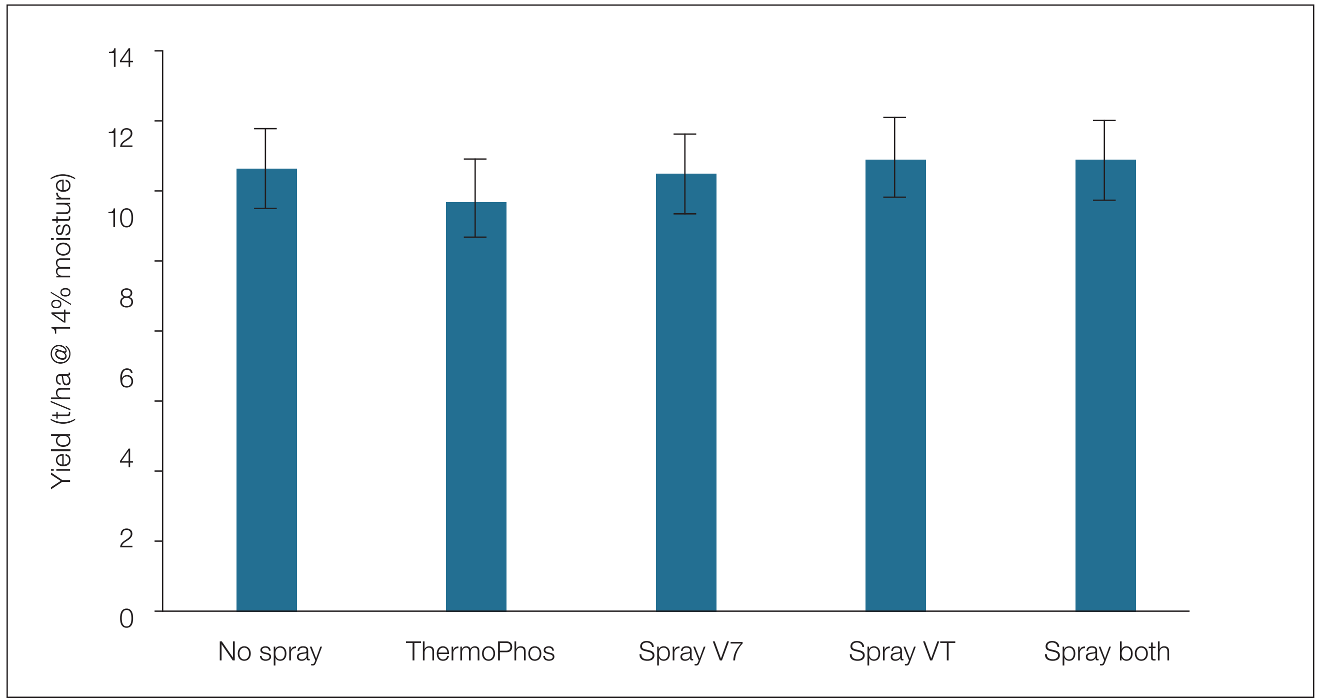

Figure 25. Maize grain yields for all hybrids and by treatment. Bar shows LSD @ 5%.

Figure 25 shows that in the 2016/17 season there was no statistical difference in yields between the treatments, when averaging hybrid results.

Discussion

In the 2016/17 season the main leaf disease present was common rust, with Northern Corn Leaf Blight (*Exserohilum turcicum*) only present at very low levels. The leaf disease scores measured suggested that all the three fungicide treatments, especially the two application treatments, had some effect on the disease incidence in the maize plants. There was no significant effect of the fungicide sprays on maize yield, contrary to several fungicide trials over the past 12 years, which have shown a significant yield increase of fungicide sprayed treatments over the unsprayed controls.

Conclusions

Results from several FAR fungicide trials on maize over the past 12 years suggest that:

1. Choosing a resistant hybrid is the most effective insurance against yield loss from leaf diseases.
2. Crops should be monitored regularly for leaf diseases throughout December (V6 onwards) to enable timely fungicide applications if weather is conducive to disease (warm and humid).
3. Late planted maize crops planted adjacent or close to early-planted crops are much more vulnerable to leaf diseases.
4. Don't apply fungicides until the ear leaf is visible (normally V12-13) and preferably fully exposed. High clearance ground sprayers or aerial spraying will be required.
5. There is seldom an economic return from applying fungicides at or after silking.
6. If dry conditions prevail during the flowering period, fungicides applied pre-tassel may provide a yield advantage by improving pollination. Some international research as shown that strobilurin/ QoIs fungicides can improve water and nitrogen use efficiency, delay senescence and improve stalk strength.
7. A single fungicide application at VT appears to be the most cost effective.
8. High water rates (200+l/ha) are more effective at protecting a large leaf area that is not necessarily at the top of the canopy.

As with all agrichemicals, it is important to read labels and observe withholding periods, especially for maize silage feed for stock.

Slow release nitrogen fertilisers in maize

Key points

- All nitrogen fertiliser treatments resulted in a significant increase in maize grain yield when applied to soil containing 58 kg/ha N.
- The timing of nitrogen application did not affect yield.
- Slow release nitrogen fertilisers resulted in the same yields as urea nitrogen fertilisers.
- Slow release nitrogen fertilisers could be a viable alternative to urea if product prices were comparable.
- Slow release nitrogen fertilisers may result in less nitrogen losses due leaching and volatilisation.

Background

Nitrogen (N) is the nutrient most often added to cropping systems, and it represents a large cost to New Zealand farmers. If not optimally managed, the application of inorganic urea nitrogen fertiliser can readily result in N volatilisation and N leaching. Using a true slow release N fertiliser may reduce the risk of volatilisation and leaching while providing the maize crop with sufficient available N, at least maintaining productivity. Vi-Ag Haracoat™ PSCU and Ballance Smartfert® are made by coating urea with sulphur and polymer coatings, which then determine the product's nitrogen release characteristics.

Slow release fertilisers are about 50% more expensive than urea, but it is possible that less N supplied as a slow release fertiliser will result in the same productivity as more N applied as urea. Slow release fertilisers are only applied once with planting, which reduces machinery/labour inputs to the crop and potential crop damage and minimising weather factors.

In a trial in 2015/16 Season, we found that Haracoat™ PSCU37 appeared to have greater nitrogen use efficiency (NUE) than urea.

Objective

This trial assessed the effect of different N fertilisers on maize grain production at NCRS.

Methods

The paddock was ploughed and spring-tine cultivated prior to planting. Deep mineral N tests were taken to 60 cm deep in September 2016 and found 58 kg N/ha. The AmaizeN calculator calculated that an additional 142 kgN/ha was required for an expected grain yield of 13 t/ha. All other plant nutrients were in excellent supply. Maize hybrid P9911 with Poncho Plus® seed treatment was planted at 90,000 seeds per hectare on 3 November 2016.

The treatments received identical crop management until harvest i.e. pre-emergence herbicides sprayed on 5 November 2016, using 150 g/ha saflufenacil (Sharpen®), 1 l/ha glyphosate and 3 l/ha acetochlor (Roustabout®) at 220 l/ha water rate applied through AI nozzles at 4 bars pressure on a 12 m boom sprayer. Leaf N tests were carried out on 15 February 2017.

Following black layer and dry down, 2.5 m of the centre two rows of each treatment plot's cobs were harvested, shelled and weighed. Moistures were measured and results converted to the standard grain yield at 14% moisture. Deep mineral N soil tests (0 to 90 cm) were also taken. The gross margin was calculated from the increased grain yield of the treatment over that of the control multiplied by the value of the grain ($350/tonne was used). Return on Investment (ROI) was calculated from the gross margin/cost of inputs (fertiliser + application).

Treatments

Six N fertiliser treatments were compared to controls with no N fertiliser added. AmaizeN was used to calculate recommended N application rates.

1. DAP + SustaiN - 100% of recommended N (60% N as starter (440 kg/ha DAP)/40% N as side-dress (110 kg/ha SustaiN).
2. SustaiN 162 (urease inhibitor N product, Ballance) - 55% of recommended N (162 kg/ha).
3. SustaiN 270 - 100% of recommended N (270 kg/ha).
4. Smartfert® (Slow release product (44% N, 90 day release), Ballance) - 85% of recommended N (270 kg/ha).
5. Haracoat™ PSCU 32 (slow release product (32% N/25% S, 120 day release) - 85% of recommended N (390 kg/ha).
6. Haracoat™ PSCU 37 (slow release product (37% N/15% S, 90 day release) - 85% of recommended N (340 kg/ha).

For each treatment, four replicates were conducted in a randomised layout.

Measurements

The following measurements and assessments were undertaken:

- Soil mineral N tests prior to planting to establish N requirement.
- Deep mineral N test at planting (one composite sample of three cores from trial site).
- Leaf N.
- Maize grain yield (t/ha @ 14% moisture).
- Deep mineral N at harvest (7 June 2017)
  - 0-30 cm
  - 30-60 cm
  - 60-90 cm

Results and discussion

The trial site experienced high rainfall over the maize growing season, as shown in Figure 26. However, most of this rainfall occurred after the period of greatest N uptake by the plant so leaching was unlikely to have been an issue. All fertiliser treatments resulted in significant increased grain production in maize, as shown in Table 14 and Figure 27. Slow release N fertilisers were as effective as urea N products. SustaiN at 55% of the AmaizeN calculated N gave similar results as the 100% SustaiN treatment.

Nitrogen use efficiency (NUE) was calculated by dividing the increase in grain yield by the increase in N application. It was similar for all fertiliser treatments, except for the SustaiN 162 treatment which had only 55% of the required N applied, giving a NUE of 72 kg/kg as compared to 39-46 kg/kg for other fertiliser treatments (Table 14). The additional N applied in other treatments was not accounted for in the soil N levels at harvest. This N may either have been present in the maize stover, or may have leached out of the soil due to the high rainfall experienced in the 2016/17 season.

Due to increased grain production, all fertiliser treatments resulted in a margin of more than $1,700/ha over the control (Figure 28), with no significant differences between the fertiliser treatments.

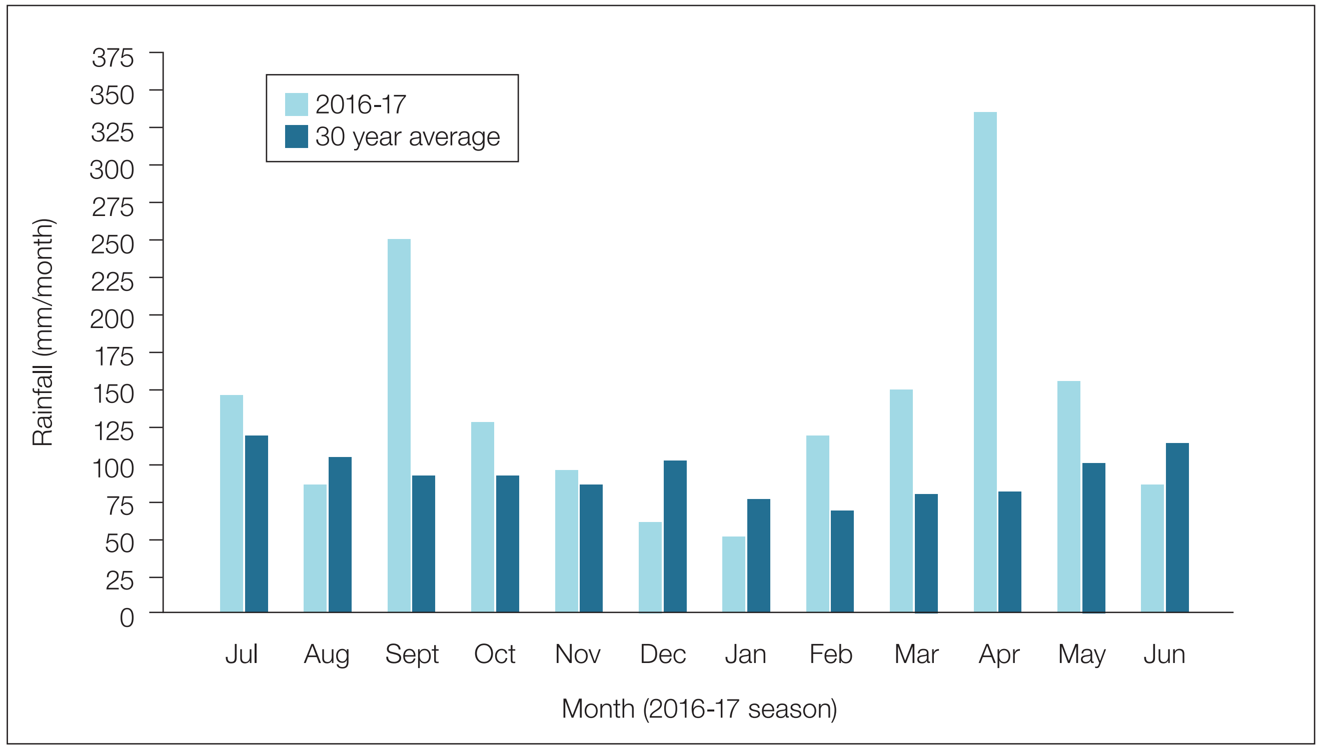

Figure 26. Monthly rainfall for Northern Crop Research Site 2016/17.

Table 14. Yield and nitrogen use efficiency (NUE) for different fertiliser treatments.

Treatment	Leaf N at silking (%)	Soil N levels at harvest (kg/ha)			
		0-30 cm	30-60 cm	60-90 cm	0-90 cm
Control	1.28 a	22.2	17.7	10.2	50.2
DAP + SustaiN	1.58 ab	29.2	30.6	17.7	77.4
SustaiN 162	1.98 c	21.0	19.0	18.3	58.4
SustaiN 270	1.75 bc	19.7	21.0	14.3	55.0
Smartfert®	1.80 bc	26.5	17.7	12.2	56.4
PSCU 32	1.98 c	23.8	26.5	21.0	71.3
PSCU 37	1.90 bc	23.8	21.0	19.0	63.8
LSD (5%)	**0.35**	**nsd**	**nsd**	**nsd**	**nsd**

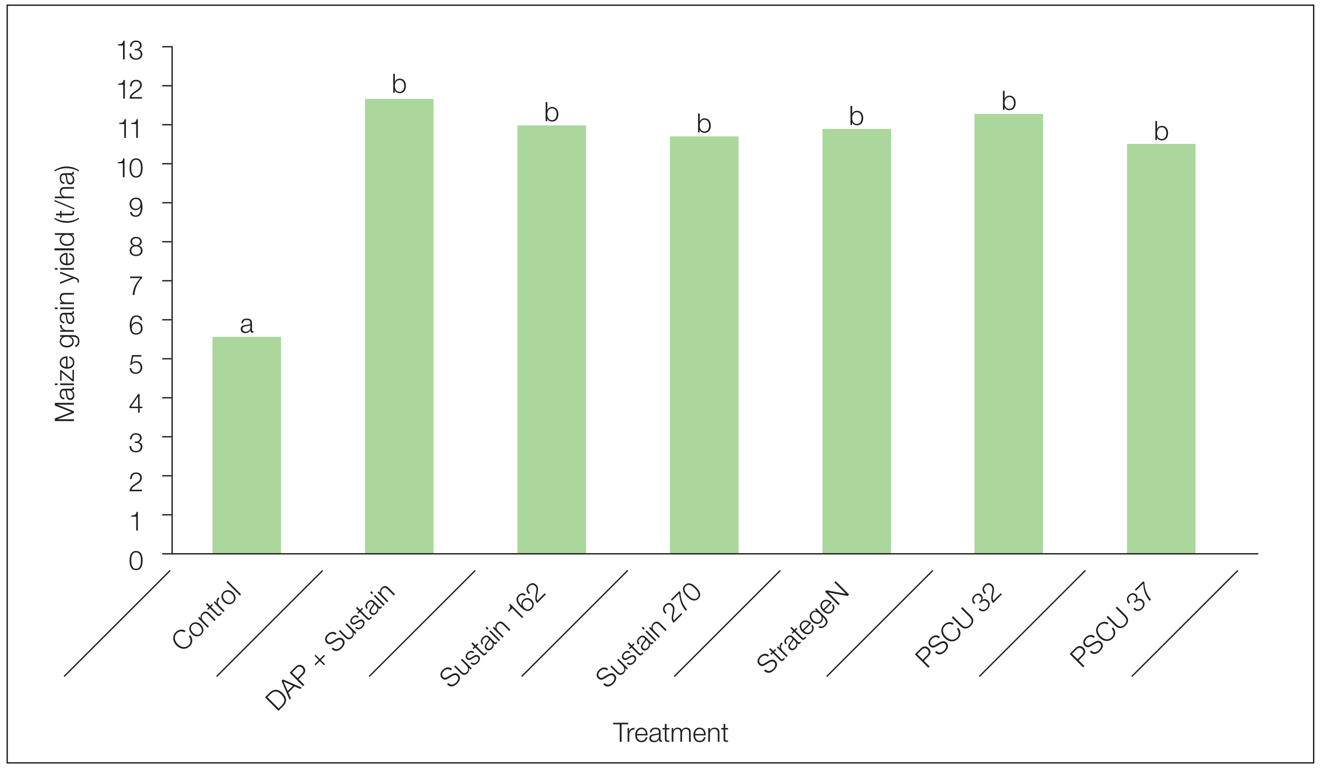

Figure 27. Maize grain yield for N fertiliser treatments. Treatments with the same letters are not significantly different (P<0.05).

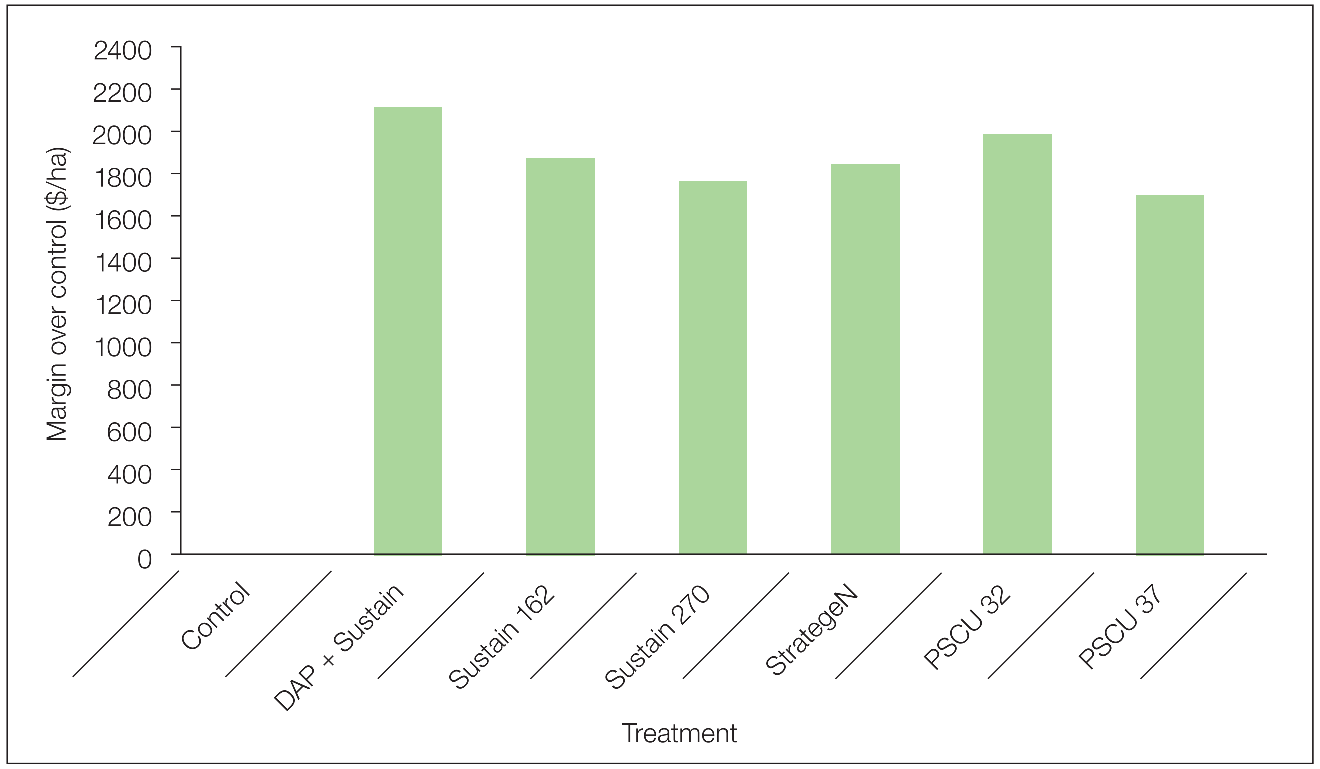

Figure 28. Margin over control for the N fertiliser treatments.

Leaf nitrogen levels at silking showed some differences between N fertiliser treatments, however the observed levels did not correspond to grain yield or soil N levels (Table 14). This indicates that leaf nitrogen may not be a predictor of grain production.

At maize harvest on 26 May 2017, soil nitrogen levels were not significantly different between the fertiliser treatments and the control. In addition, there were no differences in N levels in soil profiles across treatments.

A soil N difference might have been expected between the control and fertiliser treatments, depending on whether the applied nitrogen was used by the crop or leached by high rainfall. However, no significant differences in soil N were observed for this crop in the 2016/17 season. This may reflect mineralisation during the season, the amount of N remaining following the previous crop and the amount of fertiliser N applied.

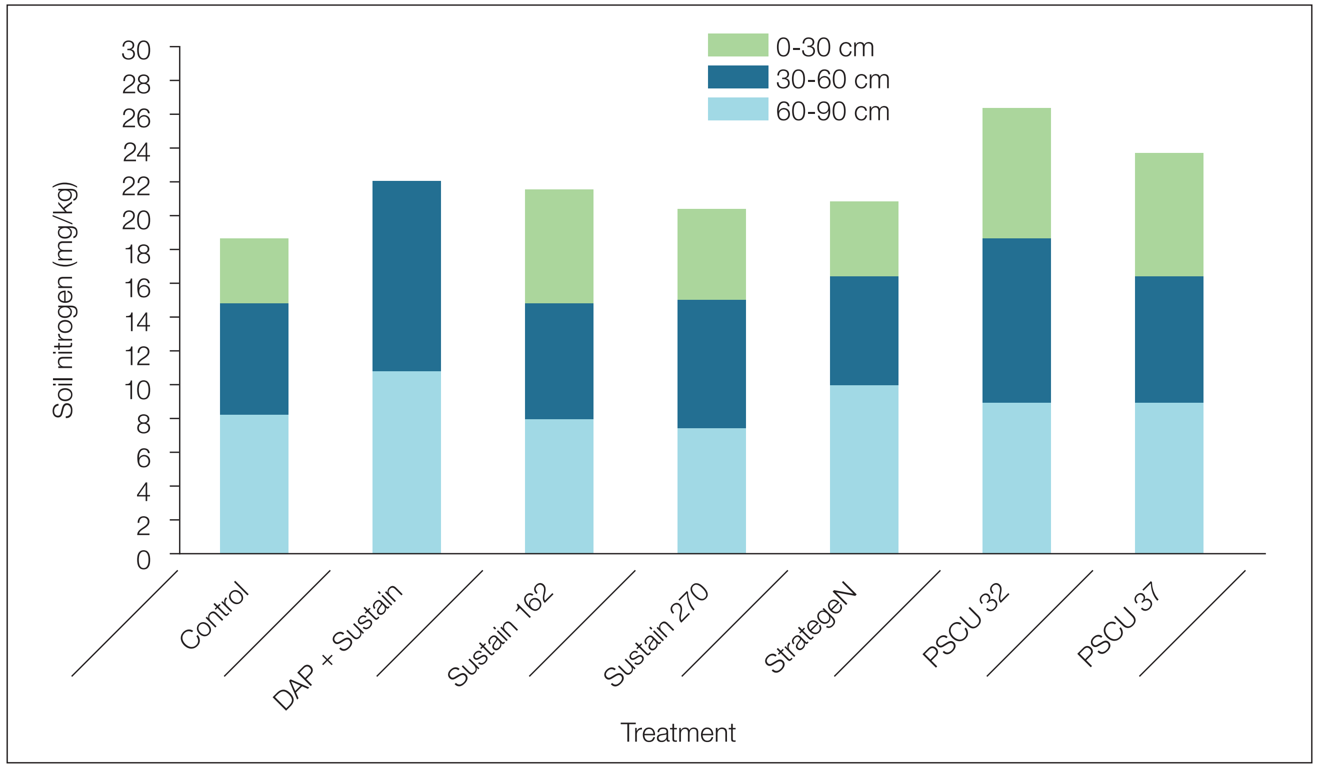

Figure 29. Nitrogen levels in soil profile at maize harvest for N fertiliser treatments.

Conclusions

All N fertilisers produced significant increases in maize grain production, with NUE ranging from 39 to 72 kg/kg. The 2016/17 trial was undertaken on an area of NCRS with lower levels of N, therefore the NUE figures were much higher than in 2015/16, where we found that lower rates of Haracoat PSCU 37 gave higher NUE (27-46 kg/kg) than just urea treatments (15 kg/kg), and higher rates of Haracoat™ PSCU 37 (19 kg/kg).

Polymer coated urea slow release fertilisers were as effective as the urea SustaiN product. SustaiN was as effective at 55% of the required N rate as at 100% recommended N, because overall grain yield was 1.3-2.5 t/ha lower than the expected 13 t/ha. It is possible that some of the fertiliser treatments would have performed better in other seasons or weather conditions, resulting in higher yields. Because of the low yielding nature of this trial this season, we applied more N than was needed by the crop in all of the fertiliser treatments. It is possible that significantly lower rates of slow release N products would have resulted in the same yield.

Current pricing of slow release N fertilisers results in a lower return on investment as compared to urea N products (a halving of the rate of application or cost of the Haracoat™ products would be required to make them economically viable). Although there was no difference between the soil N levels following the different treatments used in this trial, there may be some opportunity for polymer coated urea products to be used by growers in highly sensitive cropping environments to reduce the potential for leaching following peak rainfall.

Protecting seedlings from insect pest attack

Key points

- Seed treatments provide targeted control of seedling pests.
- Maize plots planted with Poncho® or experimental 507 treated seed had significantly higher yields than untreated plots.
- Kale plots planted with Gaucho® treated seed produced significantly higher yields than those sown with untreated seed.

Background

A trial investigating the effect of seed treatment on seedling emergence, plant damage and yield of maize and kale crops in Waikato has found that seed treatments do provide a positive benefit in terms of yield increases over untreated seed, even under severe insect pest pressure.

The trial is part of a FAR-led project, investigating the role of seed treatments on reducing the impact of insect pest attack on crop yields in New Zealand agriculture.

Seed treatments, often using neonicotinoid insecticides, are considered a more environmentally friendly means of crop protection than broad spectrum foliar sprays, as they are highly targeted (being buried in the soil with seed) and therefore do not have the same risks of environmental exposure and impact as foliar applications.

For seed treatments to work, the insect needs to sample the seedling to get a toxic dose of the insecticide. So, while there may be initial damage, it does not persist, as the insect dies. In comparison, seedlings growing from untreated seed are subject to ongoing pressure – the pests keep coming back for a free lunch.

Table 15. Mean % of maize seedlings damaged and the severity of damage on seedlings within a 2 m transect without and with seed protection recorded at each assessment.

	Treatment		
Assessment	Control	507	Poncho®
	Mean % damage		
1	85 ± 2.6	74 ± 3.2A	80 ± 3.0
2	91 ± 2.1	85 ± 2.6	91 ± 2.2
	Mean damage severity score		
1	1.9 ± 0.11	1.4 ± 0.09A	1.5 ± 0.10A
2	1.8 ± 0.09	1.5 ± 0.09A	1.5 ± 0.07A

A Significant difference from control.

Objectives

The trials were conducted along two fronts. The first involves comparing seedling survival, seedling damage and subsequent dry matter (DM) yields from plots sown with either insecticide treated or untreated seed. The second is looking at alternative seed treatments that could be used alongside, or instead of, conventional seed treatments.

Trials

Replicated trials involving both maize and kale were sown on 3 November and 29 December 2016, respectively. The seed sown was either untreated or treated with Gaucho® (imidacloprid), Poncho® (clothianidin) and an experimental chemical (507). Minimal tillage was used to maximise insect pest pressure. AgResearch entomologists counted the number of seedlings within a 0.5 m (kale) or 2 m (maize) transect and assessed for percentage and severity of damage. Severity of damage was based on a scale of 0-6 (0 = no damage and 6 + plant chewed off to the ground). Where possible, the insect causing the damage was recorded, as were subsequent DM yields. To determine if any trends were showing up, maize seedlings were assessed twice, six days apart, while kale seedlings were assessed three times, seven days apart.

Results

Results showed that the percentage of maize seedlings attacked was high (74-85%) and comparable across all treatments; this increased over the two assessments. The severity of attack was significantly greater on the control maize seedlings compared the experimental 507 and Poncho® (Table 15).

Insect attack on kale showed a similar trend, increasing over each assessment, and in the first two assessments, was significantly higher in the control seedlings, compared to Gaucho® treated seedlings. The severity of damage was also significantly higher in the control seedlings (Table 16).

The main pests in order of importance were cutworm, springtail, Argentine stem weevil and black beetle.

Table 16. Mean % of kale seedlings damaged and the severity of damage on seedlings within a 0.5 m transect, without and with seed protection recorded at each assessment.

Assessment	Treatment	
	Control	507
	Mean % damage	
1	22.6 ± 2.9	13.7 ± 2.5[B]
2	57.4 ± 3.5	22.9 ± 3.4[B]
3	97.9 ± 1.2	86.5 ± 3.0[B]
	Mean damage severity score	
1	0.26 ± 0.04	0.16 ± 0.03[B]
2	0.89 ± 0.07	0.32 ± 0.05[B]
3	1.56 ± 0.09	1.10 ± 0.06[B]

[B] Significant from control treatment

Yield measurements (t DM/ha) have also echoed the insect damage data, being higher for plants growing from treated seed. For maize, yields of 507 and Poncho® were 2% and 12% better than the control, respectively and while not significant, did show that reduced severity of insect attack did have a yield benefit (Figure 32). For kale, seed treatment provided a 40% yield benefit over non-treated seed (Figure 33).

This project is funded by the MPI Sustainable Farming Fund and a wide range of industry and grower groups including FAR. It is now entering its final year, and trials in 2017/18 will evaluate existing and new seed treatments to protect seedlings from insect pest attack, again comparing treated and untreated seed under field conditions.

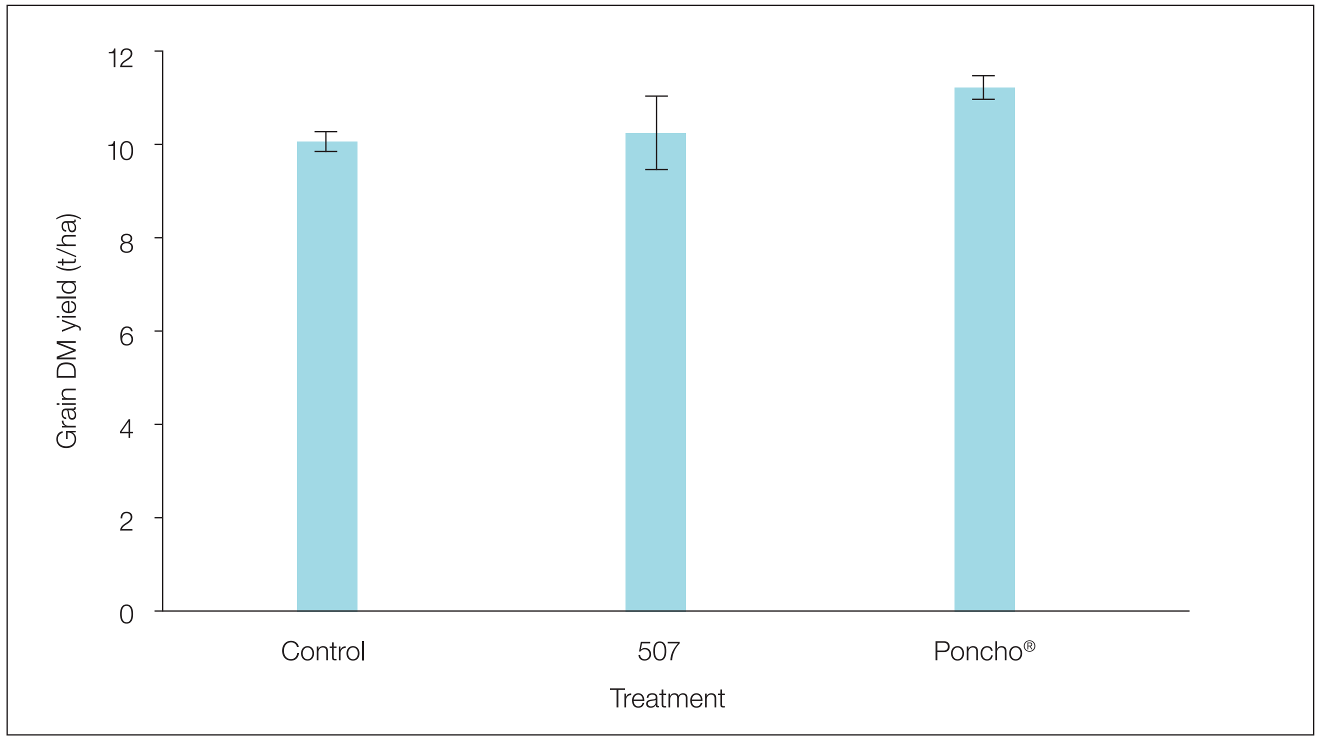

Figure 32. Maize grain yields (t/ha) from untreated and treated seed.

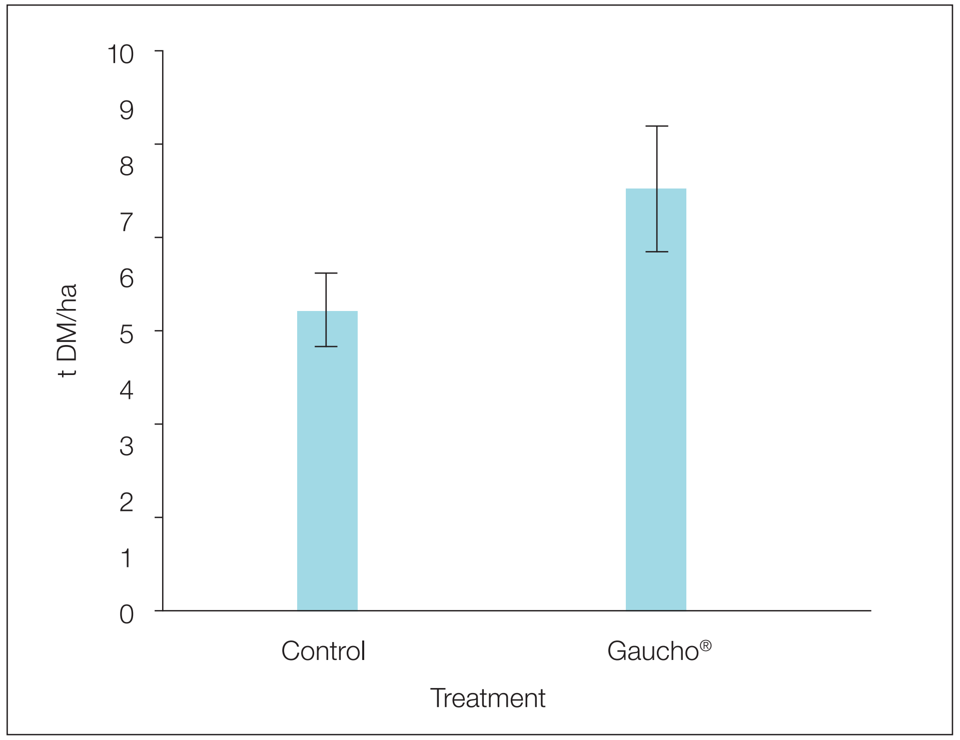

Figure 33. Kale yields (t DM/ha) from untreated and treated seed.

Figure 30. *Collembola* (Springtail) on brassica.

Figure 31. A dead caterpillar under a maize seedling grown from Poncho® treated seed.

Slug damage in relation to maize yield

Key points

- The use of slug baits significantly reduced maize damage by slugs.
- Plants which sustain heavy slug feeding shortly after emergence can achieve yields similar to plants with limited slug damage, but maturity may be delayed.

Background

FAR has recently completed a Sustainable Farming Fund project on slug pest management. This project investigated the use of cultural control methods, ways of optimising chemical molluscides and the potential for biological slug control in New Zealand. It found that even when slug populations are relatively low (12 slugs/m^2) at maize establishment, they can still cause significant economic damage to the crop.

Objective

To determine to what extent early feeding by slugs influenced final yield in maize.

Methods

The experiment comprised four pairs of plots (6 m x 10 m). Each pair had one untreated plot, and one plot treated with three applications of Endure® metaldehyde pellets at 8 kg/ha, one day, three days and eight days after drilling. Maize was no-till planted into maize stubble to encourage high slug populations.

Ten days after the third bait application, slug numbers were assessed by placing three 40 x 40 cm wooden boards in each plot, the number of established plants/m maize row were counted and ten plants were selected at random from the 2 x 2 m central sampling zone of each plot and dry weight recorded.

At harvest, six plants were randomly selected from the 2 x 2 m sampling zone. Wet weight of foliage and cobs was recorded then all materials were dry weighted. Percentage moisture content was calculated.

Results

The number of slugs found under boards was significantly lower in the bait treated plots than in the untreated plots ($P < 0.05$, Figure 34). At the first plant assessment, two weeks after planting, there were no significant differences in numbers of established plants between untreated and metaldehyde treated plots ($P = 0.092$), indicating slugs had not killed any plants (Figure 35A), however there was significant difference in the number of plants damaged by slugs (Figure 35B).

At harvest, there was no significant difference in plant total plant dry weight or cob dry weight between untreated and bait treated plants. However, there was a highly significant difference in percentage moisture content within the cobs between untreated and bait treated plants ($P<0.01$, Figure 36). This suggests that the untreated plants are less mature and will take longer to reach ideal moisture content. During harvest, it was apparent that plants from the untreated plots were more variable in size. To test if this was significant we used Bartlett's test for homogeneity of variances. While the differences in variability was not quite significant for cob weight, ($P = 0.089$), percentage moisture at harvest was significantly more variable ($P < 0.05$).

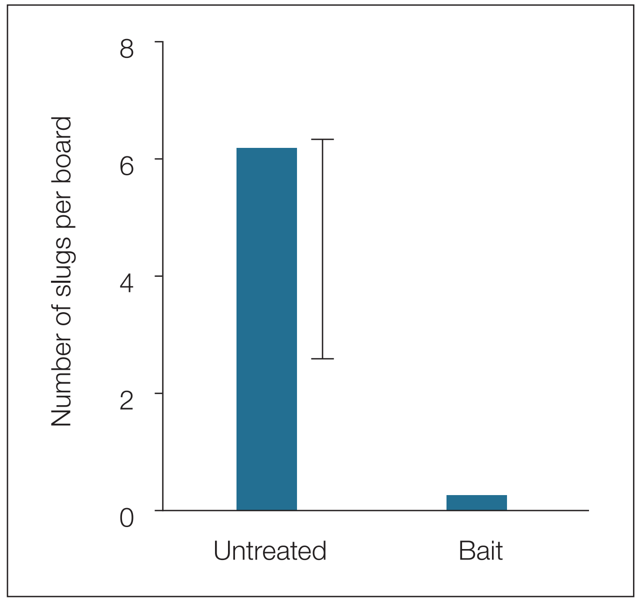

Figure 34. Mean number of slugs per refuge board in untreated plots and plots treated with three applications of metaldehyde baits. Bar = least significant difference, P = 0.05.

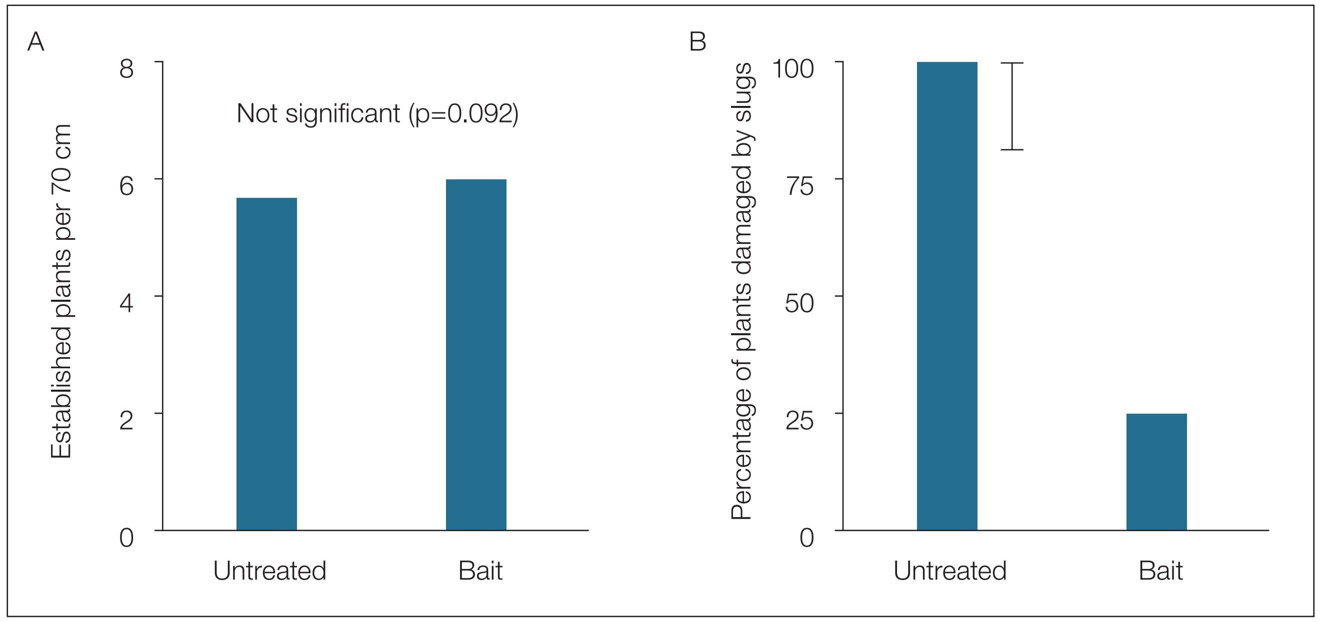

Figure 35. A) Number of maize plants established on treated (three applications of metaldehyde bait) and untreated plots at NCRS in spring 2016, in the presence of 38 slugs/m^2. B) Percentage of maize plants damaged by slug feeding in treated (three applications of metaldehyde bait) and untreated plots at NCRS in spring 2016 in the presence of 38 slugs/m^2. Bar = least significant difference, P = 0.05.

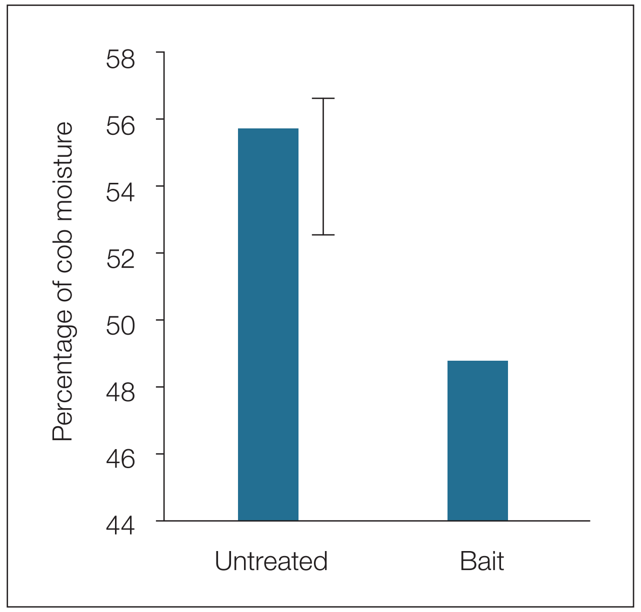

Figure 36. Percentage moisture content of cobs harvested from untreated plots and plots treated with three applications of metaldehyde baits at NCRS in 2016/17 season. Bar = least significant difference, P = 0.05.

Discussion and conclusions

These results suggest that given enough time, plants which have been grazed by slugs after emergence can achieve yields similar to plants with limited slug damage. However, maturity may be severely delayed and there appears to be more variability in plant size and maturity. It may be that plants that suffered low levels of slug damage outgrew and shaded plants with much greater damage levels.

Maize Hybrid Performance Trials (MPT)

Key points

- Third year of MPT programme, data is now presented as a multi-year multi-site data set and shows how hybrids perform over multiple seasons, and across multiple different locations.
- Yield difference between leading hybrids was not significant.
- Some Pioneer hybrids are included in the 2017/18 MPT trials.

Background

The MPT trial programme was established in 2014 to provide an independent maize hybrid-testing scheme that would provide objective measurements of the agronomic and quality performance of commercial maize hybrids available to the New Zealand arable industry across appropriate production regions.

Methods

For the 2016/17 season trials were established in the Waikato (two sites), Bay of Plenty, Rangitikei, Manawatu and Canterbury. The trial design was a fully replicated, small plot design that included standard hybrids for comparison.

The full methodology and results of the MPT programme are available on the FAR website.

Results and discussion

This is the first year we have presented multi-year, multi-site data. This is a big step forward for the MPT programme because it shows how the hybrids perform over multiple different seasons, and across multiple different locations.

To analyse this data, the trials have been separated into three zones. The NCRS MPT trial data is included in the Upper North Island region.

- Upper North Island includes Waikato and Bay of Plenty.
- Lower North Island includes Manawatu and Rangitikei.
- South Island.

The combined trial analysis is undertaken in a way to avoid an advantage to an entry being in a high yielding trial versus another being in a low yielding trial. The variations from the trial means are then averaged using a weighted average, where more weight is given to trials with higher precision (less variability).

For example, if Trial A had twice the precision of Trial B, the weighted average would be (2 x Trial A result + Trial B result)/3, and so the result would be closer to the Trial A mean than the Trial B mean.

Tables 17 and 18 show the data from multiple seasons and sites for maize hybrid performance, and are more valuable than results from a single season and/or single site as they show the hybrids ability to perform over seasons with different weather patterns. Ultimately, the most consistent performers will rise to the top of multiple year results. The more trials a cultivar has been in, the more confidence can be taken from its reported performance.

One of the six MPT sites in the 2016/17 season was established at Northern Crop Research Site, and the results are given in Tables 19 and 20.

Figure 37. Maize trials.

Table 17. Maize silage performance from Maize Hybrid Performance Trial 2014-17 in upper North Island.

Hybrid	CRM	Number of trials	Number of years	Yield (t DM/ha)
C78-S8	114	7	3	28.2
P0791	106	8	3	26.8
Plenitude	107	6	2	26.7
PAC456	108	7	3	26.3
34P88	109	5	2	26.3
Z71-F1	111	7	3	26.3
PAC432	107	7	3	26.2
Olympiad	112	6	2	25.9
C56-C4	106	8	3	25.9
N51-N4	104	6	2	25.5
C29-A1	96	6	3	25.3
PAC343	104	8	3	25.2
Afinity	100	4	2	25.1
N39-Q1	97	6	3	24.7
37Y12	95	5	2	24.6
PAC230	98	8	3	24.5
Maximus	102	6	2	24.4
P0021	100	5	2	24.4
G49-T9	104	5	2	23.3
PAC249	95	7	3	22.9
Titus	82	6	2	21.4
Mean				**25.02**
LSD 5%				**1.54**

Table 18. Maize grain performance from Maize Hybrid Performance Trial 2014-17 in upper North Island.

Hybrid	CRM	Number of trials	Number of years	Yield (t/ha @ 14% moisture)	Harvest moisture (%)
PAC432	107	7	3	14.6	21.6
PAC230	98	7	3	14.1	19.5
Plenitude	107	5	2	14.0	21.5
N51-N4	104	7	3	14.0	20.7
Afinity	100	3	2	14.0	20.0
C29-A1	96	5	3	14.0	19.6
34P88	109	5	2	14.0	23.4
37Y12	95	5	2	14.0	19.6
PAC343	104	7	3	13.9	21.2
P0021	100	5	2	13.8	20.5
PAC249	95	6	3	13.2	20.1
Olympiad	112	5	2	13.1	23.0
N39-Q1	97	5	3	12.8	19.9
Maximus	102	5	2	12.7	23.2
Titus	82	5	2	10.9	19.6
Mean				**13.20**	**21.3**
LSD 5%				**0.97**	**0.6**

Table 19. Maize Hybrid Performance Trial silage results from NCRS, 2016/17 Season.

HYBRID	CRM	Days to 50% silk emergence	Plants per hectare	Days to harvest	Harvest dry matter (%)	Yield	
						t DM/ha	Significance
C56-C4	106	88	93859	140	33.6	27.6	a
Afinity	100	90	94029	140	35.4	26.0	ab
C78-S8	114	93	89669	164	31.7	25.8	abc
P0791	106	88	95229	140	31.1	25.2	abcd
PAC343	104	88	92569	156	39.6	24.6	abcd
C29-A1	96	84	92179	137	32.8	24.5	abcd
PAC456	108	88	90602	151	32.0	24.5	abcd
PAC432	107	94	89571	158	40.0	23.8	abcde
PAC230	98	83	89033	137	32.3	23.1	bcdef
Z71-F1	111	95	95490	158	34.5	22.9	bcdef
Olympiad	112	95	95818	161	39.9	22.5	bcdef
Plenitude	107	88	94140	148	32.2	22.4	cdef
N51-N4	104	-	97589	137	33.9	22.2	cdef
N39-Q1	97	84	94084	133	31.5	22.0	def
Maximus	102	87	96120	137	29.2	21.7	def
Titus	82	77	93011	128	34.4	20.7	ef
PAC249	95	84	92330	137	31.3	20.4	ef
Brutus	105	88	95495	156	42.0	19.5	f
Mean		**88**	**93379**	**145**	**34.3**	**23.3**	
LSD 10%		**0.2**	**7229**		**1.9**	**3.5**	
CV%		**0.2**	**5.0**		**3.2**	**10.4**	

Table 20. Maize Hybrid Performance Trial grain results from NCRS, 2016/17 Season.

HYBRID	CRM	Days to 50% silk emergence	Plants per hectare	Test weight (kg/hl)	Harvest moisture (%)	Yield	
						t/ha @ 14% moisture	Significance
PAC432	107	94	94193	67.4	25.0	14.7	a
PAC343	104	88	93915	70.7	21.6	13.1	b
Afinity	100	90	92756	72.1	20.8	12.6	bc
PAC456	108	88	85557	70.8	24.2	12.5	bc
PAC230	98	83	92200	72.4	20.5	12.4	bc
C29-A1	96	83	93477	71.9	19.1	12.1	bc
PAC249	95	84	90899	71.6	20.5	12.0	bcd
N51-N4	104	90	98408	71.5	21.8	11.7	cde
Olympiad	112	95	95822	66.0	24.2	11.6	cdef
Brutus	105	88	91993	72.9	25.4	10.7	defg
N39-Q1	97	84	99631	70.5	21.0	10.4	efg
Plenitude	107	88	98411	69.3	21.9	10.2	fg
Maximus	102	87	93787	68.0	24.7	10.0	gh
Titus	82	77	97398	77.2	19.9	8.8	h
Mean		**87**	**94315**	**70.9**	**22.2**	**11.6**	
LSD 10%			**5506**	**1.2**	**1.5**	**1.41**	
CV%			**5.8**	**1.2**	**4.8**	**30.9**	

Note: Hybrids with the same letter beside them are not significantly different for the characteristic listed. When no significant difference for a given parameter is found among hybrids, "ns" (non-significant) replaces an LSD value.

Managing yield variability using Variable Rate Seeding in maize

Key points

- Using Variable Rate Seeding to plant different seed rates according to paddock management zones did not decrease maize yield.
- Variable rate seeding can be used to decrease the cost of seed in poor performing areas without reducing crop yield.
- Using Precision Agriculture tools, it is possible to tailor other crop inputs to these different management zones.

Background

Seed is one of the largest costs in growing maize crops. Currently, seeding rates are based on historic paddock yields and crop expectations. However, in any cropping paddock some areas perform better than average and others, worse than average. The optimal seeding rate for these different zones will differ. Most maize planters are able to vary the planting population on the go, so Variable Rate Seeding can be used to maximise profitability of the crop in the different zones.

Objective

For the 2016/17 maize season, a seed rate trial was established at NCRS, to investigate the effect of different planting populations in the different management zones of the paddock.

Figure 38. Variable Rate Seeding prescription for maize planting 2016.

Methods

Four replicated strips planted at 75, 90 and 105 thousand seeds per hectare were established across the three zones in the paddock. These areas all received the same rates of starter fertiliser at planting, and side-dressed nitrogen.

Management zones were determined by analysing yield data files from the combine harvester from previous harvests and for spatial trends across the paddock, and temporal (time) variability over the different years. From this data, we determined a Management Zone map, and then a proposed Variable Rate Seeding (VRS) prescription, as shown in Figure 38.

This VRS prescription was then used to establish a trial comparing VRS with fixed rate planting (Figure 39).

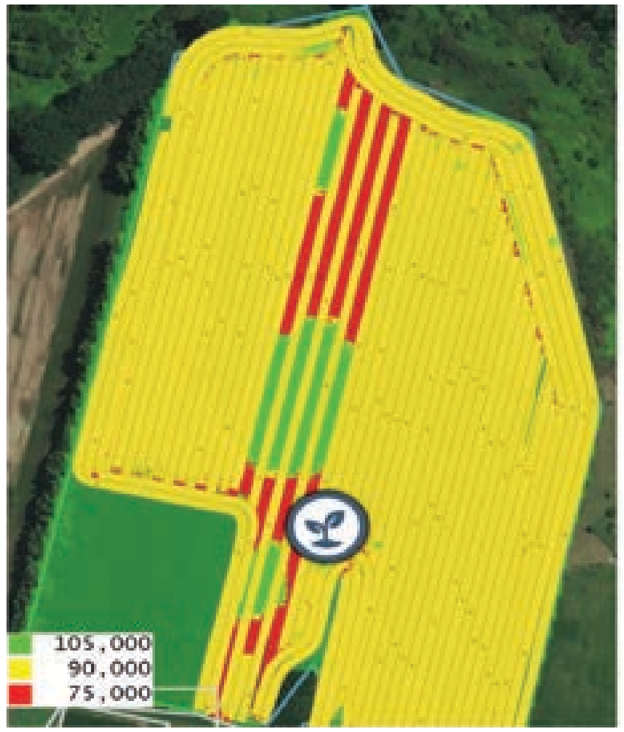

Figure 39. Map showing planter seeding rates (seeds/hectare).

Results and discussion

The maize grain crop was harvested on 4 June 2017 using a John Deere combine harvester with yield monitor and GPS. Data was recorded and analysed for each of the different management zones and seed planting rates. The average grain yield was 8.0 t/ha. Geospatial variation across the paddock is shown in Figure 40.

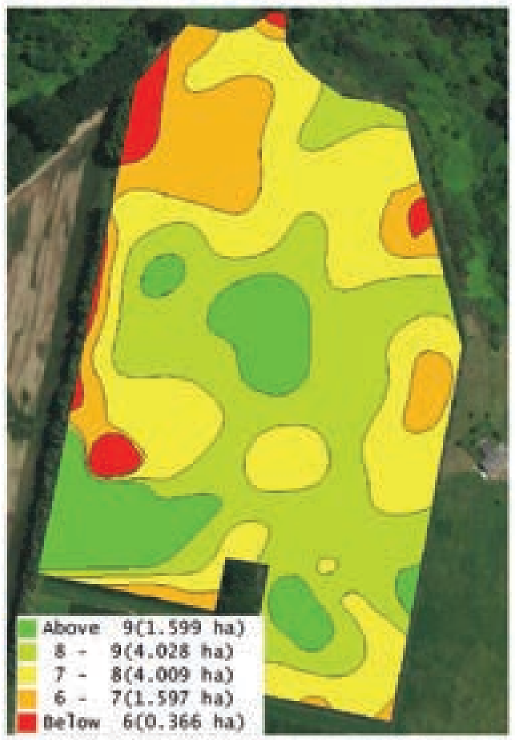

Figure 40. Maize grain yield over a paddock in 2017 (t/ha @ 14% DM).

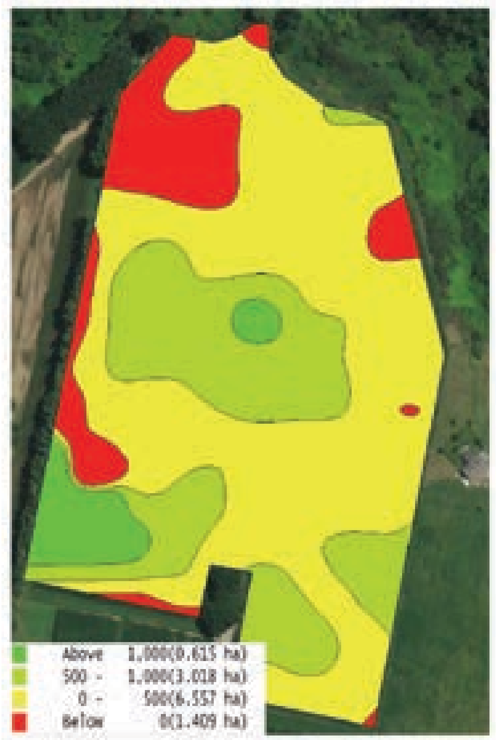

Figure 41. Calculated gross margin for maize grain crop at NCRS, 2017 ($/ha).

From this data, we calculated geospatial gross margin (Figure 41). Gross margin was calculated using a grain price of $350/tonne, and value for the land was included. The average gross margin for the paddock was $344/ha.

Using the management zone map, we calculated what the yield and gross margin would have been for the different management zones, if we had planted using variable rate seeding. These results show no significant difference between yield and gross margin from the standard and variable rate seeding. (Table 21).

Table 21. Seeding rate, yield and gross margin calculated from VRS and standard seed rates.

	Average seed rate (thousands /hectare)	Yield (t/ha @ 14% moisture)	Gross margin ($/ hectare)
Fixed seed rate	100.1	8.1	$417
Variable seed rate	96.0	8.1	$453
LSD 5%	1.6	**1.2**	

Conclusion

If the entire paddock had been planted at 90,000 seeds per hectare, the total 11.6 ha paddock gross margin would be $4,837. If planted using variable rate seeding, the paddock gross margin would be $5,255, an increase of $36 per hectare over the constant seed rate.

Forages for Reduced Nitrate Leaching

Key points

- Catch crops planted in autumn can take up large amounts of nitrogen.
- Earlier planting results in greater nitrogen uptake.
- Late termination of catch crop maximises nitrogen uptake.

Background

The Forages for Reduced Nitrate Leaching (FRNL) programme aims to reduce farming's environmental footprint by improving nitrogen (N) efficiency of the animals and/or the plants used in dairy farming.

Objectives

A field trial was conducted as part of the Forages for Reduced Nitrate Leaching (FRNL) programme to validate model findings that catch crops can reduce the risk of nitrogen (N) leaching following summer cropping or autumn forage grazing.

Methods

The experimental design included seven replicated treatments: a factorial combination of three sowing dates (31 March 2016, 27 April 2016 and 26 May 2016) and two catch crops (oats and Italian ryegrass), and a fallow control established on 31 March 2016. A base application of 400 kg N/ha as SustaiN was applied to the entire trial area, simulating soil N levels across the whole trial similar to urine patches following grazing. All crops were managed with various selective herbicides to control volunteer weeds in catch crop plots and non-selective herbicides to maintain the weed-free status of the fallow plots.

On four sampling dates, (30 June, 23 August, 5 October and 9 November 2016) soil mineral N samples were collected and crop biomass determined in each plot. The data were used to consider the risk of N leaching under each treatment, expressed as a reduction in soil mineral N levels due to uptake of N in the catch crops. No direct leaching measurements were collected in the trial.

Results and discussion

As predicted, planting date had a clear effect, with catch crops established in March taking up more residual N from the soil than those established in May. In general, oats tended to take up more N than Italian ryegrass (Table 22).

Table 22. Nitrogen uptake by cover crop species, planting date and harvest date (kg N/ha).

Catch crop species	Sowing date	Sampling date	
		October	November
Combined catch crops	March	134	149
	May	83	125
Oats	All	123	162
Ryegrass	All	95	112

Table 23. Soil Mineral N levels (0-90 cm) under oats / ryegrass catch crop established at different sowing dates.

			March sown		May sown	
		Fallow	Ryegrass	Oats	Ryegrass	Oats
Soil Mineral N (0-90 cm, kg/ha)	31 March	-	39	37	47	42
	30 June	167	67	43	170	164
	23 August	87	18	23	78	80
	05 October	55	21	22	18	57
	09 November	74	25	39	20	21

Results showed that having a catch crop established over winter and spring reduced soil mineral N levels. Establishing catch crops in March had a clear effect on soil mineral N levels at the late-June and mid-August sampling occasions, reflecting periods of high risk due to winter rainfall. By contrast, establishing catch crops in May had little effect on soil mineral N levels during the winter period, with most of the uptake occurring in spring (Table 23).

Planting a catch crop early in autumn will maximise the yield of the crop, and the N uptake, which will reduce the risk of N losses to the environment through leaching. Metabolisable energy declined and DM percentage increased between the October and November harvests. This reflected the maturing of the crops beyond their optimal levels for feed, and was more noticeable for the earlier sown catch crops.

Conclusion

These findings confirmed the predicted benefits of catch crops in reducing the risk of N leaching. The potential benefit will be dependent on factors that influence winter and spring drainage and crop growth. In general, the sooner winter crops are established in autumn the more protection is afforded.

Forages for Reduced Nitrate Leaching is a DairyNZ-led collaborative research programme across the primary sector delivering science for better farming and environmental outcomes. The aim is to reduce nitrate leaching through research into diverse pasture species and crops for dairy, arable and sheep and beef farms. The main funder is the Ministry of Business, Innovation and Employment, with co-funding from research partners DairyNZ, AgResearch, Plant & Food Research, Lincoln University, Foundation for Arable Research and Landcare Research.

For more information, go to www.dairynz.co.nz/FRNL

Crop rotation trial

Key points

- Silage yields from autumn sown faba beans were slightly higher than yields from spring sown faba beans.
- Faba beans ensile well up to 54% DM. This trial is continuing, and further results will be reported next year.
- The effect of crop rotation on mazie grain yield will be measured in the 2018 harvest.

Background

Internationally the classic maize rotation is based on maize one year, followed by soybeans the next, then maize again. The use of different species, and a mix of monocot species (maize) and broadleaf legume species (soybean) give multiple advantages:

- Ability to control grass weeds in broadleaf crops
- Ability to control broadleaf weeds in maize
- Nitrogen fixing in the soybean reducing nitrogen inputs required by the maize crop

While soybeans can be grown in regions of New Zealand with high heat units (Northland, Gisborne), there is no facility to process the soybeans to become palatable to stock. Combined with the low international price of soybeans means they are not an economically viable crop for New Zealand production. Therefore, two other legumes, gland clover cv. Prima and faba bean cv. Ben, were included in maize rotation trials at NCRS.

Objectives

- To investigate productivity of faba beans and gland clover as forage and/or grain crops.
- To better understand yield and quality of faba beans as a whole plant silage at different maturities.
- To investigate the performance of maize following eighteen months of faba beans or clover.
- To calculate the profitability of maize following legume crops.

An increased understanding of faba bean agronomics, yield, quality and conservation under New Zealand conditions, will allow a better evaluation of the crop's usefulness in New Zealand farm systems.

Methods

The trial site had been planted in maize for at least the previous five seasons. It was rotary hoed after the maize crop was harvested to incorporate maize residue, and then sowed with a combination power harrow/drill/roller on 10 May 2016. Strips of 6.1 m wide, 100 m long, were planted with either faba bean (300 kg/ha), gland clover (6 kg/ha) or ryegrass (25 kg/ha) following maize for grain. Four randomised replicates were established.

Weed management in the three crops was carried out by best practice, and no nitrogen was applied to the legumes or the ryegrass.

Results and discussion

Dry matter cuts were taken from the gland clover on 9 November 2016, and the yield was 4.6 t DM/ha.

In the faba bean plots, quadrats were harvested and yield was determined at four different maturities. Material was wilted in a shed for 36 hours then processed with a garden shredder before being ensiled into vacuum packages.

Faba bean plant dry matter percentage was good for silage making until 22 December, when it became too dry. Dry matter yield was around 8.8 t DM/ha, and did not change across harvest dates. Visual appearance of the faba beans changed a lot, from a quite green crop to a mostly dry crop with dead, black roots. Forage quality increased up to the third harvest (22 December) but had declined by the final harvest date (4 January 2017).

Figure 42. Faba beans on 23 November 2016.

The pH readings of around 4 means successful fermentation occurred up to the third harvest (medium late), while the late harvest pH near 6 indicates little or no fermentation occurred. This was also confirmed with fermentation acid profile, i.e. the lactic acid to acetic acid ratio was around 4-5:1 for first three harvest, but no fermentation acids were detected at the final harvest.

Faba beans ensiled well when dry matter was between 19.2% and 28.6%. Late harvested wilted material at 59.7% DM did not ensile.

The faba bean grain was harvested on 26 January 2017. At 2.3 t/ha of grain the yield was considered low for faba bean, as was the whole plant dry matter yield.

Conclusion

Silage yields of spring harvested faba beans grown over winter in this trial were slightly higher than New Zealand and overseas spring sown faba beans. Faba beans ensile well up to 54% DM. This trial is continuing, and further results will be reported next year.

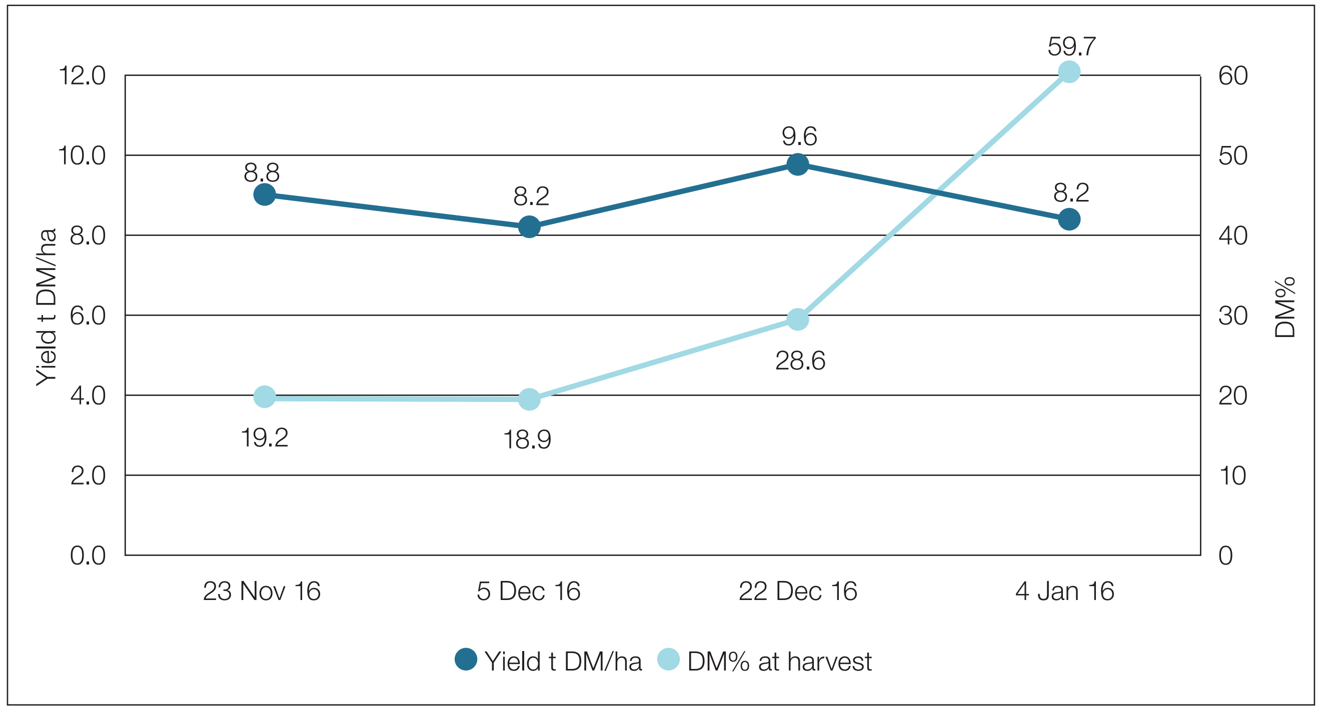

Figure 43. Yield and dry matter percentage of faba beans at different harvest dates in 2016/17.

Table 24. Faba bean yield and quality at different harvest dates in 2016/17.

Harvest date		23 Nov 16	5 Dec 16	22 Dec 16	4 Jan 17
Crop stage		**Early**	**Medium early**	**Medium late**	**Late**
Fresh	Dry matter (%)	19.2	18.9	28.6	59.7
	Soluble sugars	12.3	6.8	5	1.2
After ensiling	Dry matter (%)	27.2	32.7	57.5	77.7
	pH	3.9	4	4.4	5.9
	ADF (% of DM)	46.7	48.3	44.5	51.8
	NDF (% of DM)	53.4	57.3	56.3	63.4
	Soluble sugars (% of DM)	4.3	2.7	5.4	3.6
	Starch (% of DM)	0.7	1.7	7	3.4
	C Fat (% of DM)	1.4	1.4	1	0.2
	DOMD	48.2	45.4	49.4	38.3
	ME (MJ/kg DM)	7.7	7.2	7.9	6.1
	Lactic acid	6	4.6	2.3	0
	Lactic : Acetic acid	3.2	4.2	4.6	5.3

Miscanthus

Key points

- Miscanthus may have a role as a shelter belt, sediment trap crop or animal bedding.
- Miscanthus has a low feed value as a forage crop.

Miscanthus (*Miscanthus x giganteum*) was transplanted into a strip at NCRS in September 2014. It was planted to investigate its suitability as a crop for the application of dairy shed effluent (DSE), as it uses nutrients to grow rapidly, and reduce the risk of the nutrients leaching from the soil profile.

The miscanthus was harvested in January and June 2017, giving a total yield of 19 t DM/ha. This is a higher yield than the 15.3 t DM/ha in the year from April 2015 to April 2016.

Miscanthus has a low feed value, and therefore may have a limited use in the dairy feed ration (Table 25). However, it has been used as a shelterbelt crop in the South Island, as travelling irrigators can travel through it. Work by the Bio-Protection Research Centre at Lincoln University has found that the increase in pasture dry matter production caused by the shelter effect of the miscanthus shelter is greater than the loss in dry matter from the area producing miscanthus.

Figure 44. Miscanthus in May 2017.

Table 25. Feed value of miscanthus.

	7 May 2015	11 December 2015	15 April 2016	9 January 2017	2 June 2017
Yield (t DM/ha)		11.8	3.6	16.3	2.7
Dry matter %	37.1		32.1	33.0	28.5
Crude protein % of dry matter	7.9		6.2		
Metabolisable energy (MJ/kg DM)	5.7		6.2		
Soluble sugars % of dry matter	7.9		3.4		
Starch % of dry matter	1.8		0.6		

Milling wheat test plot

Key points

- Growing milling quality wheat is feasible in Waikato.

Background

North Island flour mills largely use Australian wheat, while in the South Island, locally grown milling wheat is used. Australian wheat can be easily imported at a commodity price dictated by the world wheat price and it is uniform in quality, making it easier for milling. However, there could be an opportunity for North Island arable growers to produce high quality milling wheat. In 2016 a 50 x 50 m trial area at NCRS was planted in winter wheat (cultivar Reliance) in order to assess yield, quality and the potential viability of producing milling wheat.

Objectives

To assess yield, quality and the potential viability of producing milling wheat in Waikato.

Methods

In 2016 a 50 x 50 m trial area at NCRS was planted in winter wheat (cv. Reliance).

Fertiliser rate was established using soil testing and the Sirius Wheat Calculator.

Results and discussion

Spring was cooler and wetter than usual, contributing to lower than usual growing degree day accumulation, and this was followed by a relatively dry period in December and January. Overall, it was a challenging season, which would have restricted yields. The plot yielded 7.19 t/ha of grain, and the protein level was 13.7%.

Conclusion

The four-year average yield of Reliance wheat in the Cereal Performance Trials under irrigation is 10.6 t/ha, therefore the yield of this plot is acceptable. The protein percentage was high, however, it is likely that with greater yields this would have been lower. At field scale, yields of over 13 t/ha have been reported in Hawke's Bay, proving the North Island is capable of high yields.

Table 26. Wheat management actions and information.

Action	Date	Details
Cultivation	27 May	Plough and power harrow
Drilling	2 June	Cultivar, Reliance; sowing rate 120 kg/ha
Herbicide application	8 June	Firebird® (flufenacet and diflufenican) @ 300 ml/ha
Fertiliser application	12 July	200 kg/ha sustain (46% N)
Fungicide application	10 October	Opus® (epoxiconizole) @ 1 l/ha + Comet® (strobilurin) @ 800 ml/ha
Fungicide application	24 November	Opus® (epoxiconizole) @ 1 l/ha + Comet® (strobilurin) @ 800 ml/ha
Set up bird netting	6 December	Netting put up to protect sample harvest areas
Harvest	13 January	Four x 1m² quadrats harvested

Endnote

This is the third season FAR has produced an annual summary of trials undertaken at Northern Crop Research Site. We hope that the results presented are of value to you. If you have any comments or observations about the work reported on here, or have suggestions to make about further work you would like to see done, please contact us:

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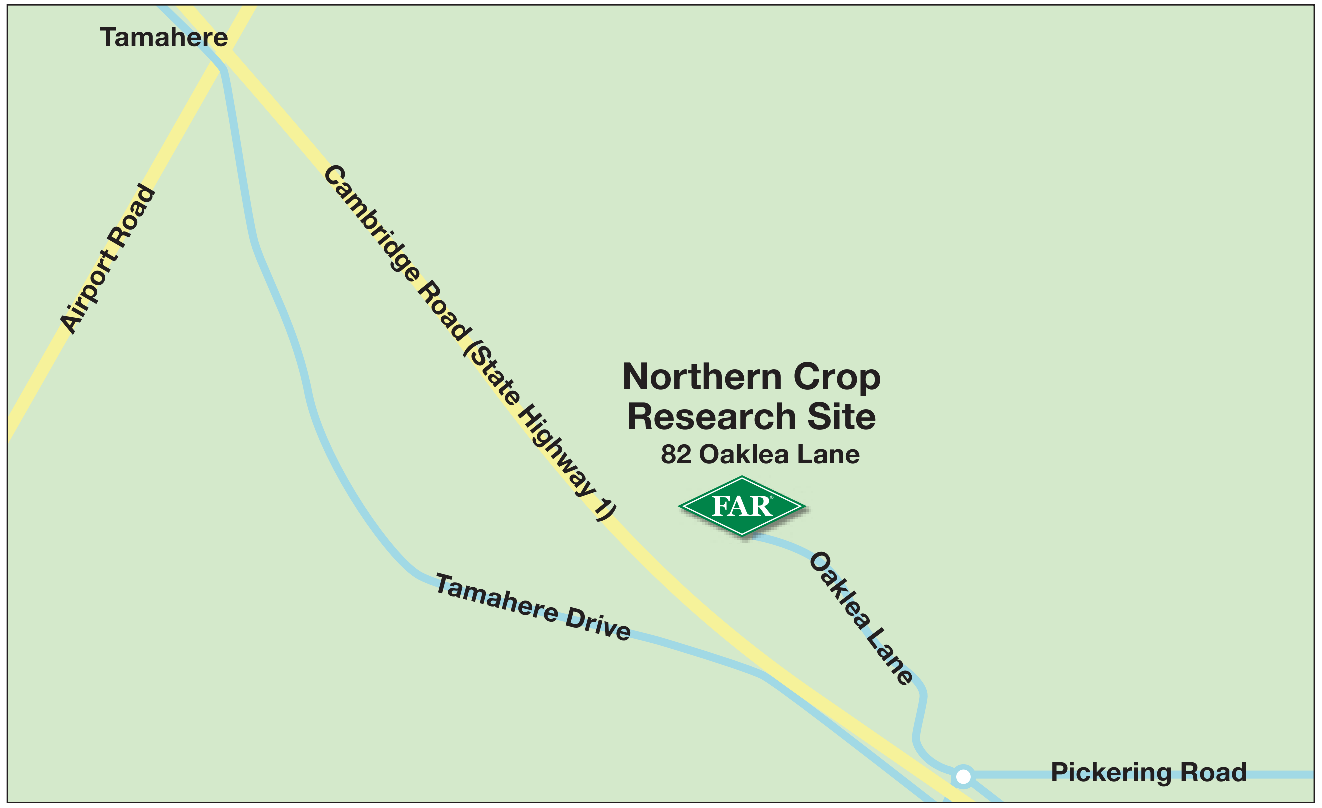

Acknowledgements

We acknowledge the assistance and support of the following:

AgResearch Limited

AGrowQuip New Zealand Limited

Dairy NZ

Genetic Technologies Limited

John Austin Limited

John Deere New Zealand

Maize Technical Committee, NZPBRA

Ministry for Business, Innovation and Employment

MPI Sustainable Farming Fund

Plant & Food Research Limited

W Sinton Limited