Carbon Positive Milestone 9

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1 Overview

In this milestone report we report on the 2024 McCain process pea crop, planted 3rd of September (Milestone 9), and harvested on the 26th of November. This is the first year the trial has grown two crops in a season, with a green dwarf bean crop planted on 28th December 2024. An overview of planting and initial crop monitoring of the bean crop is provided. The beans are due to be harvested end of March and harvest information will be reported in Milestone 10.

This report also includes results from spring Labile Carbon sampling and Visual Soil Assessments completed in November 2024.

1.1 Milestone 9

Date: 1 Feb 2025	Milestone 9
Milestone description	Year 3 Progress as per planned milestones
Target Outcome	Showcasing growing mixed crops under alternative management systems.
Activities undertaken	PSG Meeting to review milestone reports, Year 3 summer process crops established, crop monitoring, outreach Field Day Further activities as per Annual Project Plan and Annual Science Plan.
Deliverables / evidence of completion / achievement of Outcome	Trial results, copies of all extension material and reports. Photos of events (preferred but not essential) PSG and TAG meeting minutes. Deliverables as per milestones within Annual Project Plan and Annual Science Plan.
MPI Funding amount	$109,203.55
Co-Funding contribution	$46,801.52
Total	$156,005.07

1.2 Milestone 9 Activities Plan

Activity	Completion Date	Details	Completed
PSG Meeting to review milestone reports	1/02/25		
Year 3 spring crop development monitoring (peas) continued	Ongoing		
Canopy development	Weekly	Weekly from germination to closure using Canopeo App	☑
Agronomic observations/ crop health monitoring	Weekly	Weekly crop walks alongside field agronomist- Thursday 2pm	☑
Soil Nitrate Quick Test	Fortnightly	Fortnightly, at three depth increments 0-15cm, 15-30cm, 30-45cm	☑
Observable deficiencies recorded	Weekly	Foliage test if concerns	N/A
Tissue testing	Monthly	Pre-flowering	
Pest and disease presence	Weekly	~~Relative Slug Activity.~~ Monitor for aphids and thrips.	☑
Record applied nutrients	1/02/25	All granular and foliar nutrient applications recorded	☑
Record agrichem applications	1/02/25	All herbicides, insecticides, fungicides applications recorded	☑
Record biological product applications	1/02/25	All biological product applications recorded	☑
Record irrigation events	1/02/25	By linear as required according to monitoring	☑
Soil moisture probe	Weekly	LandWISE –GroPoint sensors to 90cm (15cm intervals) and neutron probe via Tipu Services	☑
Water sensitive paper testing	1/02/25	Ahead of first spray applications (drone + ground application)	N/A
Soil temperature	Weekly	In planting line (GroPoint sensors) + iButton	☑
EIQ Risk Assessment calculated	Ongoing	AgChem applications https://cals.cornell.edu/new-york-state-integrated-pest-management/risk-assessment/eiq/eiq-calculator	☑
eDNA sample collection	15/11/24	Samples sent to Syrie	☑
Year 3 spring harvest measurements (peas)	1/02/25	Estimated harvest date 4th December - Actual date 25th November	☑
Harvestable yield	1/02/25	1.25m x 2m sub plots per plot- hand harvested and run through mini viner	☑
McCains harvestable yield	1/02/25	Details to be confirmed with McCain	☑
Non harvested yield	1/02/25	Details to be confirmed with McCain	☑
Year 3 spring crop analysis (peas)	1/02/25		
Factory quality assessments	1/02/25	Graded as per McCain maximum defect levels + TR daily leading up to harvest.	☑
Crop tissue N and C	1/02/25	Commercial lab assessment	☑
Residue biomass	1/02/25	Landwise harvest and weighed	☑
Residue N, C and DM%	1/02/25	Commercial lab assessment	☑
Year 3 summer process crop established (beans)	25/12/24	Beans estimated planting date- 24th December – Actual date 28th December	☑

Soil prepared as agreed to by OAG	25/12/24		☑
Planting managed as agreed to by OAG	25/12/24		☑
Year 3 summer crop development monitoring (beans)	Ongoing		
Establishment percentage	1/02/25	Germination and population determined as per McCains guidance- 2 x 1m counted per sub plot (4 sub-plots/plot)	☑
Canopy development	Weekly	Weekly from germination to closure using Canopeo App	☑
Agronomic observations/ crop health monitoring	Weekly	Weekly crop walks alongside field agronomist	☑
Soil Nitrate Quick Test	Fortnightly	Fortnightly, at two depth increments 0-15cm, 15-30cm	☑
Observable deficiencies recorded	Weekly	Foliage test if suspicious	N/A
Tissue testing	Monthly	~~After transplant,~~ pre in-row closure (side dressing), post harvest	MS10
Pest and disease presence	Weekly	~~Sticky traps,~~ Relative Slug Activity	Underway
Maturity date	TBC	Seed length- measured by picking the biggest bean on 5 plants from 4 subplots/plot, getting the largest seed from each bean and lining them up and measuring. Completed every 2 - 3 days	N/A
Record applied nutrients	1/02/25	All granular and foliar nutrient applications recorded	☑
Record agrichem applications	1/02/25	All herbicides, insecticides, fungicides applications recorded in ProductionWise	☑
Record biological product applications	1/02/25	All biological product applications recorded	☑
Record irrigation events	1/02/25	By linear as required according to monitoring, all treatments same	☑
Soil moisture probe	Weekly	LandWISE –GroPoint sensors to 90cm (15cm intervals) and neutron probe via Tipu Services	☑
Water sensitive paper testing	1/02/25	Ahead of first spray applications	N/A
Soil temperature	Weekly	In planting line (GroPoint sensors)	N/A
EIQ Risk Assessment calculated	Ongoing	AgChem applications https://cals.cornell.edu/new-york-state-integrated-pest-management/risk-assessment/eiq/eiq-calculator	☑
Outreach field day	Monthly	Monthly crop field walks	☑

1.3 Seasonal weather

The early crop of peas was planted when soil moisture was high. Using a heavy planter on wet, weakly structured soil has had a significant effect on soil condition, particularly in the Hybrid treatment. Following planting conditions were dry, and only 46.7 mm of rainfall was received between planting and harvest, so the crop was regularly irrigated. We experienced warm air temperatures, nearing 29°C during the pea crop. Average daily maximum temperature was 20°C from September through to end November.

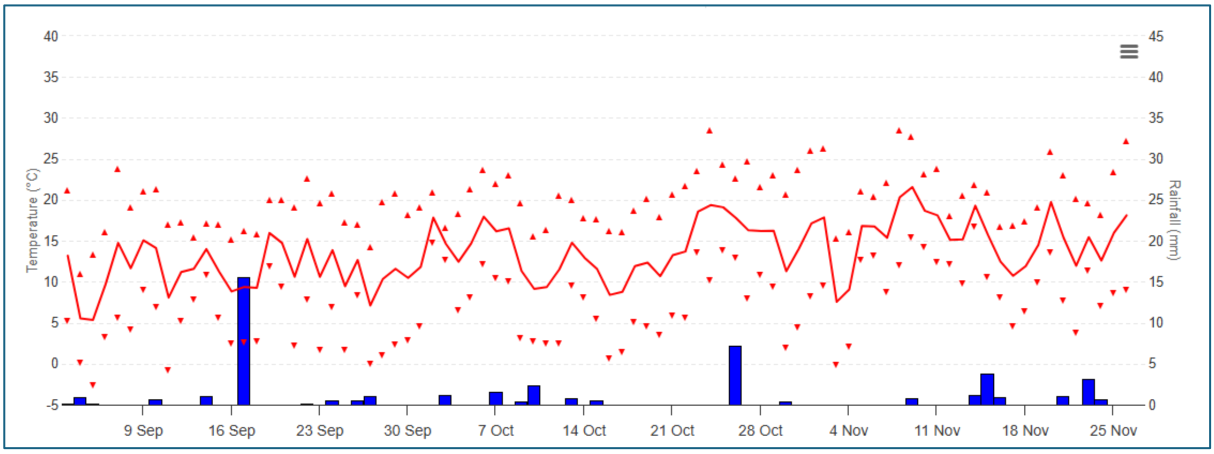


Figure 1 Temperature and Rainfall data (Ruahapia Road Weather Station 3rd September – 26th November, retrieved from HortPlus MetWatch)

Between pea harvest and bean planting, we received 56.3 mm of rainfall, 45 mm of which was received in the two weeks before planting. This rainfall had the potential to delay planting, however through careful monitoring, alongside McCain and Nicolle Contracting it was decided that conditions on our target date were optimum.

Soil moisture was adequate through the first part of January, as we received 36 mm rainfall between the 28th of December and 12th of January. Irrigation for the beans started with a light application on the 12th of January, the second application began on the 15th of January. Air temperatures have been more moderate since beans were planted, not exceeding 27°C, the average daily maximum is 21.2°C.

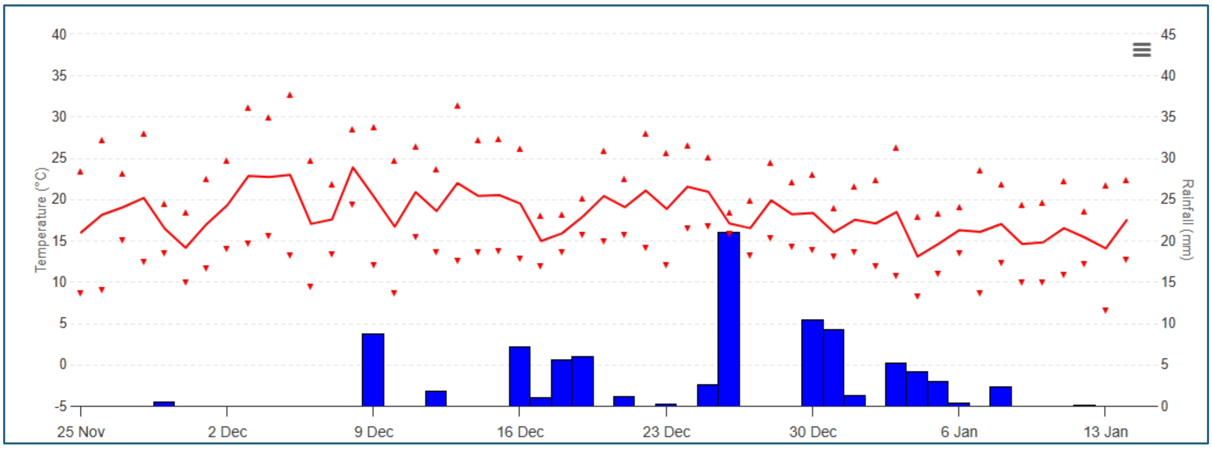


Figure 2 Temperature and Rainfall data (Ruahapia Road Weather Station 25th November – 14th January, retrieved from HortPlus MetWatch)

2 Spring soil monitoring

2.1 Labile carbon sampling

Sampling was carried out after peas had been sown in the conventional and hybrid treatments, and regenerative treatment left in cover crop.

2.2 Bulk density (g cm-3)

Table 1 Showing Bulk density by treatment at different depth intervals

Sample Depth	Conventional	Hybrid	Regenerative	Average
0-150	1.50	1.52	1.37	1.46
150-300	1.47	1.53	1.40	1.47
300-600	1.55	1.58	1.49	1.54
0-300	1.49	1.52	1.38	1.46
0-600	4.53	4.63	4.25	4.47

In the surface 150 mm, there was no significant difference between the conventional and hybrid treatments ($p=0.058$) but there was between the hybrid and regenerative and conventional and regenerative treatments ($p<0.001$). In the 150-300 depth band, the conventional and hybrid ($p=0.146$) and conventional and regenerative treatments ($p=0.168$) showed no significant difference, but the hybrid treatment was more dense than the regenerative treatment ($p=0.008$). Similarly, at 300-600 mm, there was no significant difference between the conventional and hybrid or conventional and regenerative ($p=0.127$) treatments, but the regenerative treatment was less dense than the hybrid ($p=0.018$) treatment.

Overall, after cultivation and planting the pea crop in the conventional and hybrid plots while leaving the regenerative plots in cover crop, the soil bulk density in the regenerative treatment was less dense than the other two treatments. The no-till hybrid treatment was slightly, but not significantly, more dense than the fully cultivated conventional treatment.

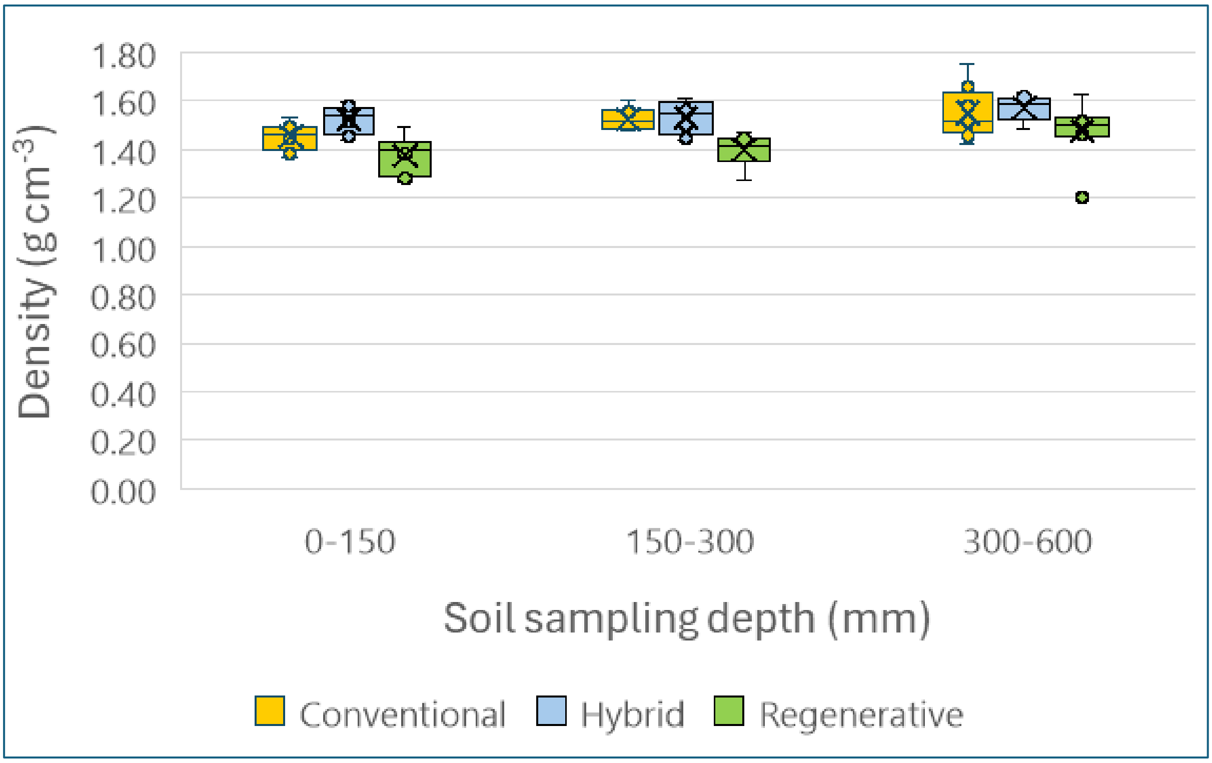


Figure 3 Box plot showing spring 2024 soil bulk density (g/cm^3) by depth, by treatment

2.2.1 Hot Water Extractable (Labile) Carbon (T ha-1)

Table 2 Showing Hot Water Extractable Carbon (T/ha) by treatment at different depth intervals

Sample Depth	Conventional	Hybrid	Regenerative	Average
0-150	1.86	1.74	1.49	1.70
150-300	1.90	1.89	1.84	1.88
300-600	1.65	1.82	1.71	1.73
0-300	3.76	3.63	3.33	3.57
0-600	5.41	5.45	5.04	5.30

The hot water extractable carbon (HWEC) was not significantly different between treatments. Overall, the average value 0-600 mm was lower in the regenerative treatment (5.04 T ha^{-1}) than the conventional (5.41 T ha^{-1}) or hybrid (5.54 T ha^{-1}) treatments and the regenerative treatment also showed greatest variation.

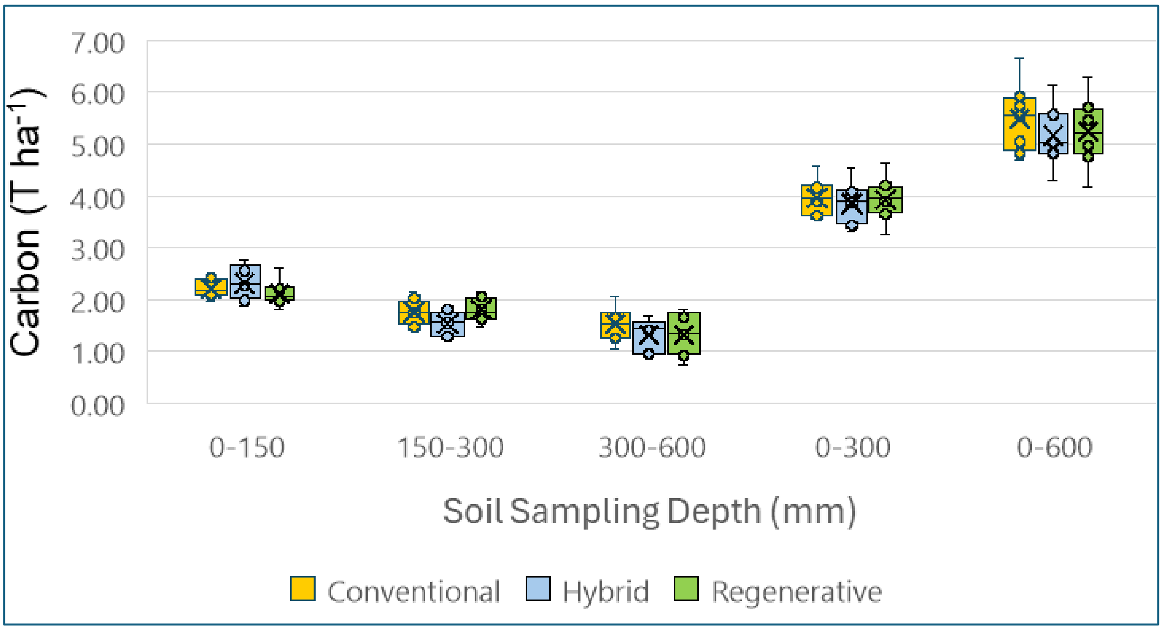


Figure 4 Box plot showing spring 2024 soil Hot Water Extractable Carbon (T/ha) by depth, by treatment

2.2.2 Microbial Biomass Carbon (T ha-1)

Table 3 Showing Microbial Biomass Carbon (T/ha) by treatment at different depth intervals

Sample Depth	Conventional	Hybrid	Regenerative	Average
0-150	0.32	0.30	0.27	0.30
150-300	0.32	0.32	0.32	0.32
300-600	0.28	0.31	0.30	0.30
0-300	0.63	0.62	0.59	0.62
0-600	0.91	0.94	0.89	0.92

Average microbial biomass carbon (MBC) was slightly but not significantly higher in the conventional than hybrid or regenerative treatments in the surface 150 mm and slightly but not significantly lower in the deeper 300-600 mm soil. Note that estimated soil microbial biomass carbon is calculated from HWEC, using published (Ghani et al, 2003) correlation equation: MBC_{est} = HWEC x 0.13 + 26. Therefore, the minor differences between HWEC and MBC are the result of estimated "below detection level" values.

2.2.3 Hot Water Extractable Organic Nitrogen (T ha-1)

Table 4 Showing Hot Water Extractable Organic Nitrogen (T/ha) by treatment at different depth intervals

Sample Depth	Conventional	Hybrid	Regenerative	Average
0-150	0.18	0.15	0.13	0.15
150-300	0.16	0.16	0.15	0.16
300-600	0.16	0.15	0.14	0.15
0-300	0.34	0.31	0.28	0.31
0-600	0.50	0.46	0.42	0.46

Hot water extractable organic nitrogen was slightly but not significantly higher in the conventional than hybrid or regenerative treatments at all depths, possibly reflecting longer spray-out of the winter cover crop and extra cultivation prior to pea sowing.

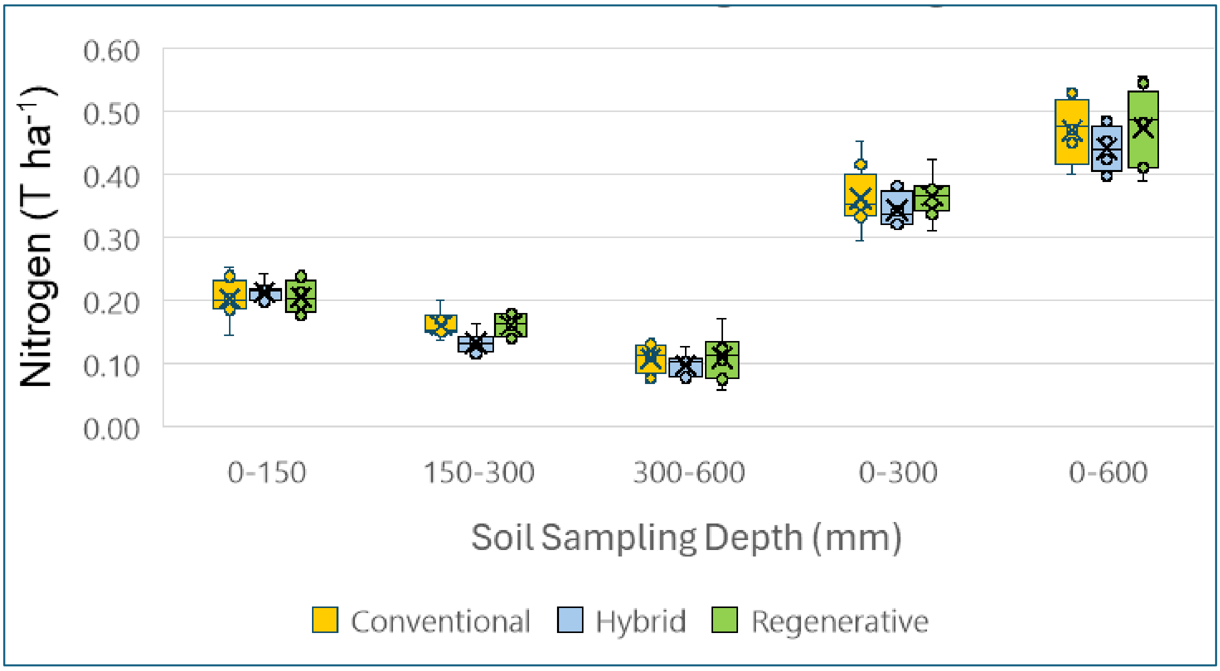


Figure 5 Box plot showing spring 2024 soil Hot Water Extractable Nitrogen (T/ha) by depth, by treatment

2.2.4 Potentially Mineralisable Nitrogen (T ha-1)

Table 5 Showing Potentially Mineralisable Nitrogen (T/ha) by treatment at different depth intervals

Sample Depth	Conventional	Hybrid	Regenerative	Average
0-150	0.17	0.14	0.13	0.14
150-300	0.15	0.15	0.14	0.15
300-600	0.15	0.14	0.13	0.14
0-300	0.32	0.29	0.27	0.29
0-600	0.47	0.43	0.40	0.43

Potentially Mineralisable Nitrogen was also slightly but not significantly higher in the conventional treatment and lower in the regenerative treatment at all depths, again possibly reflecting longer spray-out of the winter cover crop and extra cultivation prior to pea sowing in the conventional plots.

2.3 Visual Soil Assessment

Spring Visual Soil Assessments (VSAs) were completed in late November. Four VSAs were done per plot within the 4m long sub-plots from which most other data is collected.

A modified VSA score card is used, which includes structure, porosity, colour, mottles, tillage pan and earthworms but excludes degree of clod development and soil erosion. A score <8 is Poor, 8 – 21 Moderate and >21 Good. The modified score card can be found in Appendix 1.

Table 6 Showing Spring Visual Soil Assessment scores and ranking, by treatment.

Treatment Plot Number	Weighted Soil Structure Score	Weighted Soil Porosity Score	Weighted Soil Colour Score	Weighted No. + colour of mottles Score	Weighted Tillage Pan (Fig. 6) Score	Weighted Earthworm Score	Earthworm Count	VS Ranking Score	VS Ranking
Conventional	3.56	1.88	2.00	3.94	1.91	0.13	1.38	13.41	Moderate
1	3.375	1.6875	2	4	2	0	0.3	13.0625	Moderate
6	3.375	2.0625	2	3.75	2	0.5	3.3	13.6875	Moderate
9	4.125	1.6875	2	4	1.875	0	0.5	13.6875	Moderate
11	3.375	2.0625	2	4	1.75	0	1.5	13.1875	Moderate
Hybrid	2.81	2.20	2.50	4.00	1.69	1.00	3.81	14.20	Moderate
2	2.625	2.4375	2	4	2.5	2.5	8.0	16.0625	Moderate
4	2.8125	2.0625	2	4	1	0.5	2.5	12.375	Moderate
8	2.4375	2.25	4	4	2	1	2.8	15.6875	Moderate
12	3.375	2.0625	2	4	1.25	0	2.0	12.6875	Moderate
Regenerative	4.03	3.77	3.25	4.00	4.00	3.25	12.13	22.30	Good
3	3.75	3.9375	4	4	4	3.5	13.8	23.1875	Good
5	4.125	4.0125	3	4	4	4	14.8	23.1375	Good
7	3.9375	3	3	4	4	3	10.8	20.9375	Good
10	4.3125	4.125	3	4	4	2.5	9.3	21.9375	Good

Comparing the overall VSA Ranking Scores, the Regenerative treatment is significantly higher than both the Conventional and the Hybrid treatments ($p < 0.001$) which are not significantly different to one another.

The scores achieved by each treatment can be related to the winter/spring management. The main variation is in structure, porosity and presence of a tillage pan. In both the Conventional and Hybrid treatments, cultivating and planting peas when the soil was wet has impacted structure and porosity, and contributed to the development of a tillage pan (at slightly different depths in each treatment).

Figure 6 shows average Visual Soil Assessment scores determined since project initiation. Between tomato planting in October 2023 and June 2024, several months after winter cover crop establishment, VSA scores improved across all treatments. The Regenerative treatment scored in the *Good* range, while the other treatments scored *Moderate*. November sampling found the Regenerative treatment, which had remained in winter cover crop, still scored in the range of *Good*. The scores of the other two treatments had dropped, with the lower scores attributed to mechanical damage resulting from planting early peas in wet soil.

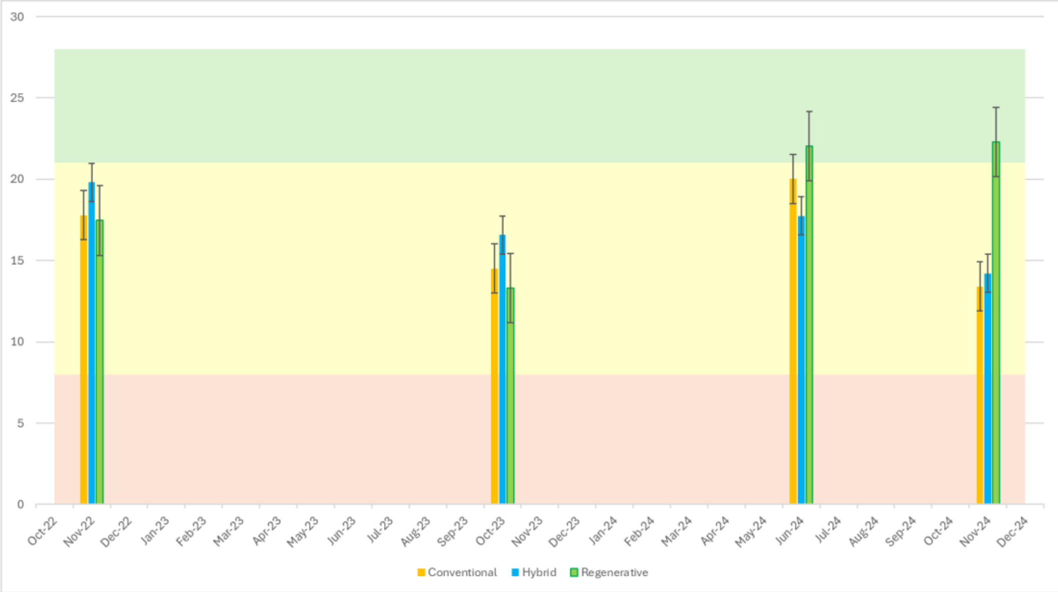


Figure 6 Clustered column chart showing average Visual Soil Assessment Scores over time, by treatment. Coloured bands relate to total ranking score <8 Poor (red), 8 – 21 Moderate (yellow), >21 Good (green). Error bars show the range of scores for each treatment.

2.4 Earthworm eDNA

Earlier this year, Hill Laboratories announced a new soil test for earthworm eDNA, specifically assessing *Aporrectodea caliginosa*, New Zealand's most common earthworm species. The test is currently calibrated to 7.5 cm deep pastoral soil samples, and not to 15 cm samples used for cropping soils. We have engaged with Hill Labs and AgResearch co-developer Dr Nicole Schon regarding the potential application of the test to horticultural or cropping soils. When our spring VSA assessments were completed, all the earthworms found were collected and sent to Nicole for identification. Soil samples were collected to 15 cm depth from each plot and sent to Hills for analysis.

The data collected and analysed showed somewhat positive correlations between earthworm numbers and *A. caliginosa* eDNA. Given the time of year the test was completed the earthworm populations were low, which was seen in the test results. We will explore options for a project strengthening the test for 15 cm samples from horticultural soils

3 Cover crop termination – Regenerative treatment

The Regenerative treatment was planted in a diverse mix of black oats, vetch, buckwheat, tillage radish, sunflower, crimson clover and Persian clover. Regenerative plots were not planted in a pea crop. The cover crop remained actively growing for a month after peas were planted in the other two treatments. The exclusion of peas from these plots aimed to reduce the intensity of the treatment, leave the soil in a restorative phase for longer after the intensive tomato crop, and avoid driving heavy machinery on wet soils.

We planned to leave the cover crop growing until approximately one month ahead of bean planting and would terminate mechanically with a roller crimper. The beans would be direct drilled into the remaining mulch. The key to success for this plan was that all species in the mix would get to a critical stage of maturity (different for each species) at the same time, allowing them to be killed effectively by the roller crimper. This is a no-till, no-herbicide way of ground preparation pre-crop. At the end of winter, the dominant species were oats and tillage radish. The buckwheat and sunflowers were killed by early frosts, and the legumes had just started to grow significantly as conditions warmed.

By late September the radish was flowering prolifically and there was a risk that the plant would set and shed viable seed. In places, the radish had hit the tillage pan (not gone through it as anticipated) and had popped themselves up to 12 cm out of the ground (Figure 7).

Figure 7 Radish flowering with new pods developing (left) and radish root pushing up out of the ground (right).

At the time, the oats were still some way off flowering, so the timing of the two species was not conducive for the roller crimper to work. The Operations Advisory Group decided to mulch the cover crop on the 1st of October to stop the radish flowering (Figure 8).

Figure 8 Regen cover crop being mulched.

A biological digestor plus liquid nitrogen fertiliser was applied before and after the plots were disced lightly to mix soil with the plant residues, aiming to enhance breakdown and promote nutrient release. The plots were then left undisturbed for nearly two months until the end of November. Over this time the oats and some vetch and radish regrew, and some weeds established, which meant further intervention was required to terminate the cover crop.

The Regenerative plots were disc-ripped and rolled at the same time the other two treatments were worked after pea harvest. This aimed to cut off and bury the oat regrowth, level the surface, and create a seed bed for bean planting (Figure 9).

Figure 9 Disc ripper working all treatments

4 Year 3 Spring crop monitoring – Peas

4.1 Canopy development

Canopy cover is measured weekly in all treatments using the Canopeo phone application, which measures fractional green canopy cover (FGCC). FGCC can be used to estimate canopy development and light interception. Figure 10 shows the canopy cover in all treatments from the time of planting peas through to harvest.

The chart shows that the Hybrid treatment pea crop was slower to establish than the Conventional treatment and never achieved the same canopy cover percentage. This reflects the lower measured plant populations in the Hybrid plots. The soil was wetter and soil temperature lower in the Hybrid treatment and the planter left defined slots leaving some seed exposed, which may have been targeted by birds or slugs.

The Regenerative treatment was not planted in peas, but canopy cover was still measured while in the cover crop and after the cover crop was terminated. Figure 10 shows that after termination, the canopy covers slowly increased. This is due to oat, vetch and radish regrowth.

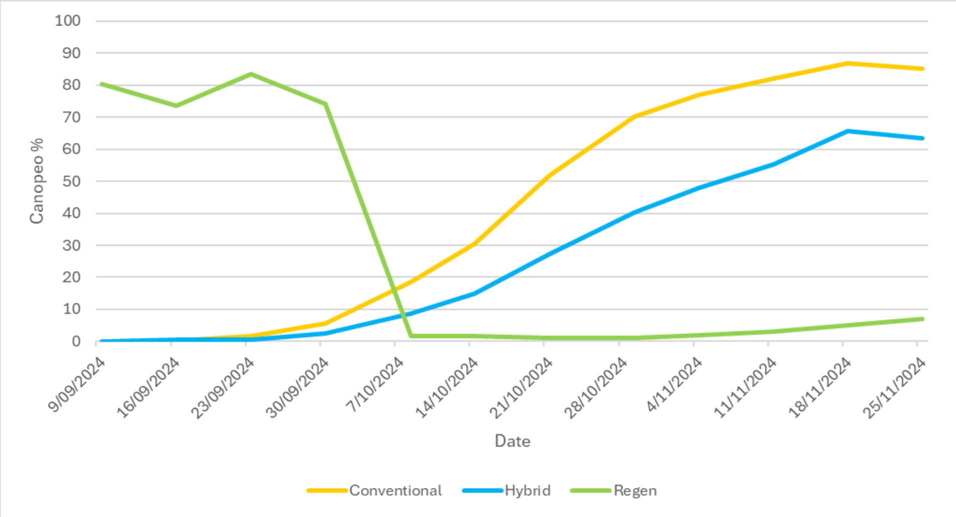


Figure 10 Line chart of canopy cover percentage by treatment from pea planting through to

The Regenerative treatment was left fallow for nearly two months while the peas were growing and will remain so for another two months before the bean crop is planted. This is a very long time to have very few living roots and exposed soil.

4.2 Soil temperature

Soil temperature was measured for the first three weeks after planting. Lower soil temperatures in the Hybrid treatment probably contributed to the slower establishment in these plots (Figure 11).

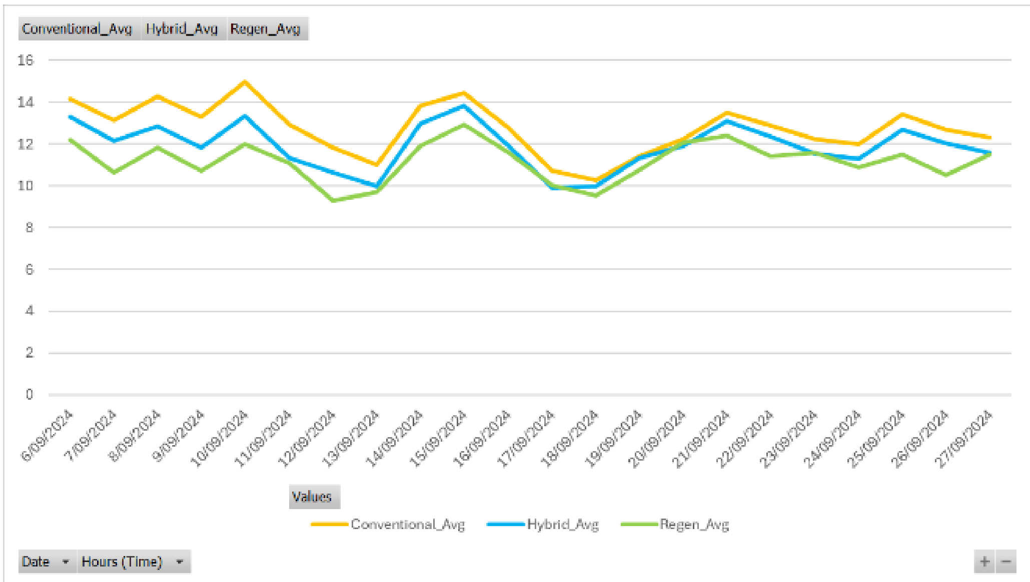


Figure 11 Line chart showing average daily soil temperatures at seed sowing depth (post planting) by treatment, (retrieved from MS 8 report.

4.3 Agronomic observations

Weekly Operations Advisory group field walks held from pea planting through to harvest were well attended by both McCain Foods and Heinz-Wattie's as well as growers and technical field staff as required. In comparison to last year's tomato crop, peas are in the ground for less time and have significantly fewer inputs. The group paid particular attention to the Regenerative treatment management and possible next steps. There were many discussions about soil condition in the treatments and the overall Regenerative philosophy which has been a welcomed addition to the crop agronomy discussion.

After planting, a pre-emergence herbicide is typically applied, followed by a minimum of 10 mm of water. With no rain forecast, and no need to irrigate, the pre-emergence herbicide was not applied, as for McCain pea crops this year. A post-emergence herbicide was applied across both treatments. Both treatments were relatively weed free until wireweed took off in some places toward the end of the season.

A fungicide was recommended for application in early to mid-November. Due to the warm, dry season the crop was maturing faster than anticipated and we were too close to the harvest window to apply the fungicide, which had a 14 day pre-harvest interval. The fungicide was not applied, however disease pressure was low, and there was no adverse effect to the crop.

4.4 Soil Nitrate Quick Test

Soil nitrate levels were measured fortnightly in all three treatments using the Nitrate Quick Test and FAR conversions. Nitrate was measured at 0 – 15 cm and 15 – 30 cm increments. Through to late winter, nitrate levels were similar across treatments. In late July the Conventional and Hybrid were sprayed out, terminating their cover crops. The gradual increase in the amount of soil available nitrogen where peas were planted probably results from cover crop decomposition. The Regenerative treatment cover crop continued growing, using and thus reducing the amount of available soil nitrate. In early October, the Regenerative cover crop was mulched, terminating much of the crop. Nitrogen in the cover crop began to be released through October, but the plots were in fallow.

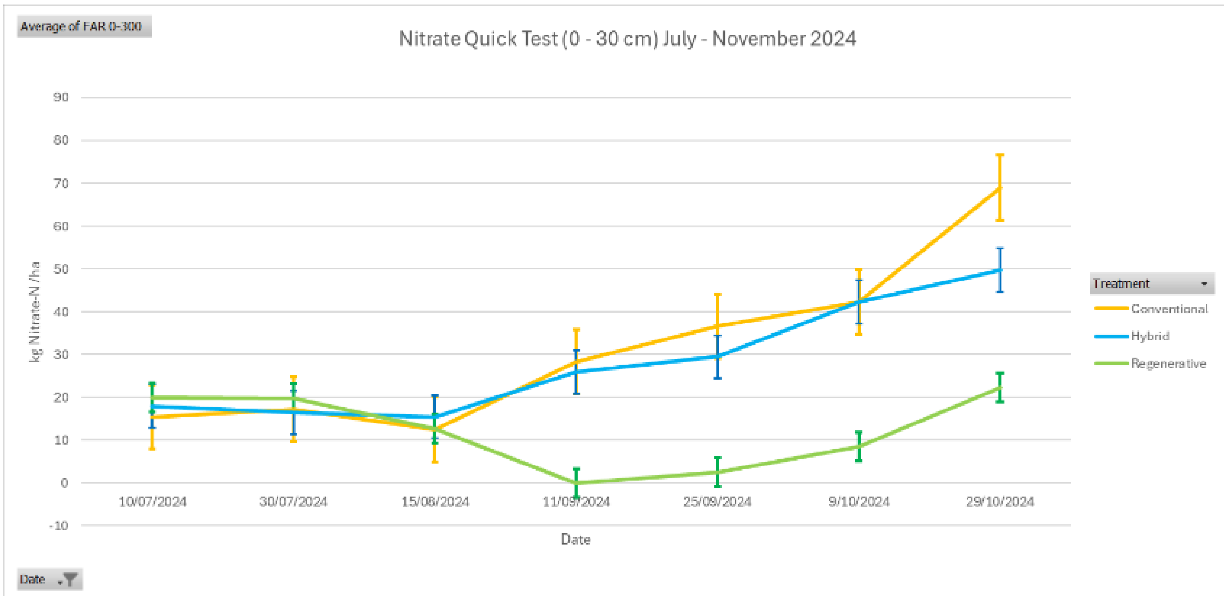


Figure 12 Line chart showing available nitrogen (kg N/ha) at 0 – 30 cm from July to November 2024, by treatment

4.5 Observable deficiencies recorded

No observable deficiencies recorded.

4.6 Tissue testing

Tissue testing only completed at harvest.

4.7 Pest and disease presence

No significant pest or disease pressure observed.

4.8 Record applied nutrients

No nutrients were applied to peas in the Conventional or Hybrid treatments. The Regenerative treatment had two applications of dissolved nitrogen applied with a bio stimulant.

Table 7 Regenerative treatment nutrient applications

Product	Product Nutrient %	Application rate/ha	Nutrient applied/ha
Ammonium sulphate	21% N 24% S	20 kg/ha	4.2 kg N/ha 4.8 kg S/ha
Low biuret urea	46% N	20kg/ha	9.2 kg N/ha

4.9 Record agrichemical applications

4.9.1 Herbicides

4.9.1.1 Conventional and Hybrid Treatments (Pea crops)

Lack of moisture meant a pre-emergence spray was not required and only a post-emergence herbicide was applied when leaf wax levels were adequate to avoid damage to the pea plants. Wax levels are impacted by external factors like irrigation, rainfall and hot sunny weather, and were checked using the Crystal Violet test. The application followed irrigation and was split over two days to allow wax build up.

Table 8 Herbicide applications- Conventional and Hybrid Treatments

Action	Type	Product	RateL/ha	Water Rate	Application Date
Spraying out	Herbicide	Weedmaster Ts470	4.5	300	30/07/2024
Spraying out	Herbicide	Sharpen	0.015	300	30/07/2024
Post- emerge Plots 1 ,2, 8, 9	Herbicide	Bruno Quantum	2.5 0.2	300	17/10/2024
Post-emerge Plots 4, 6, 11, 12	Herbicide	Bruno Quantum	2.5 0.2	300	18/10/2024

4.9.1.2 Regenerative treatment (no pea crop)

No herbicides were applied to the Regen treatment between end of July and end of November 2024.

4.9.2 Fungicides

The pea seed used for both the conventional and hybrid treatments was treated with Wakil XL, a fungicide used to control damping-off, Downy Mildew and *Ascochyta spp*. This is a standard seed treatment for pea seed in New Zealand. Wakil XL contains 175 g/kg Metalaxyl-M, 50 g/kg Fludioxonil and 100 g/kg Cymoxanil. The seed is treated with 2 kg of Wakil XL per tonne of seed and seed is sown at 220kg/ha.

No fungicides were applied to any treatment post-planting

4.9.3 Insecticides/Molluscicides

No insecticides were applied to any treatment.

Slug bait (Molluscicide) was applied to all treatments one month before pea planting. The Hybrid treatment had a second application at planting as this treatment was direct drilled. The Conventional treatment had been cultivated which would have reduced the population, and therefore did not warrant a second application.

Table 9 Insecticide/Molluscicide applications - all treatments

Slug bait applications	Conventional	Hybrid	Regenerative
29/7/2024	IronMax 7 kg/ha	IronMax 7 kg/ha	IronMax 7 kg/ha
3/9/2024	Nil	IronMax 7 kg/ha	Nil

4.9.4 Biologicals

Biological products were used in both the Hybrid and Regenerative treatments this spring.

Table 10 Biological applications - all treatments

	Conventional	Hybrid	Regenerative
3/9/2024 Pea planting	Nil	Trichoderma 0.21kg/ha	Nil
1/10/2024 Residue digestor	Nil	Nil	Digestor (Biostart) 4L/ha
14/10/2024 Residue digestor	Nil	Nil	Digestor (Biostart) 4L/ha

Trichoderma was used as a seed treatment in the Hybrid plots. Trichoderma is compatible with Wakil XL and has been used in Wattie's trials in the South Island where they have seen positive results with yield increases in beans and carrots. Trials for peas have been variable, which is typical of peas, however the OAG decided it would be worth including. The Trichoderma was hand-mixed on to the seed in a wheelbarrow on the morning of planting.

Biostart Digestor was used in the Regenerative treatment to enhance breakdown of the mulched residue and encourage the release of nutrients from the biomass grown over the winter. Two applications were applied with dissolved nitrogen, two weeks apart (one before mulching and one after).

4.10 Record irrigation events

All irrigation events have been recorded, by quadrant. There were six irrigation events for the peas. The Regenerative treatment, still in cover crop, was irrigated as well. In total 98 mm of water was applied to each plot.

Table 11 Irrigation application, by quadrant

Quadrant	Total irrigation applied (mm)
Q1 (Plots 1,2,3)	98
Q2 (Plots 4,5,6)	98
Q3 (Plots 7,8,9)	98
Q4 (Plots 10,11,12)	98

4.11 Soil moisture measurements

Soil moisture probes/tubes (GroPoint + Tipu Services) were removed from the plots before pea harvest. GroPoint sensors have been replaced after bean planting to avoid damage. The GroPoint soil moisture sensors continued to have problems in peas, and a neutron Probe service was engaged to provide weekly monitoring. Data collected from the pea crop using GroPoint sensors suggested there was inadequate sensor to soil connection, so a soil-slurry was used in the beans.

4.12 Neutron Probes

A neutron probe soil moisture report for Quadrant 1 (Blocks 1-3) is shown in Figure 13.

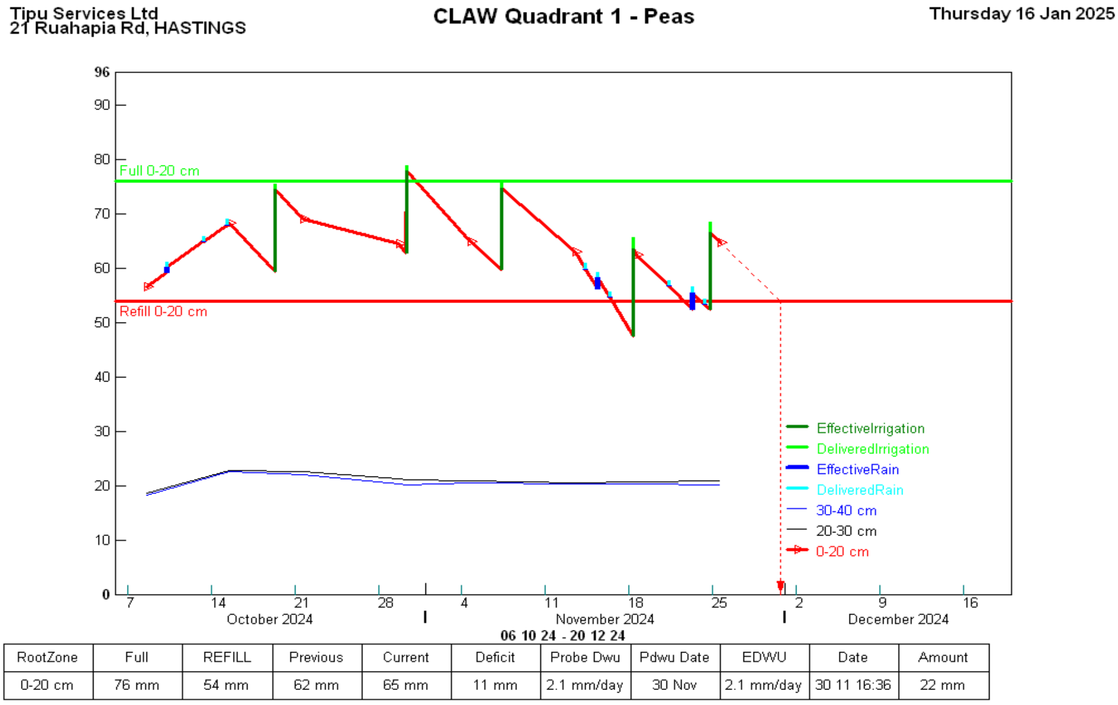


Figure 13 Soil moisture report provided by Tipu Services showing that irrigation was required and applied to avoid crop stress.

4.13 Water sensitive paper testing

Water sensitive paper is used to check efficacy of spray application. No insecticides or fungicides were applied to either treatment, so water sensitive paper was not used. This will be completed for the next crop.

4.14 EIQ Risk Assessment calculated

The Environmental Impact Quotient (EIQ) was calculated for each treatment. Products like IronMax slug bait, and biological products are not in the database so cannot be included in the calculation.

Table 12 Pea EIQ by treatment

Treatment	Field Use EIQ (converted to hectare)	Consumer EIQ (converted to /hectare)	Worker EIQ (converted to hectare)	Ecological EIQ (converted to hectare)
Conventional	319.3	93.4	592.8	272.1
Hybrid	319.3	93.4	592.8	272.1
Regenerative	N/A	N/A	N/A	N/A

The EIQ tool was updated in July 2024, with changes made to the background formula, so the actual EIQ scores are different to the planned ones. All previous EIQ scores will be updated accordingly. A full breakdown can be found in Appendix 3.

4.15 eDNA sample collection

Collection of eDNA samples was completed for Syrie Hermans (AUT) on the 10th of December, in line with previous sampling dates. Five cores were taken to 10 cm, bagged separately and submitted to Syrie for analysis.

5 Year 3 Spring crop harvested – Peas

The Carbon Positive McCain Foods pea crop was harvested on the 26th of November, approximately one week earlier than anticipated. Due to the warm, dry weather, crops around the region matured faster than expected and harvest dates were pulled forward. The peas were slightly less mature than optimum on the day of harvest. Due to McCain factory schedules, we had the option of the 26th of November or the next window potentially 10 days later, which would have been much too late. Plots were sampled by hand-harvesting in the morning to determine biomass and harvestable yield. The pea viner arrived at lunchtime. The hand-harvested samples along with samples collected directly from the harvester were processed that afternoon using the McCain Foods mini-viner in Waipawa.

5.1 Harvest data

5.1.1 Hand-harvest data

For hand-harvested yield, four subplots were measured per plot. In each sub plot, all plant material was removed from 2 x 1m^2 quadrats (one at each end of each 4 m long subplot). All material was placed into large plastic bags, transported to Waipawa and weighed. Whole vines were run through the McCain mini-viner to separate peas from the vine and pod. All peas removed were placed into a labelled bag and weighed to determine total pea fresh mass. From the separated peas and vines the following was measured:

- Tenderness Rating (TR) (McCain Foods TR meter, Waipawa)
  - A measure of pea maturity and factor in price paid for peas
  - Peas washed and subsample taken from peas that have been sorted by mini-viner. 1-2 TRs completed per sub-plot depending on volume of peas.
- Carbon and Nitrogen Lab Tests (Hill Laboratories)
  - One combined sample of peas per plot
  - One combined sample of residue per plot
- Dry matter % (Centre for Land and Water)
  - Subsample of peas dried at 65 C for three days
  - Subsample of residue dried at 65 C for three days.

5.1.2 Machine-harvest data

All plots in each treatment were harvested into one truck. Fresh weights of the pea in each plot were recorded from the pea viner, so a total plot weight could be determined. The total plot weight can be compared to hand harvested values but is not the value used to calculate paid weight. Four pea subsamples per plot were taken from the pea viner for TR analysis to compare with the subplot measurements. No individual plot factory scoring was completed.

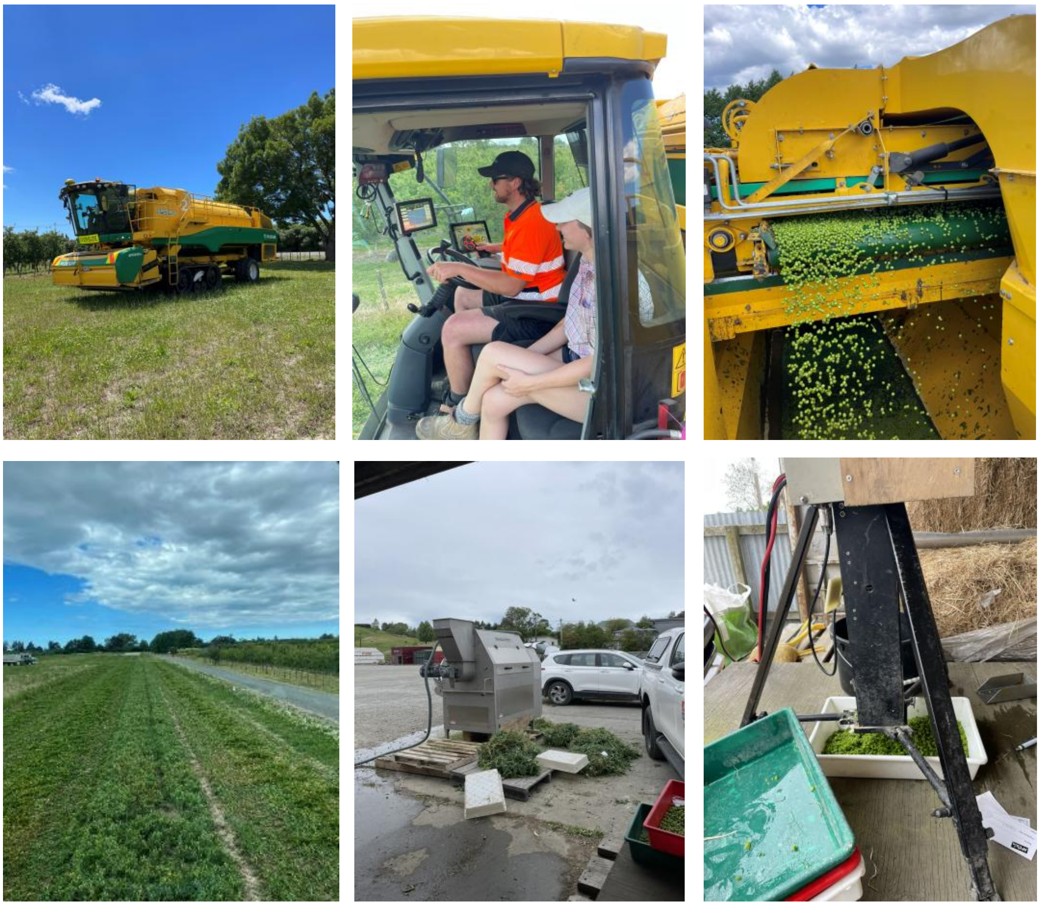


Figure 14 Photos from pea harvest 2024

5.1.3 Harvestable yield

The Conventional treatment grew significantly more peas that the Hybrid treatment (p<0.001) (Figure 15). The Conventional treatment produced an average of 5.74 T/ha of fresh weight peas, compared to 4.69 T/ha for the

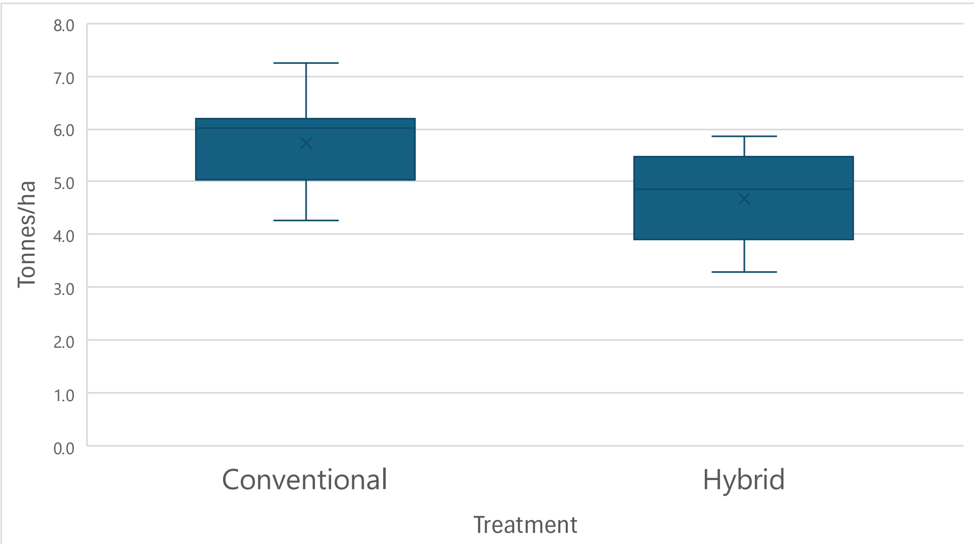


Figure 15 Box and whisker graph showing tonnes of peas harvested per hectare (hand harvest) by treatment.

Hybrid treatment. Our target yield was 6 T/ha, but we note that all Hawke's Bay pea crops are reported be much lower yielding this season.

5.1.4 McCain Foods harvestable yield

The pea viner harvested an average of 7 T/ha of pea fresh mass in the Conventional treatment and 4.5 T/ha in the Hybrid treatment (Figure 16). This also showed the Conventional treatment yielded more than the Hybrid treatment (p=0.001).

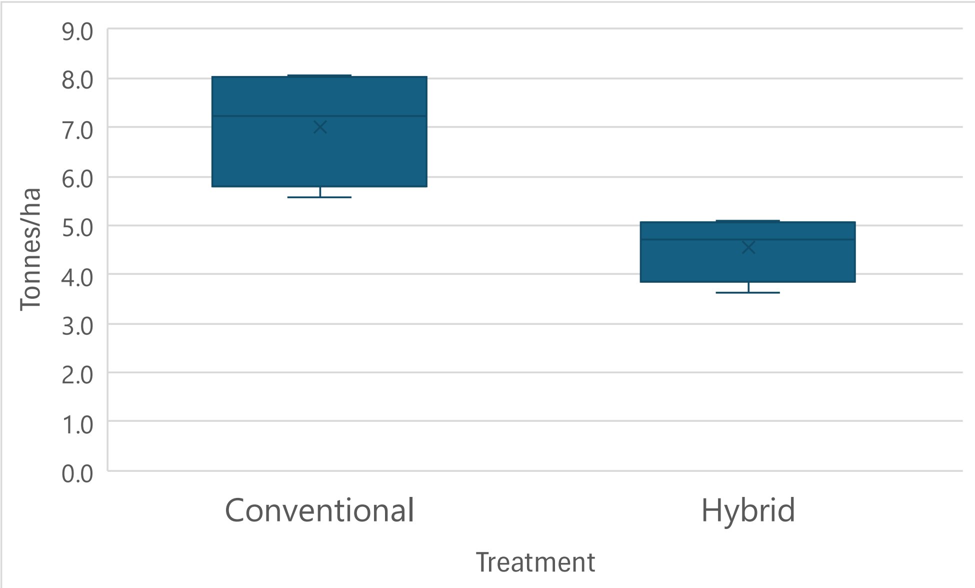


Figure 16 Box and whisker graph showing tonnes of peas harvested per hectare (machine harvest) by treatment.

5.1.5 Non-harvested yield

The total vine grown per hectare was determined pre-harvest from the hand-harvested plots. Almost all of this material was left in the field after harvest. The Conventional treatment grew on average 30.3 T/ha of fresh mass vine (including pods), compared to the Hybrids 24.4 T/ha (Figure 17). The Conventional treatment grew significantly more biomass ($p<0.001$)

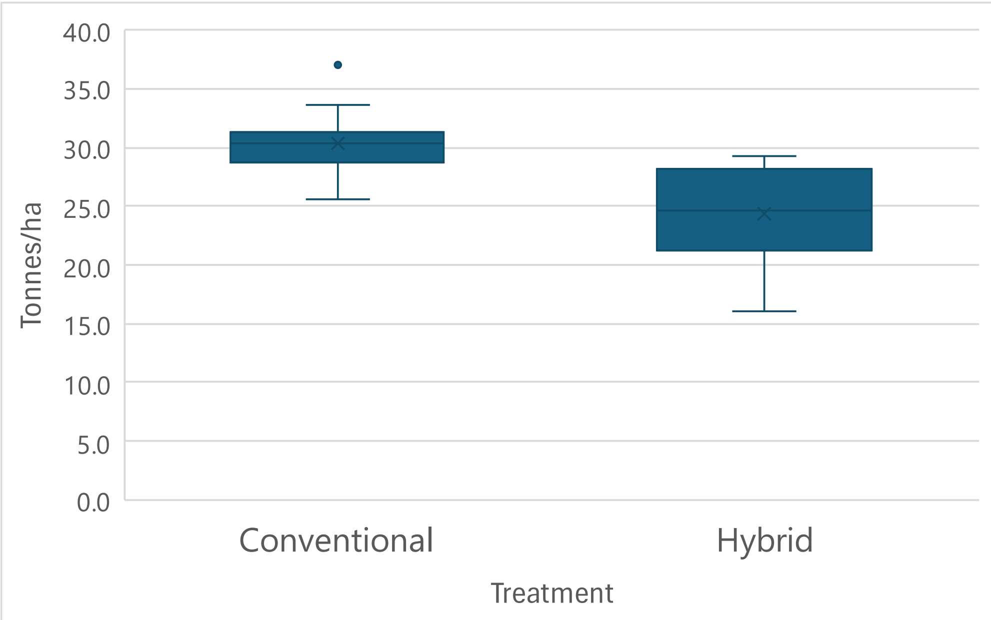


Figure 17 Box and whisker graph showing tonnes of vine grown per hectare, by treatment.

5.2 Factory quality assessments

5.2.1 Tenderness Rating (TR)

The only quality assessment measured for the peas was Tenderness Rating, a unit used to assess pea maturity and determine price paid per tonne of product. Typically, the lower the TR the higher the payment. The scale on the y axis is from 80 – 125, 80 is approximately the lowest TR reading possible, anything lower will be too

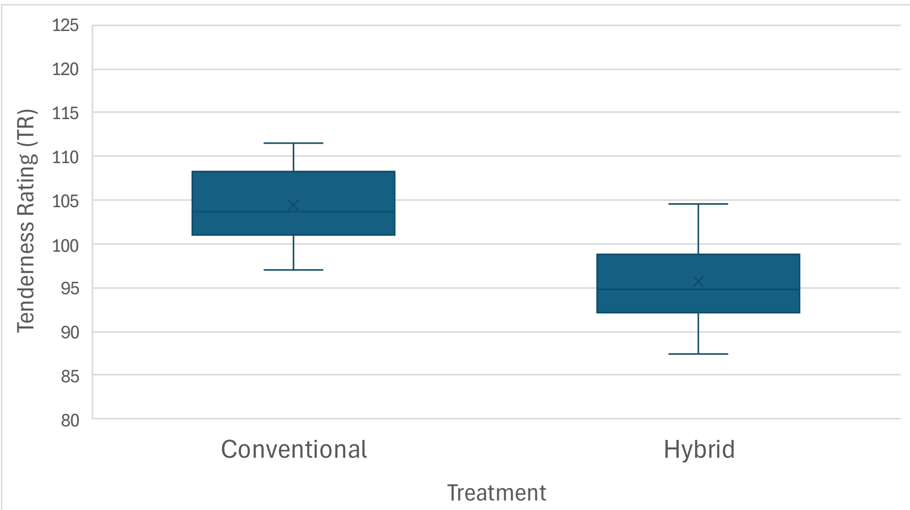


Figure 18 Box and whisker graph showing the peas tenderness rating, by treatment.

small to sample. Anything above 125 is in the lowest payment bracket on the factory schedule. The Conventional treatment was slightly more mature and had a significantly higher average TR of 104 compared to the Hybrid of 95 ($p<0.001$) (Figure 18).

5.3 Crop tissue N, C and DM%

5.3.1 Dry matter

A subsample of peas from each subplot was dried to determine dry matter percentage and then multiplied by the mass of vine hand harvested. The Conventional treatment average dry matter percentage was 20.36%, was significantly higher than the Hybrid treatment at 19.69% ($p=0.00017$). This difference likely relates to the maturity of the peas in each of the treatments.

When compared to total amount of dry matter per hectare (Figure 20), there is no significant difference in total dry matter in the peas ($p=0.352$).

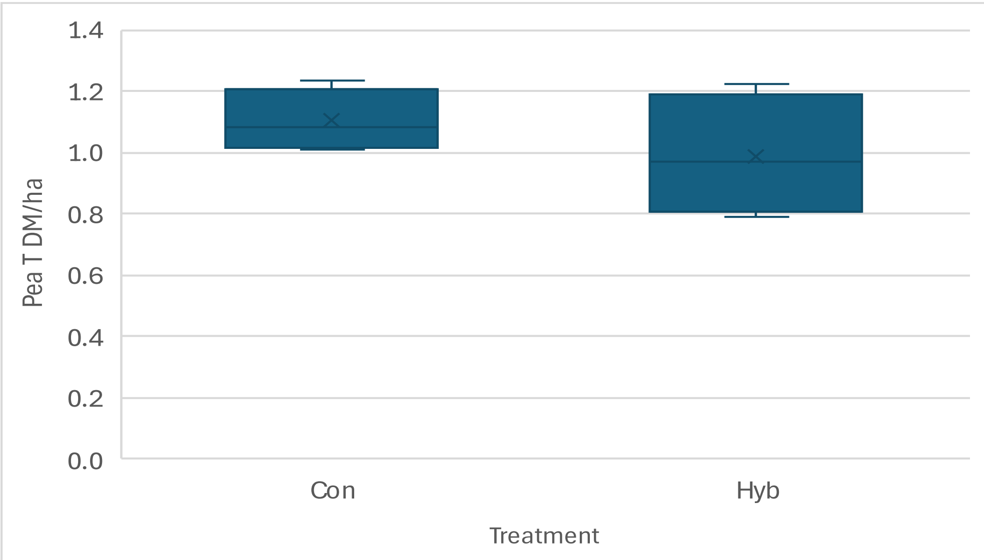


Figure 19 Box and whisker graph showing pea dry matter T/ha, by treatment.

5.3.2 Nitrogen

Crop tissue nitrogen percentage was determined by Hill Laboratories. The Conventional treatment had an average nitrogen percentage in peas of 4.3% versus 4.15% in the Hybrid treatment. This difference is not significant ($p=0.20$).

To determine amount of nitrogen removed in peas, the pea dry matter (T/ha) is multiplied by the laboratory determined nitrogen percentage (Figure 20). There is no significant difference in amount of nitrogen removed from Conventional and Hybrid treatments (p=0.250).

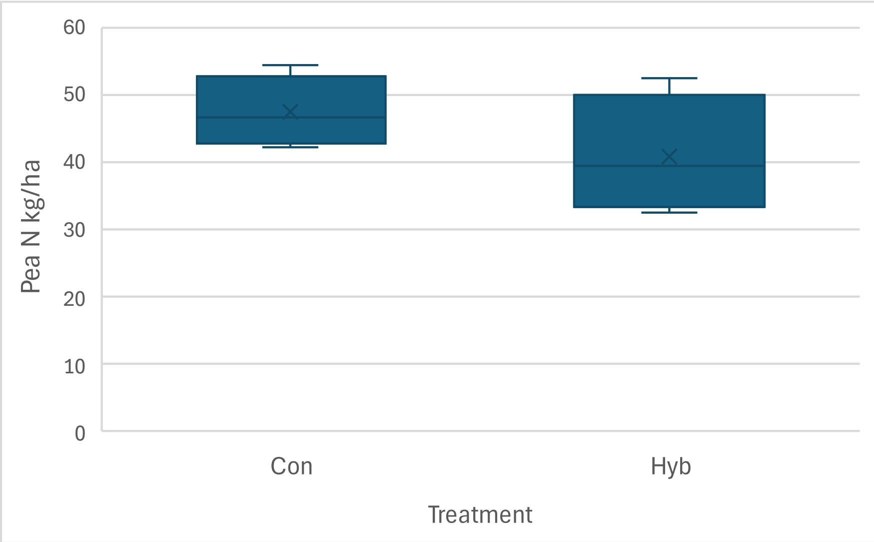


Figure 20 Box and whisker graph showing pea nitrogen amount kg N/ha, by treatment.

5.3.3 Carbon

Pea carbon percentage was determined by Hill Laboratories. The average carbon percentage in the Conventional treatment was 42.65%, which is statistically higher than the Hybrid treatment of 42.13% (p<0.001).

Amount of carbon removed in peas is calculated using the pea dry matter amount multiplied by carbon percentage completed by Hill Labs. The y axis scale has been adjusted to show treatment differences more clearly. The Conventional crop had significantly more carbon accumulated in the peas than the Hybrid (p=0.001), and therefore significantly more carbon was removed from the paddock at harvest (Figure 21).

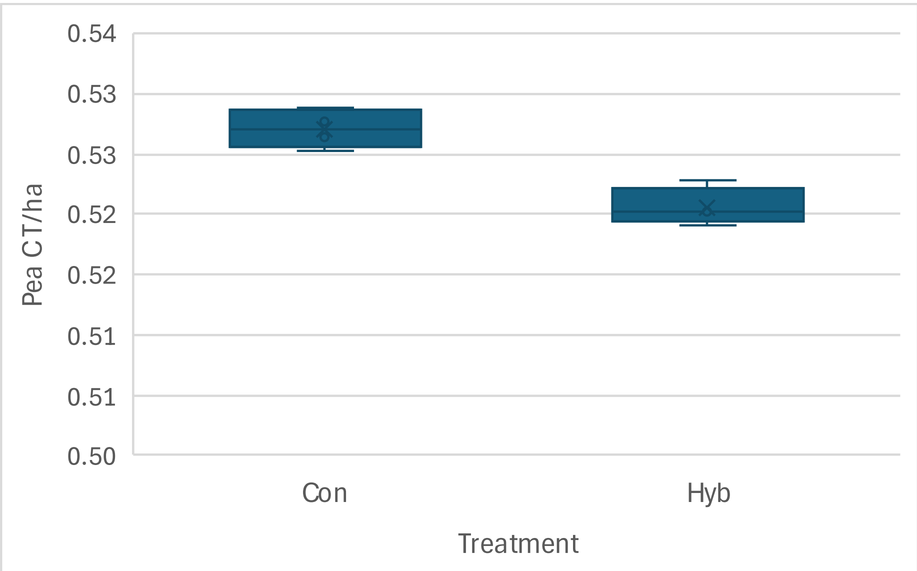


Figure 21 Box and whisker graph showing pea carbon amount T/ha, by treatment.

5.4 Residue tissue N, C and DM%

5.4.1 Dry matter

The fresh mass vine was subsampled and weighed to determine vine dry matter grown per hectare. The Conventional treatment had 5.3 T/ha of dry matter in vine and was significantly higher than the Hybrid treatment of 4.4 T/ha (p= 5.27 x 10-5).

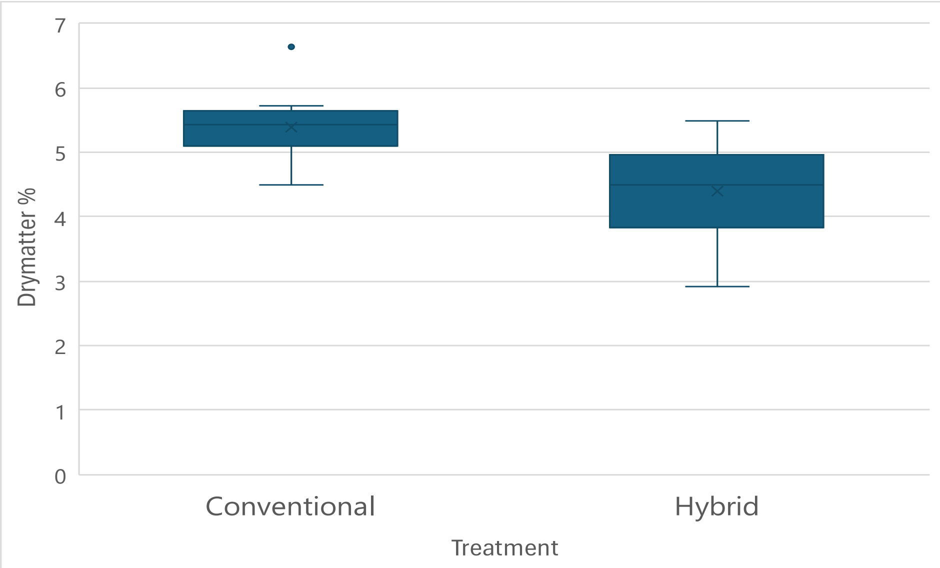


Figure 22 Box and whisker graph showing vine dry matter tonnes per hectare, by treatment.

5.4.2 Nitrogen

Vine residue was determined by Hill Laboratories. There was no significant difference in average nitrogen percentage between the Conventional treatment at 2.75% DM and the Hybrid treatment at 2.93% (p=0.127).

Nitrogen amount in residue is calculated using amount of dry matter in vine multiplied by the nitrogen percentage (to give kg/ha). This is mainly relevant for the Hybrid treatment, which had the residue retained vs the Conventional which had the residue baled (albeit not all residue is picked up by the baler). The nitrogen retained in dry matter, will likely be available to the following crop, rather than exported off farm. There was no significant difference between the treatments in the amount of N in pea vine residue (p=1.27) (Figure 23).

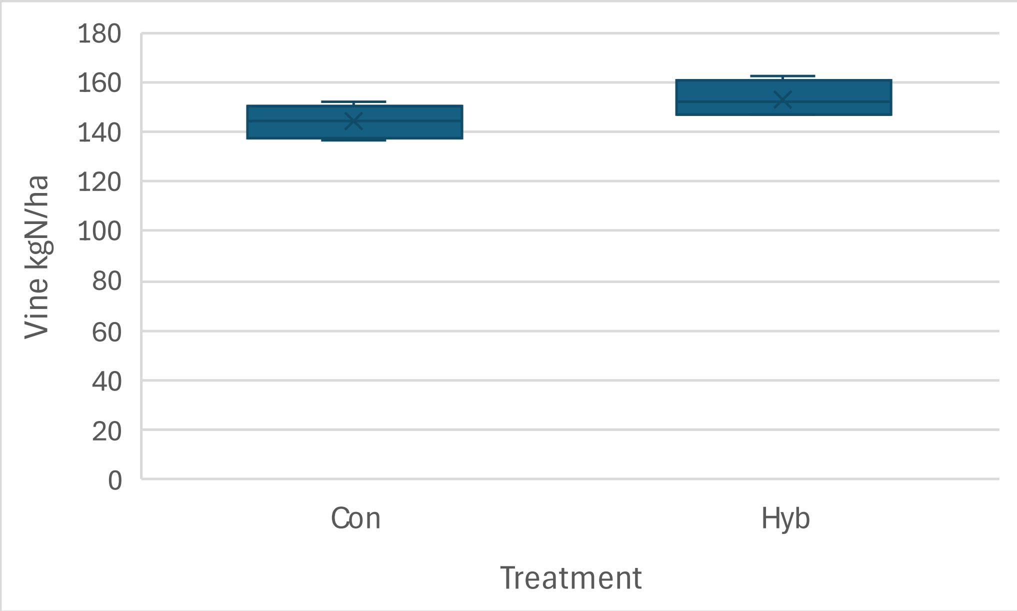


Figure 23 Box and whisker graph showing vine nitrogen amount, kilograms per hectare, by treatment.

5.4.3 Carbon

Carbon percentage of vine was determined by Hill Laboratories. The average carbon percentage of the Conventional treatment was 43.3% and the Hybrid 43.35%, with no significant differences between treatments (p=0.785).

Total amount of carbon in vine is calculated by multiplying vine dry matter by laboratory determined carbon percentage. The y axis has been adjusted to capture detail of data. There is no significant difference in amount of carbon in residue (p=0.78) (Figure 24). Some of the residue in the conventional treatment was exported off

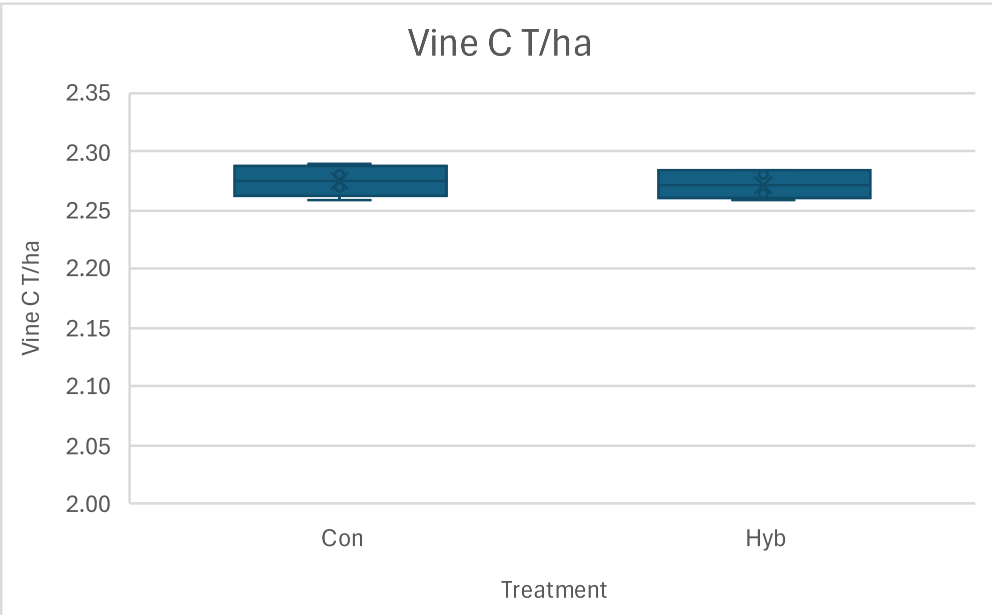


Figure 24 Box and whisker graph showing vine carbon amount tonnes per hectare, by treatment.

farm as bales, so some of this carbon has been removed from the system, where the residue in the Hybrid treatment has been retained.

5.5 Gross margins

Gross margins calculated for the Conventional and Hybrid treatments for the pea crop used estimated costs gathered from contractors using standard per hectare pricing, rather than research trial prices.

The price paid per tonne of peas varied between treatments, the Hybrid treatment, with a lower TR earned a higher price per tonne compared to the Conventional treatment.

The lease cost used is typical for the Heretaunga Plains for the period the peas were grown. It is higher than the McCain Foods estimated lease cost for peas which are more commonly grown on lower value and unirrigated land.

The Conventional treatment had the pea vine baled and sold, whereas the Hybrid had the vine incorporated to retain nutrients. On this basis, the Conventional treatment had an additional source of revenue above and beyond the peas. The value of retained nutrients in the Hybrid plots has not been considered but may show in future crops as a reduced demand for fertiliser.

Table 13 Gross margins for peas grown under Conventional and Hybrid treatment scenarios.

Sum of Gross Profit			
Item	**Conventional**	**Hybrid**	**Regen**
Land Lease	-$ 1,750.00	-$ 1,750.00	-$ 1,750.00
Pre Plant	-$ 1,114.63	-$ 304.63	$ -
Molluscicide	-$ 167.53	-$ 167.53	$ -
Ground Preparation	-$ 810.00	$ -	$ -
Herbicide	-$ 71.10	-$ 71.10	$ -
Spraying	-$ 54.00	-$ 54.00	$ -
Soil Test	-$ 12.00	-$ 12.00	$ -
Planting	-$ 1,010.40	-$ 1,302.23	$ -
Biostimulant	$ -	-$ 14.30	$ -
Molluscicide	$ -	-$ 167.53	$ -
Ground Preparation	-$ 85.00	-$ 85.00	$ -
Planting	-$ 195.00	-$ 195.00	$ -
Seed	-$ 730.40	-$ 730.40	$ -
Mulching	$ -	-$ 110.00	$ -
Growing	-$ 498.32	-$ 498.32	$ -
Herbicide	-$ 114.32	-$ 114.32	$ -
Irrigation	-$ 384.00	-$ 384.00	$ -
Harvest	$ 4,290.20	$ 3,757.50	$ -
Balage	$ 355.00	$ -	$ -
Grand Total	$ 271.85	-$ 97.68	-$ 1,750.00

The Conventional treatment had higher input costs as there were four tractor passes to prepare for planting. The Hybrid had some additional products such as Trichoderma applied. The Conventional treatment gross margin shows a small profit of $271.85. The Hybrid gross margin showed a small loss of $97.68. A full breakdown of treatment operational costs can be found in Appendix 4.

The Regenerative treatment, while not planted in peas, has incurred the cost of the land lease, but foregone the income from a crop. Thus, by excluding the pea crop, there has been a loss of income for this treatment. This will be reflected in the next gross margins, where the full cost of land lease for the Regenerative treatment will be charged to the beans, and only half for the other two treatments.

We note that establishing winter cover crops was accounted for in the Tomatoes' gross margin analyses, and the termination for Conventional and Hybrid in the Peas' gross margins. The cost of terminating the Regenerative cover crop will be accounted for in the Beans' gross margins.

6 Year 3 Summer crop established – Beans

6.1 Soil preparation

Soil preparation for beans is important for planting and harvest. A perfect seed bed will be as smooth as a 'billiard table' according to our contractors. An even planting surface is important for uniform germination, ideally with few large clods that may impact the efficacy of residual herbicides. For the harvester, a level surface ensures as many beans as possible are harvested, without picking up other extraneous vegetative material and soil.

Soil preparation for beans was the same across all treatments. The Conventional and Hybrid treatments (ex-peas) and the Regenerative treatment (ex-cover crop/fallow) were all disc ripped on the 28th of November, one month ahead of the target planting date. A disc ripper is a non-powered, primary cultivation implement. In a

Figure 25 Working disc ripper

single pass it can incorporate residue, alleviate compaction and level the soil surface. The disc ripper we used had a set of scalloped discs, followed by ripper legs, another set of scalloped discs, and then a packer roller. For the purpose of seed bed preparation, another roller was added to break up lumps and consolidate the soil.

At the end of spring, the Conventional and Hybrid treatments which had grown peas had more compaction issues than the Regenerative treatment which was left fallow.

Secondary cultivation i.e., power harrow, disc or strip till, was anticipated in the Conventional and tentatively in the Hybrid treatment once the soil had settled, aiming to break up the larger clods which had been brought to the surface.

To reduce weed pressure ahead of planting, we wanted to create a stale seed bed by leaving plots fallow after disc ripping, encouraging weed germination, and then spraying out. A power harrow pass 10-14 days ahead of planting would undo some of the work done to create a stale seed bed in the prior two weeks. The Operations Advisory Group determined that the seed bed created by the disc ripper was adequate for planting and no further cultivation was completed.

All plots were sprayed out with glyphosate + Kwickin on the 23 December 2024.

6.2 Planting

Beans were planted by Nicolle Contracting on the target date of 28th December 2024. The bean variety used was PV998 sown at 380,000 seeds/ha. Each treatment had a different fertiliser product or rate applied (see Applied Nutrients below). The Hybrid and Regenerative treatments had a Trichoderma biological seed treatment dusted on the seed.

Figure 26 Photos from bean planting

7 Year 3 Summer crop monitoring – Beans

7.1 Population

Beans were planted at 380,000 seeds/ha and began to emerge on the 3rd of January. Bean emergence/population was measured by counting 2 x 1 m of row in each of the four subplots per plot, once the first two leaves had unfurled. Population was counted from 11 days post planting to estimated full population at 17 days after planting (Figure 27).

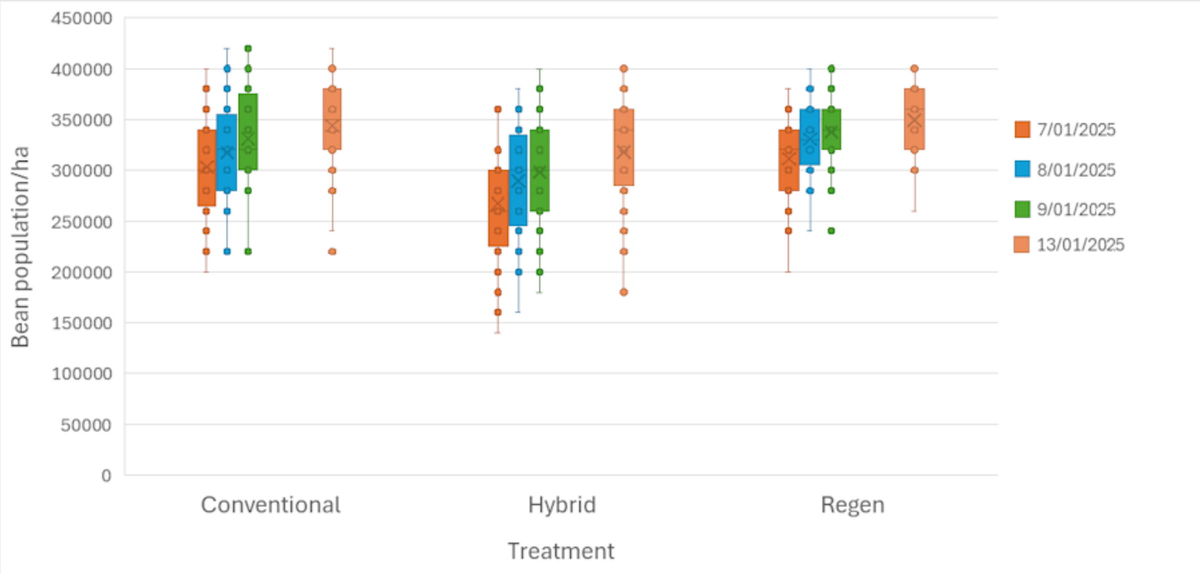


Figure 27 Box plot showing bean population 11 – 17 days post planting.

Population counts on the 13th of Jan showed no significant difference between the Conventional treatment and the Regen treatment (p=0.58). There was a significant difference between the Conventional and Hybrid (p=0.05) and the Hybrid and the Regenerative treatment (p=0.009). The Hybrid may have had a lower population due to slug damage, and measurement subplots may need to move to better represent the plots. This will be assessed with the McCain agronomists.

Table 14 Final population count, by treatment

Treatment	Final Population
Conventional	343750
Hybrid	318125
Regenerative	349375

7.2 Canopy development

Canopy development is measured weekly using the Canopeo App (slight change in scheduling due to Christmas break). The beans began to emerge on the 3rd of January (approx. six days after planting), and by the 6th of January, defined rows were visible. At the time of reporting growth plants have recovered from pre-emerge herbicide stress and canopy cover is starting to increase more rapidly.

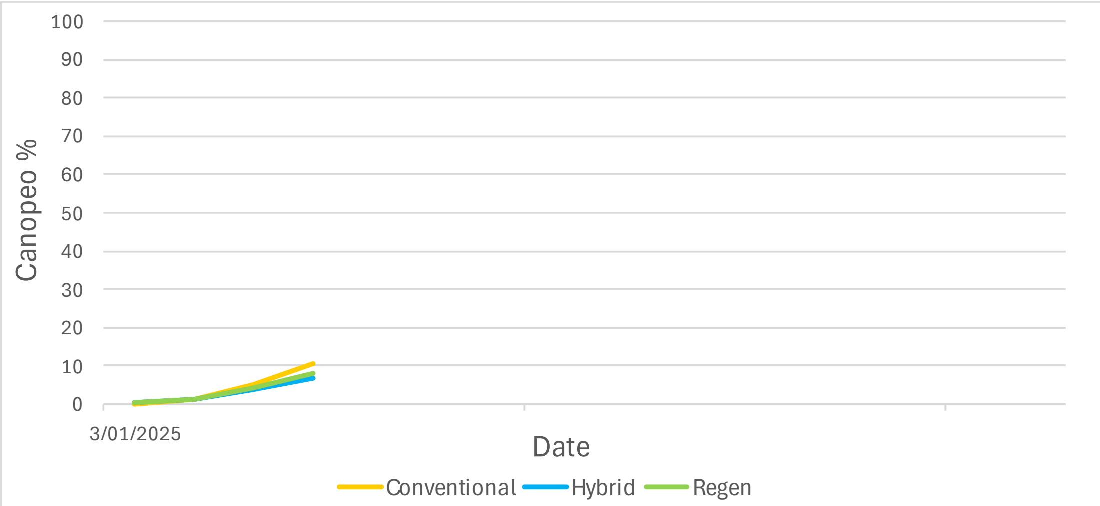


Figure 28 Chart showing bean canopy cover percentage, by treatment

7.3 Agronomic observations

Weekly field meetings continue to be attended by McCains, Heinz-Wattie's and other members of the OAG. Commentary to date has confirmed that emergence has been good and reasonably uniform. The plots are all relatively weed free, although a few volunteer peas, mallow and thorn apple have emerged.

The next action will be post-emerge herbicide application, which will be dictated by weed size and crop growth stage.

7.4 Soil Nitrate Quick Test

Soil nitrate levels in the top 30 cm of the soil profile, October 2024 – January 2025, are shown Figure 29.

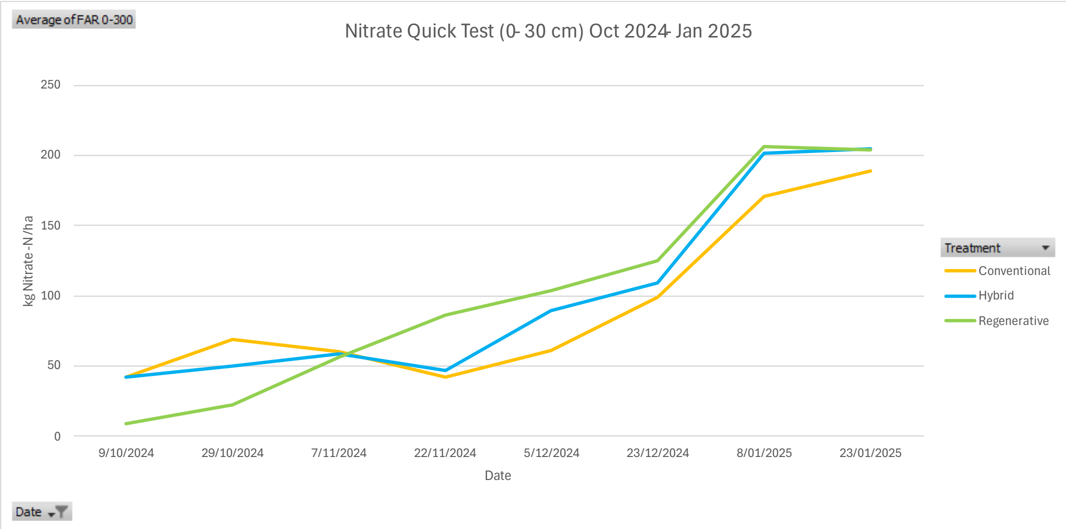


Figure 29 Line chart showing available nitrogen (kg N/ha) at 0 – 30 cm from July to November 2024, by treatment

The Regen cover crop was actively growing and using available soil nitrogen until it was mulched on the 7th of October. Soil nitrogen levels were rising but lower than the other two treatments through October. From early November, as the cover crop broke down, soil nitrogen levels continued to increase through December.

The Conventional and Hybrid treatments had similar N levels at the beginning of October. Both treatments had small increases in N early November, before dropping off toward the end of November at harvest, presumably because the peas were using available soil N.

After pea harvest, N levels in both treatments increased steadily, the Hybrid had slightly higher N levels than the Conventional, likely due to the retention of pea vine in the Hybrid, compared to the Conventional which had much of the vine baled and removed. The Hybrid had on average 153 kgN/ha in the vine residue presumably breaking down ahead of bean planting and into January. Some vine remained in the Conventional treatment, as the baler did not pick it all up, but it was much less than in the Hybrid treatment.

In early January the N levels in the Regen and Hybrid treatments were slightly higher than the Conventional treatment.

7.5 Observable deficiencies recorded

No observable deficiencies recorded.

7.6 Tissue testing

None to date. Will complete later in the season.

7.7 Pest and disease presence

Slug damage was recorded in all plots, visually appearing to be worse in the Hybrid treatment where pea vine residue remained on the soil surface. Slug bait was applied to each treatment accordingly.

Minor rabbit damage was recorded in all most plots, with some new shoots completely eaten. Rabbit bait has been set and shooting undertaken.

Presence of aphids was noted on 16 January. No disease presence recorded to date.

7.8 Record applied nutrients

7.8.1 Planting Fertiliser

Granular fertiliser was drilled near to the seed through the bean planter. All treatments had a standard fertiliser product applied at planting. The Regenerative treatment had the addition of a granulated Humate product applied at planting, which was mixed into the Nitrabor (see7.9.4 Biologicals).

Table 15 Applied fertiliser products - planting

Treatment	Product	Rate kg/ha	N	P	K	S	Ca
Conventional	YaraMila Complex	250	12% (30kgN)	5% (12.5kgP)	15% (37.5kgK)	8% (20kgS)	-
Hybrid	YaraLiva Nitrabor	200	15.4% (30.8kgN)				18.3% (36.6kgCa)
Regenerative	YaraLiva Nitrabor	150	15.4% (23.1kgN)				18.3% (27.5kgCa)

7.9 Record agrichemical applications

7.9.1 Herbicides

Pre and post-planting and pre-emergence herbicides have been applied to all plots. A Basagran application is scheduled but to date there is insufficient weed presence to justify application. Given Basagran can be damaging to the crop, it will be avoided if possible.

Table 16 Herbicide applications - all treatments

Treatment	Timing	Product	Active Ingredient	Product Rate /ha	Date
Conventional	Spray out	Weedmaster Ts470	Glyphosate	3	23/12/2024
	Spray out	Kwickin	Adjuvant	1.5	23/12/2024
	Pre-emerge	Director	Clomazone	0.55	29/12/2024
	Pre-emerge	Frontier-P	Dimethenamid-P + Polymeric amine phosphate	0.55	29/12/2024
	Pre-emerge	Backrow Max	Adjuvant	0.4	29/12/2024
	Post-emerge	Basagran	Bentazone	2.5	24/1/2025
	Post-emerge	Spreadwet 1000	Non ionic	0.075	24/1/2025
Hybrid	Spray out	Weedmaster Ts470	Glyphosate	3	23/12/2024
	Spray out	Kwickin	Adjuvant	1.5	23/12/2024
	Pre-emerge	Director	Clomazone	0.55	29/12/2024
	Pre-emerge	Frontier-P	Dimethenamid-P + Polymeric amine phosphate	0.55	29/12/2024
	Pre-emerge	Backrow Max	Adjuvant	0.4	29/12/2024
	Post-emerge	Basagran	Bentazone	2.5	24/1/2025
	Post-emerge	Spreadwet 1000	Non ionic	0.075	24/1/2025
Regenerative	Spray out	Weedmaster Ts470	Glyphosate	3	23/12/2024
	Spray out	Kwickin	Adjuvant	1.5	23/12/2024
	Pre-emerge	Frontier-P	Dimethenamid-P + Polymeric amine phosphate	0.55	29/12/2024
	Pre-emerge	Backrow Max	Adjuvant	0.4	29/12/2024
	Post-emerge	Basagran	Bentazone	2.5	24/1/2025
	Post-emerge	Spreadwet 1000	Non ionic	0.075	24/1/2025

A spray error applied a double dose of Frontier-P to one plot. It caused a degree of leaf burn and plant growth has been reduced, so consideration will be taken when analysing the yield at the end of the season.

7.9.2 Fungicides

7.9.2.1 Seed treatment

Imported bean seed is required to be treated with fungicides. McCain use a range of fungicide seed treatments- list of treatments included below in Table 17.

Table 17 Fungicide - seed treatments

Seed treatments	Active Ingredient	Rate per kg seed
Thiram 90 WDG	Thiram	50 g
Apron XL	Metalaxyl-M	1 ml
Captan 600 Flo	Captan	2 ml

7.9.3 Insecticides/Molluscicides

No insecticides applied to date, however due to presence of slugs, slug bait (molluscicide) has been applied to all treatments.

Table 18 Molluscicide applications, all treatments

Treatment	Timing	Product	Active Ingredient	Product Rate /ha	Date
Conventional	Post-emerge	Arxada Axcela	30g/kg metaldehyde	7	10/01/2025
Hybrid	Post-emerge	Arxada Axcela	30g/kg metaldehyde	7	10/01/2025
Regenerative	Post-emerge	IronMax	24.2.g/kg iron phosphate anhydrous	7	10/01/2025

7.9.4 Biologicals

Biological products have been integrated into the treatments, on the recommendation of the Operations Advisory Group.

The Regenerative treatment has received a 'biological' application each time a synthetic product has been applied to 'soften' the impact to soil microbes, or to improve plant performance. The Hybrid has had some biological products applied, where practical. The Conventional has not had any biological products applied, typical of the standard McCain programme.

Timing	Conventional	Hybrid	Regenerative
Spraying out	-	-	2 L/ha Fluvic Acid
Planting	-	0.2 kg/ha Trichostart	0.2 kg/ha Trichostart
	-	-	5 kg/ha Omnia Humates
Pre-emerge herbicide	-	6 L/ha Mycorrcin	6 L/ha Mycorrcin
Growth stimulant	-	1 L/ha Foliacin	1 L/ha Foliacin
	-	1.5 L/ha BioMaris	1.5 L/ha BioMaris

7.10 Record irrigation events

Plots were irrigated when fallow in mid-December prior to cultivation. Since planting there have been two applications to maintain moisture in the root zone.

Table 19 Irrigation application, by quadrant

Quadrant	11/13 Jan	15/17 Jan	Total irrigation applied (mm)
Q1 (Plots 1,2,3)	12	13	25
Q2 (Plots 4,5,6)	12	13	25
Q3 (Plots 7,8,9)	12	13	25
Q4 (Plots 10,11,12)	12	13	25

7.11 Soil moisture measurements

Soil moisture probes/tubes (GroPoint + Tipu Services) were removed from the plots before pea harvest. GroPoint sensors have been replaced after bean planting to avoid damage.

7.12 Hydrosense

A Hydrosense handheld TDR is being used (measuring to 20 cm). Three weekly measurements were completed. Readings show that the Regenerative plots have significantly higher ($p < 0.001$) soil moisture content in the root zone than the Conventional and Hybrid plots which are not different ($p = 0.70$).

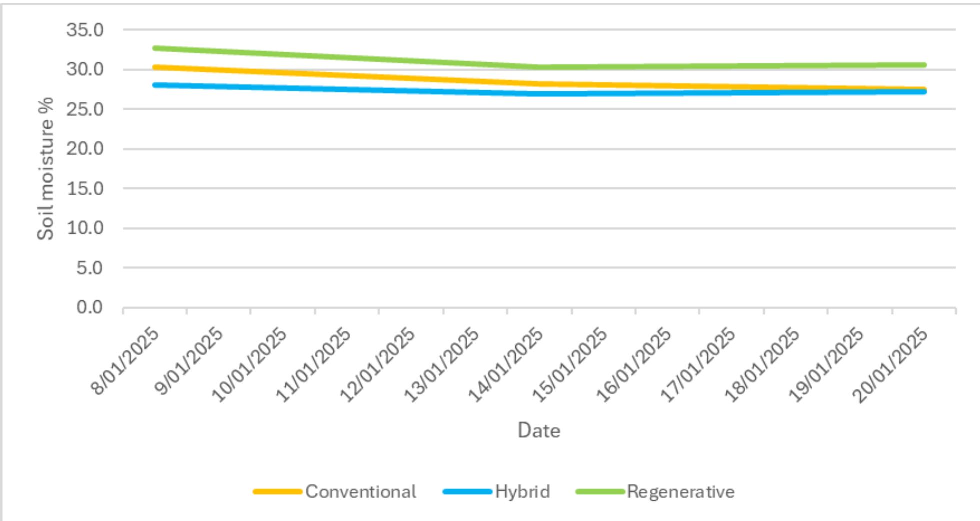


Figure 30 Soil moisture % Hydrosense to 20cm

Table 20 Hydrosense average weekly soil moisture, by treatment

Treatment	8/01/2025	14/01/2025	20/01/2025
Conventional	30.24	28.19	27.47
Hybrid	28.02	26.93	27.23
Regenerative	32.66	30.36	30.56

7.13 GroPoint

GroPoint sensors have been in each plot. The sensors measure soil moisture and temperature to 90 cm depth. A slurry applied during installation appears to have solved soil measurement glitches and sensible data are being collected. However, a close watch will be maintained until the units are demonstrated to be working correctly.

Data are collected every 5 minutes and blocked into 15 minute intervals. A considerable degree of data cleaning was required at the outset but should be more straightforward now all sensors and data capture and transfer units are operating correctly. An example chart of data is shown in Figure 31. The upticks in soil moisture correspond to irrigation events of 12 and 13 mm. The data suggest water is rapidly moving from the upper soil to lower soil in Plot 11, but not in the other two plots which are already wet. This needs to be field checked over coming weeks.

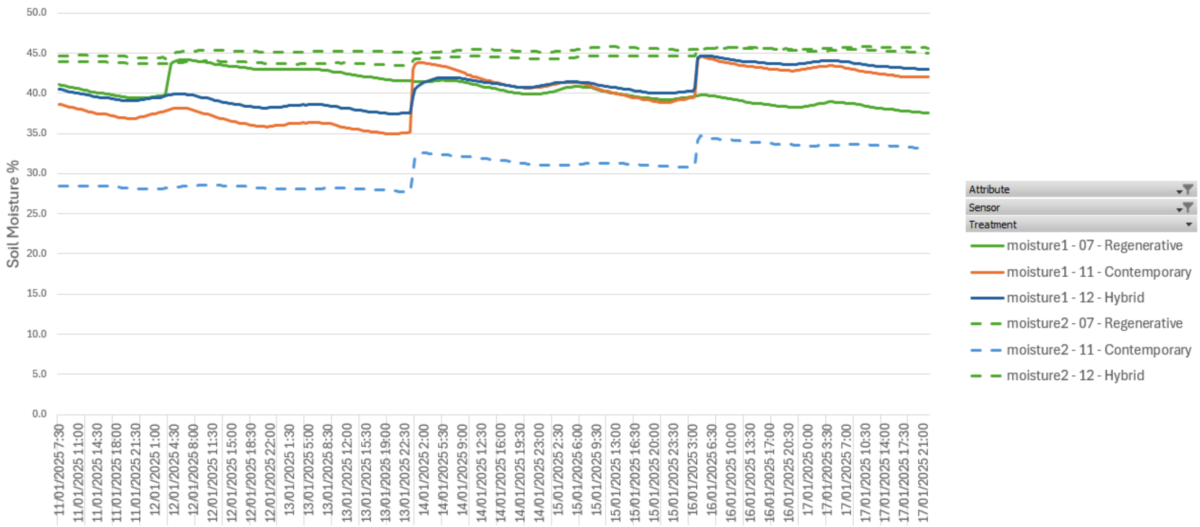


Figure 31 Example of GroPoint data from three sensors at two soil depths showing percent soil moisture and the effect of irrigation events.

7.14 Water sensitive paper testing

No fungicides or insecticides have been applied to date so not yet completed.

7.15 EIQ Risk Assessment calculated

Environmental Impact Quotient is being assessed as crop protection products are used. At the time of reporting, all of the treatment EIQ scores are attributed to herbicides. Weed management is one of the biggest considerations for beans, so early applications to supress weeds are required.

There was significant debate about the use of glyphosate in the Regenerative treatment for weed control ahead of planting. The decision was made to use glyphosate at a low rate (as with other treatments), to terminate weeds that had germinate since disc ripping. This application proved very effective and allowed for the creation of a stale seed bed.

The difference in scores between treatments is a single residual herbicide application of Director (Clomazone). This product is used as a pre-emerge herbicide, often in combination with Frontier-P. The OAG was concerned that the clomazone may remain in soil for an extended period and could impact the growth of subsequent crops. It was removed from the Regenerative treatment. Based on the feedback from agronomists and growers, this may have a significant impact on the success of the next crop, however, did not have a huge impact on EIQ.

EIQ from the seed treatment is still being calculated, awaiting information from importers. Based on label rates there is suspicion that one of the fungicide treatments may have a significant impact on EIQ.

Table 21 Bean EIQ to date by treatment

Treatment	Field Use EIQ (converted to hectare)	Consumer EIQ (converted to /hectare)	Worker EIQ (converted to hectare)	Ecological EIQ (converted to hectare)
Conventional	167.3	48.2	317.2	136.9
Hybrid	167.3	48.2	317.2	136.9
Regenerative	152.5	43.5	290.8	123.1

8 Seasonal canopy covers

Canopy cover is measured weekly using Canopeo. This records fallow periods as well as crop development. An interesting note related to canopy cover is that the Regenerative treatment had <10% canopy cover between the beginning of October and middle of January (approx. 14 weeks), the average cover over this time has been 2.2%.

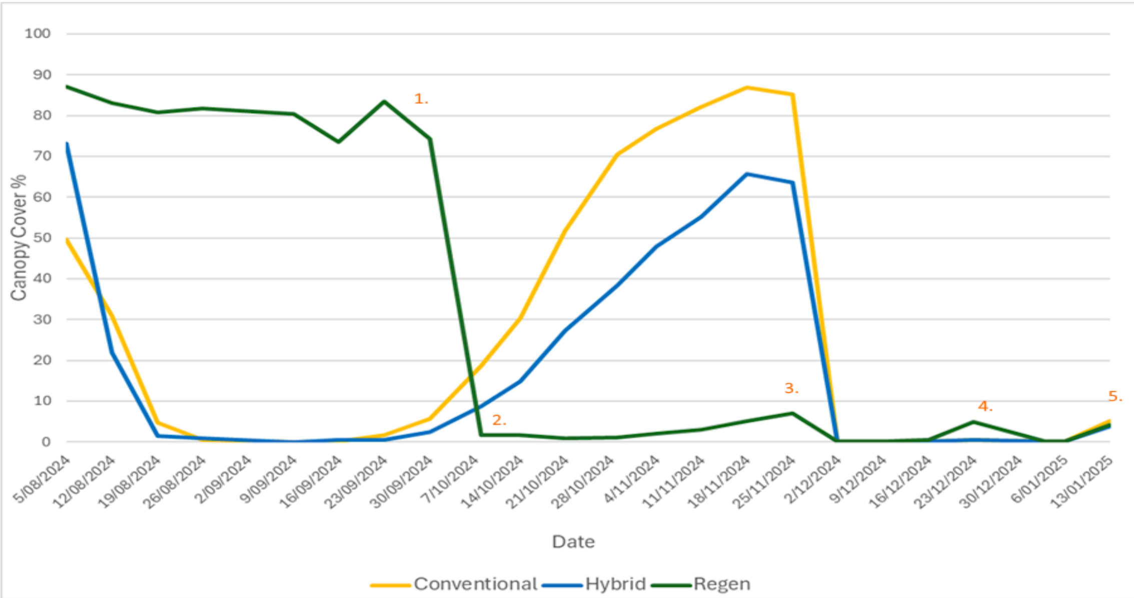


Figure 32 Chart showing canopy cover percentage August 2024 - January 2025

. There are key events that have led to this outcome.

1. Radish setting seed (faster maturing than other species)
2. Cover crop mulching to terminate radish
3. Discing oat regrowth, aim to mechanically terminate
4. Oat regrowth and weeds sprayed ahead of beans
5. Bean growth

The Regenerative principles include ‘keep living roots in the soil’ and ‘keep the soil covered’. In this context, cover crop management has been sub-optimal as for nearly 27% of the year the soil has been fallow. It would be prudent for the OAG to consider cover crop mixes and termination options and the outcome from the 2024 cover crops to minimise leaving bare soil.

9 Outreach

9.1 Weekly agronomy field walks

Our Operations Advisory Group met weekly to discuss the development of the pea crop and the ongoing management of the Regenerative treatment ahead of beans. Meetings have been attended by McCain and Kraft-Heinz Wattie’s staff, as well as growers and advisors.

As the beans were planted just after Christmas, and two of our field walks fell on statutory holidays, field walks resumed for the beans in early January. To date progress has been satisfactory and the beans are looking good.

Figure 33 Images from weekly field walk discussions - peas

9.2 Outreach field walks

9.2.1 Team Progressive (5 September 2024) **Milestone 8

In early September just after the peas were planted, we hosted "Team Progressive", a group of minimum tillage maize farmers from Northland and Waikato, to discuss the Carbon Positive project, our observations, and lessons to date.

Figure 34 Team Progressive visit September 2024

9.2.2 October Cover Crop Field Walk (15 Oct 2024)

Mid-October a field walk was held to discuss lessons from two years of growing cover crops (Figure 35 Cover crop discussion field walk). A demonstration area of different potential future cover crop options was planted outside the main trial area provide the opportunity to trial different termination methods and view results.

Figure 35 Cover crop discussion field walk

We demonstrated mulching and a roller crimper and had treated some of the area days in advance to demonstrate the outcomes. The field walk was well attended by growers, MPI, Regional Council, and technical field staff, and provided interesting discussion on potential next steps. A full summary can be found on the LandWISE website (https://www.landwise.org.nz/2024/10/03/lessons-from-two-years-of-winter-cover-crops/).

9.2.3 January Bean Field Walk (21st January 2025)

The first monthly field walk of 2025 was held on the 21st of January 2025. The field walk was attended by a dozen or so people from a range of different industries, who brought a range of interesting perspectives to the trial.

Figure 36 January field walk 2025

9.3 Conferences and seminars

9.3.1 Leaderbrand Regenerative Cropping Seminar

We attended the Leaderbrand Regenerative Cropping event in Tairawhiti on 12 November and presented lessons from our cover cropping experiences. The information delivered was an updated version of the talk given to the Hawke's Bay Future Farming conference in September.

Through discussion at the Leaderbrand event, we found that both projects are finding integration of regenerative principles challenging, especially when harvest dates, and therefore planting dates, are relatively fixed. In pastoral and arable systems, there is much greater flexibility and activities such as cultivation and planting can be adjusted to suit. In process and fresh vegetable growing the planting date is set by factory or market requirements to receive harvested crops on specified dates.

A notable quote was "If you just want to do one of these things, like multi-species cover cropping, minimising soil disturbance by cultivation, or avoiding herbicides, it is relatively straight forward. But when you try to include them all in a new system, it rapidly becomes a nightmare!"

9.4 Articles and newsletters

9.4.1 Grower Magazine October Issue 2024

Conventional versus Regen: Gearing up for a Carbon Positive summer (page 30 – 33) https://www.hortnz.co.nz/news-events-and-media/magazines/october-2024-nzgrower-and-orchardist-vegetable-growing/

9.4.2 Grower Magazine November Issue 2024

Earthworm Tests: New Soil Health Measures (page 48 – 50)

https://issuu.com/hortnz/docs/nzgrower_and_orchdist_vege_growing_november_2024?fr=xKAE9_zU1NQ

9.4.3 LandWISE October Newsletter

Featuring: Carbon Positive cover crop updates https://www.landwise.org.nz/2024/10/10/cover-crop-update/

9.4.4 LandWISE November Newsletter

- McCain pea production https://www.landwise.org.nz/2024/11/29/2024-mccains-pea-production/
- Pea harvest data https://www.landwise.org.nz/2024/11/29/2024-pea-harvest-results/
- Hills earthworm eDNA test https://www.landwise.org.nz/2024/11/29/earthworm-edna-at-the-microfarm/

10Appendices

10.1 Modified VSA Score Card

Visual Indicator	VS Score 0= Poor 1= Moderate 2= Good Condition	Weighting	Maximum Score
Porosity		X 3	6
Colour		X 2	4
Mottles		X 2	4
Structure		X 3	6
Earthworm abundance	>35= 2 29-35= 1.5 22-28= 1 15-21=0.5 <15= 0	X 2	4
Tillage Pan		X 2	4
		Maximum score	28

Soil Quality Assessment	Ranking Score (Baseline Sampling
Poor	<8 (<30% of total score)
Moderate	8 – 21 (30-74% of total score)
Good	>21 (>74% of total score)

10.2 Irrigation schedule by quadrant

		Target Depth (mm)
Q1		98
	2-Oct-24	16
	19-Oct-24	16
	30-Oct-24	16
	7-Nov-24	16
	18-Nov-24	18
	24-Nov-24	16
Q2		98
	4-Oct-24	16
	15-Oct-24	16
	1-Nov-24	16
	4-Nov-24	16
	21-Nov-24	18
	22-Nov-24	16
Q3		98
	2-Oct-24	16
	19-Oct-24	16
	30-Oct-24	16
	6-Nov-24	16
	19-Nov-24	18
	24-Nov-24	16
Q4		98
	3-Oct-24	16
	15-Oct-24	16
	1-Nov-24	16
	5-Nov-24	16
	20-Nov-24	18
	23-Nov-24	16

10.3 EIQ by treatment - Peas

10.3.1 Conventional

Date Used	Treatment	Product Type	Product	Active Ingredient	AI %	Product Rate	Unit	Application Area	Field Use EIQ (converted to hectare)	Consumer EIQ (converted to /hectare)	Worker EIQ (converted to hectare)	Ecological EIQ (converted to hectare)
30/07/2024	Conventional	Herbicide	Weedmaster TS470	Glyphosate	47	4.5	L	ha	192.7	55.8	373.1	149.2
30/07/2024	Conventional	Herbicide	Sharpen	Saflufenacil	70	0.015	kg	ha	0.7	0.2	1.5	0.7
3/09/2024	Conventional	Fungicide	Wakil	Metalaxyl- M	17.5	0.42	kg	ha	5.2	3.0	5.9	6.9
3/09/2024	Conventional	Fungicide	Wakil	Fludioxonil	5	0.42	kg	ha	2.5	1.0	3.2	3.5
3/09/2024	Conventional	Fungicide	Wakil	Cymoxanil	10	0.42	kg	ha	3.0	1.7	5.4	2.0
17/10/2024	Conventional	Herbicide	Bruno	Cyanazine	50	2.5	L	ha	105.8	28.9	193.0	95.1
17/10/2024	Conventional	Herbicide	Quantum	Diflufenican	50	0.2	L	ha	9.4	2.7	10.6	14.6

10.4 Hybrid

Product Type	Product	Active Ingredient	AI %	Product Rate (Total/Crop)	Product Measurement Unit	Application Area	Field Use EIQ (converted to kg/hectare)	Consumer EIQ (converted to kg/hectare)	Worker EIQ (converted to kg/hectare)	Ecological EIQ (converted to kg/hectare)
Herbicide	Weedmaster TS470	Glyphosate	47	4.5	L	ha	192.7	55.8	373.1	149.2
Herbicide	Sharper	Saflufenacil	70	0.015	kg	ha	0.7	0.2	1.5	0.7
Herbicide	Bruno	Cyanazine	50	2.5	L	ha	105.8	28.9	193.0	95.1
Herbicide	Quantum	Diflufenican	50	0.2	L	ha	9.4	2.7	10.6	14.6
Fungicide	Wakil	Metalaxyl- M	17.5	0.42	kg	ha	5.2	3.0	5.9	6.9
Fungicide	Wakil	Fludioxonil	5	0.42	kg	ha	2.5	1.0	3.2	3.5
Fungicide	Wakil	Cymoxanil	10	0.42	kg	ha	3.0	1.7	5.4	2.0

10.5 Treatment gross margin breakdown - Peas

10.5.1 Conventional Treatment

Row Labels	Sum of Expense	Sum of Revenue	Sum of Gross Profit	Sum of Gross Margin
Land Lease	$ 1,750.00		-$ 1,750.00	
Pre Plant	$ 1,114.63		-$ 1,114.63	
Ground Preparation	$ 810.00		-$ 810.00	
Herbicide	$ 71.10		-$ 71.10	
Molluscicide	$ 167.53		-$ 167.53	
Spraying	$ 54.00		-$ 54.00	
Soil Test	$ 12.00		-$ 12.00	
Planting	$ 1,010.40		-$ 1,010.40	
Ground Preparation	$ 85.00		-$ 85.00	
Planting	$ 195.00		-$ 195.00	
Seed	$ 730.40		-$ 730.40	
Growing	$ 583.32	$ 4,730.20	$ 4,146.88	$ 0.88
Herbicide	$ 114.32		-$ 114.32	
Irrigation	$ 384.00		-$ 384.00	
Harvest		$ 4,290.20	$ 4,290.20	$ 1.00
Balage	$ 85.00	$ 440.00	$ 355.00	$ 0.81
Grand Total	$ 4,458.35	$ 4,730.20	$ 271.85	5.75%

10.5.2 Hybrid Treatment

Row Labels	Sum of Expense	Sum of Revenue	Sum of Gross Profit	Sum of Gross Margin
Land Lease	$ 1,750.00		-$ 1,750.00	
Pre Plant	$ 304.63		-$ 304.63	
Herbicide	$ 71.10		-$ 71.10	
Molluscicide	$ 167.53		-$ 167.53	
Spraying	$ 54.00		-$ 54.00	
Soil Test	$ 12.00		-$ 12.00	
Planting	$ 1,302.23		-$ 1,302.23	
Biostimulant	$ 14.30		-$ 14.30	
Ground Preparation	$ 85.00		-$ 85.00	
Molluscicide	$ 167.53		-$ 167.53	
Planting	$ 195.00		-$ 195.00	
Seed	$ 730.40		-$ 730.40	
Mulching	$ 110.00		-$ 110.00	
Growing	$ 538.32	$ 3,797.50	$ 3,259.18	$ 0.86
Herbicide	$ 114.32		-$ 114.32	
Irrigation	$ 384.00		-$ 384.00	
Harvest	$ 40.00	$ 3,797.50	$ 3,757.50	$ 0.99
Grand Total	$ 3,895.18	$ 3,797.50	-$ 97.68	-2.57%

10.6 EIQ by treatment – Beans (to date)

10.6.1 Conventional

Date Used	Treatment	Crop	Product Type	Product	Active Ingredient	AI %	Product Rate	Field Use EIQ (/ha)	Consumer EIQ (/ha)	Worker EIQ (/ha)	Ecological EIQ (/ha)
23/12/2024	Conventional	Bean	Herbicide	Weedmaster TS470	Glyphosate	47	3 L/ha	128.5	37.3	248.8	99.6
29/12/2024	Conventional	Bean	Herbicide	Director	Clomazone	36	0.55L/ha	14.8	4.7	26.2	13.8
29/12/2024	Conventional	Bean	Herbicide	Frontier P	dimethenamid-P	72	0.55 /ha	24.0	6.2	42.0	23.5
24/1/2025	Conventional	Bean	Herbicide	Basagran	Bentazone	48	0.075L/ha	66.2	23.7	84.8	89.9

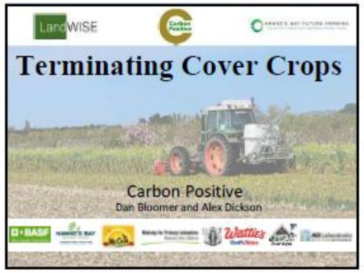
10.6.2 Hybrid

Date Used	Treatment	Crop	Product Type	Product	Active Ingredient	AI %	Product Rate	Field Use EIQ (/ha)	Consumer EIQ (/ha)	Worker EIQ (/ha)	Ecological EIQ (/ha)
23/12/2024	Hybrid	Bean	Herbicide	Weedmaster TS470	Glyphosate	47	3 L/ha	128.5	37.3	248.8	99.6
29/12/2024	Hybrid	Bean	Herbicide	Director	Clomazone	36	0.55L/ha	14.8	4.7	26.2	13.8
29/12/2024	Hybrid	Bean	Herbicide	Frontier P	dimethenamid-P	72	0.55L/ha	24.0	6.2	42.0	23.5
24/1/2025	Hybrid	Bean	Herbicide	Basagran	Bentazone	48	0.075L/ha	66.2	23.7	84.8	89.9

10.6.3 Regenerative

Date Used	Treatment	Crop	Product Type	Product	Active Ingredient	AI %	Product Rate	Field Use EIQ (/ha)	Consumer EIQ (/ha)	Worker EIQ (/ha)	Ecological EIQ (/ha)
23/12/2024	Regenerative	Bean	Herbicide	Weedmaster TS470	Glyphosate	47	3 L/ha	128.5	37.3	248.8	99.6
29/12/2024	Regenerative	Bean	Herbicide	Frontier P	dimethenamid-P	72	0.55L/ha	24.0	6.2	42.0	23.5
24/1/2025	Regenerative	Bean	Herbicide	Basagran	Bentazone	48	0.075L/ha	66.2	23.7	84.8	89.9

10.7 Presentation to Leaderbrand Regenerative Cropping Seminar



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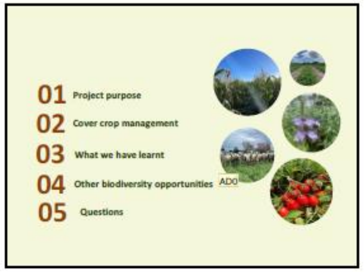

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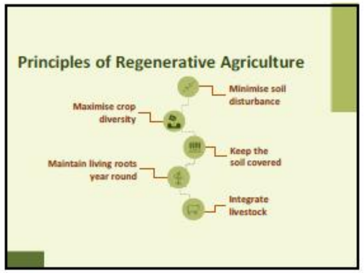

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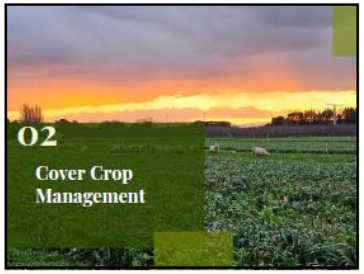

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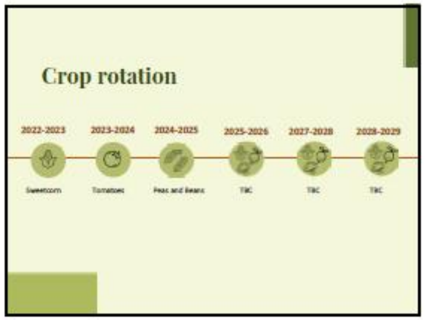

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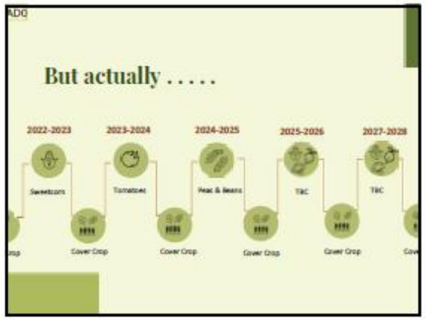

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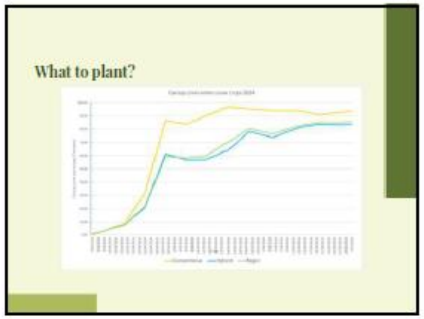

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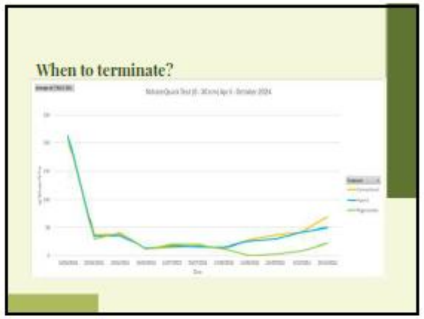

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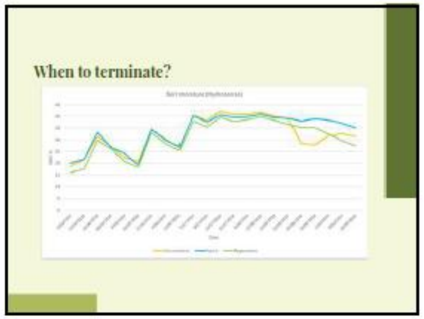

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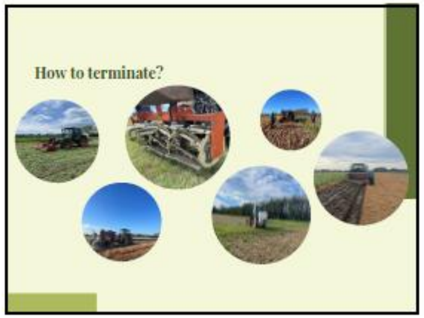

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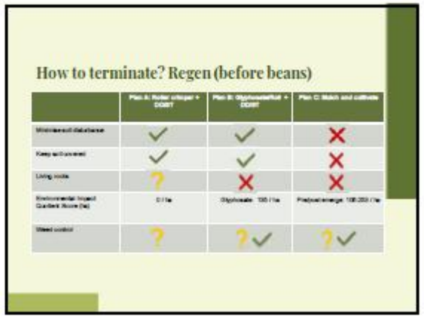

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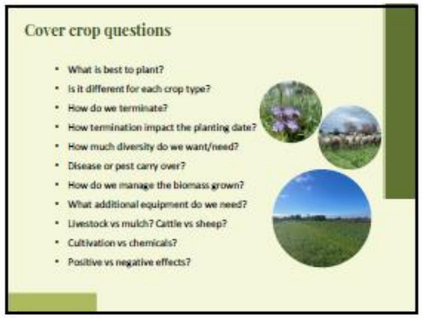

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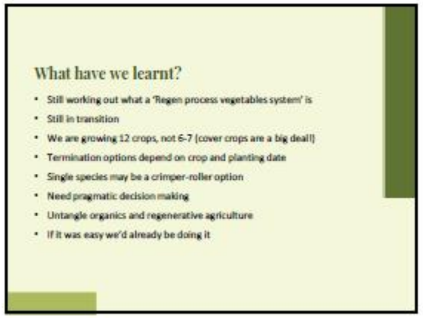

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