Carbon Positive Milestone 8

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Due 1st October 2024

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Milestone 8

Date: 1 Oct 2024	**Milestone 8**
Milestone description	Year 3 Planning Completed
STOP / GO	MPI approval of Annual Science Plan
Target Outcome	Scientific knowledge of regenerative agriculture principles and transition
Activities undertaken	PSG reviews progress and plans, TAG reviews science plans, Year 3 spring process crops established, soil carbon testing and crop monitoring. On site Field Day. Magazine article and websites updated. Further activities as per Annual Project Plan and Annual Science Plan.
Deliverables / evidence of completion / achievement of Outcome	MPI approved Annual Science Plan (with milestones). PSG approved Annual Project Plan (with milestones). 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	$147,569.15
Co-Funding contribution	$63,243.92
Total	$210,813.07

Milestone 8 Activities Plan

Activity	Completion Date	Details
PSG reviews progress and plans	1/10/24	
TAG reviews science plans	1/09/24	
Year 3 process crop operational plan completed	1/08/24	
Soil monitoring	1/10/24	
Basic soil testing	1/08/24	Standard soil test suite to 15 cm (Commercial Labs)- 1 test per plot
Hot water extractable carbon (intermediate sampling)	Nov- MS9	0-15cm, 15-30cm, 30-60cm 8 x 50mm cores per plot. Combine and send composite sample for lab testing (East and West end)
Visual Soil Assessment	Oct- MS9	4 samples per plot, before crop established
Earthworm counts	Oct- MS9	4 samples per plot, group by worm type, count, weigh
Soil infiltration rate	1/10/24	In-situ test- ring or disc permeameter
Soil moisture release curve	1/10/24	Neutron probe- Tipu Services
Soil temperature	Daily	Daily from 2 weeks pre-planting. Simple 12 cm thermometer.
Soil penetration resistance	1/10/24	5 transects at 20cm apart in transect (10 readings across bed) to 50cm.
Cover Crop monitoring		
Canopy development	Weekly	Weekly- eight images take per plot (two per sub-plot)
Soil moisture	Weekly	Weekly- eight Hydrosense II readings (two per sub-plot)
Soil Nitrate Quick Test	Every 3-4 weeks	At two depth increments 0-15cm, 15-30cm, and where applicable 30-45cm. Completed 1 month pre plant, 1 week pre plant, and then fortnightly through growing season
Biomass	10/08/24	Recorded before grazing or crop termination. 4 x 0.25m2 quadrats cut and dried to determine kgDM/ha.
Year 3 Spring process crop established (peas)		Estimated planting date for peas 28th August 2024
Soil prepared as agreed to by OAG	1/09/24	
Planting managed as agreed to by OAG	1/09/24	
Calibrate Irrigator	Before first irrigation	Irrig8 lite
Year 3 spring crop development monitoring (peas)	Ongoing	
Establishment percentage	15/09/24	1m2 x 4 subplots. Population counts completed once everything has had time to emerge, targeting 100-120 plants/m2
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
Tissue testing	Monthly	Pre-flowering and post harvest
Pest and disease presence	Weekly	Relative Slug Activity. Monitor for aphids and thrips.
Maturity date	1/02/25	Flower counts, 3 plants per sub plot (12 plants total). Use McCain instruction document.
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) OR neutron probe via Tipu Services
Water sensitive paper testing	1/10/24	Ahead of first spray applications (drone + ground application)
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
On Site Field Day	Monthly start- Sept	Monthly field walk starting August (before peas planting)
Magazine article and website updated	1/10/24	

1. Overview

In this milestone report we provide data relating to the winter cover crops, winter soil monitoring, autumn Hot Water Extractable Carbon (labile carbon) results and details of the first few weeks since our spring crop of peas that were planted on the 3rd of September.

As part of this milestone the TAG have reviewed the Annual Science Plan, and we have prepared the Science Activities Plan for the year (related to the crops we are growing) and Operations Plan to outline the intentions for each treatment, for the next 12 months. As with any plan relating to agriculture or horticulture, which is at the mercy of the weather, we do expect changes to be made almost immediately, which is the nature of what we do. In our learning from last year, we have discussed several potential deviations from our 'Plan A' and have a range of different management options in the toolbox that we can use where needed.

2. Year 3 cropping plan

Winter cover crops were planted on the 22nd of March after our successful tomato season with Heinz-Wattie's. The Conventional treatment was planted in annual ryegrass which was grazed by sheep in July. The Hybrid and Regenerative were both planted in a diverse mix, predominantly oats, tillage radish and vetch which survived the winter, with buckwheat, sunflowers and clovers also included in the mix.

This year is a McCain year for growing crops, and process peas followed by dwarf green beans will be planted this season. Peas will be planted in the Conventional and Hybrid treatments, with the Regenerative treatment left in cover crop through the spring. The decision to do this is to leave the Regenerative plots in a 'restorative' phase for longer following the tomatoes, to reduce some of the intensity of the treatment, and to avoid soil damage by planting peas early in the season, into wet soils.

Planning for the year was completed over the last six months with the Operations Advisory Group, comprised of the processors, regenerative advisors, growers, contractors and others who have provided time and expertise to set the trial up for the 2024-2025 cropping season. This is the first double crop of the trial, so there are additional demands from the OAG in planning for two crops, and we are grateful for the time they give to support the project.

Our target planting date for peas was the 28th of August. Planting was delayed due to above optimum soil moisture levels and were planted on the 3rd of September (six days late) by Mike Kettle Contracting and crop measurements are underway. shows canopy cover over the season, where the Conventional treatment (annual ryegrass) almost reaches over 95% canopy cover in mid-May, before decreasing to 35% cover in mid-July after grazing (some of this due to lambs trampling grass into the mud). The grass was allowed to grow for a short period ahead of spraying out. Once sprayed, the canopy cover appears to increase, however this will likely be due to rain washing residual mud off the leaves. There is a sharp decline in canopy cover from early August as the grass dies off. While cover appears to be almost 0%, this measure only considers the green cover and doesn't factor the residual material that is still covering the soil surface.

Both the Hybrid and Regenerative treatment were planted in the same diverse cover crop mix. Given the composition of the mix, being predominantly oats, the Hybrid did not reach full canopy cover, and the Regen treatment is yet to reach this stage. Both treatments followed the same pattern of growth until the Hybrid treatment was sprayed out, and canopy cover (green cover) declined sharply.

Similar to the Conventional treatment, the Hybrid has residual material covering the soil surface. The Regenerative treatment will remain in cover crop until it is terminated ahead of planting beans.

Figure 4-2 Showing winter cover crops. Conventional and Hybrid treatments had been sprayed, with Regenerative treatment still growing. shows rainfall and temperature data from spraying out the Conventional and Hybrid treatments, and pea planting. There was a rainfall event almost weekly that amount to over 10 mm of rainfall, which was enough to keep the soil at or above field capacity through the month of August which made preparation for pea planting somewhat challenging as there were only short periods of good drying weather.

We are meeting with McCain agronomists and other OAG members weekly, as we did last season with Wattie's, to evaluate progress from the prior week and plan for the following week.

The pea crop will be harvested in early December, followed by a three week mandatory fallow period ahead of planting beans on approximately the 24th of December. Key decisions to be made will be related to the management of pea hay/residue, termination of the regenerative cover crop (when and how), as well as crop inputs for each of the treatments.

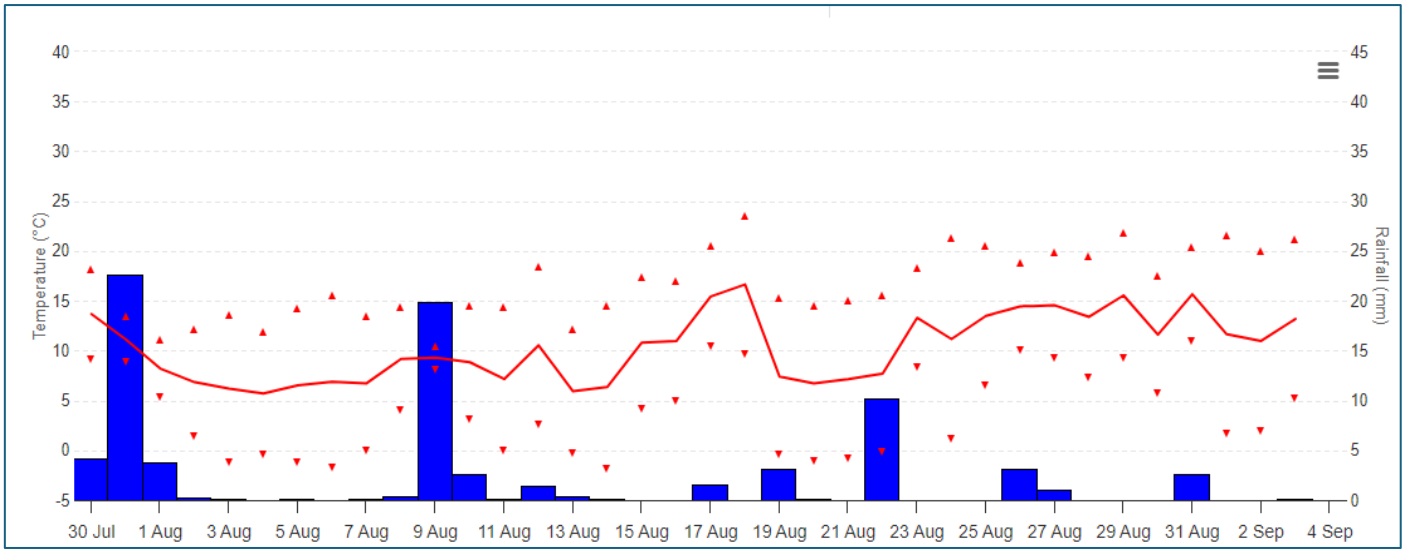

Figure 2-1 Temperature and Rainfall data (Ruahapia Road Weather Station 30th July – 4th September retrieved from HortPlus MetWatch)

3. Soil Monitoring

3.1 Basic soil testing

Samples were collected from each plot for basic soil tests on the 29th of July, approximately one month ahead of planned planting date.

There is variation between plots with pH ranging between 6.2 – 6.8, Olsen P 36 – 80 mg/L, Potassium 22 – 29 MAF, Potentially Available Nitrogen 76 – 105 kgN/ha, Potentially Mineralisable Nitrogen 85 – 193 kgN/ha and Boron 1 – 1.4 mg/kg. In Appendix 1 soil test results for all plots can be found with comparison to 2023 results.

To summarise the comparison to the 2023 results pH has largely remained constant, with some plots having had a slight increase in pH. Olsen P levels have reduced in nine plots, with slight increases in remaining three plots. Potassium levels have reduced in ten plots. Potentially Available Nitrogen has reduced in ten plots, and Potentially Mineralisable Nitrogen has reduced in nine plots. Boron has increases in eight plots. The reduction in Phosphorus, Potassium and Nitrogen levels are likely linked to the nutrient demand from last season's tomato crop and the amount of nutrient that will have been exported from the plots. Soil test results were sent to Mark Redshaw from Yara Crop Nutrition to develop nutrient recommendations for each crop.

3.2 Hot water extractable carbon

Soil samples to 600 mm were collected for the autumn/post-harvest labile carbon (Hot Water Extractable Carbon Test) in May 2024, but results had not been received at the time of Milestone 7 reporting. Two samples (East end and West end) were submitted for lab testing for each of three depths for each plot. Each sample comprised four combined cores. Bulk density was determined for each of the two ends of the plot. Mean labile carbon stocks (T/ha) were determined for each depth (0 – 150 mm, 150 – 300 mm and 300 – 600 mm) for each treatment (**Error! Reference source not found.**).

Table 3-1 Mean Hot Water Extractable (Labile) Carbon stocks (T/ha) by treatment by soil sampling depth.

Mean HWE Carbon (T/ha)	Sampling Depth			Depth Weighted Total
	0-150 mm	150-300 mm	300-600 mm	0-600 mm
Conventional	1.51	1.10	0.97	3.59
Hybrid	1.47	1.14	0.99	3.59
Regenerative	1.41	1.29	0.99	3.69
Mean of all treatments	1.46	1.18	0.98	3.62

The total stocks in the top 600 mm soil profile were 3.59 T/ha in the Conventional and Hybrid treatments and 3.69 T/ha in the Regenerative treatment (**Error! Reference source not found.**).

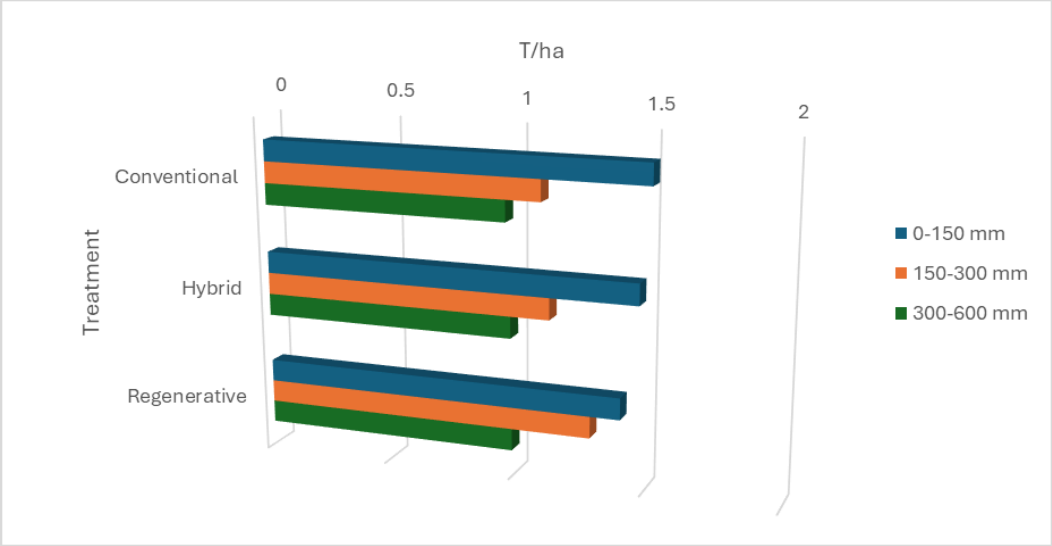

Figure 3-2 Stacked bar chart showing autumn 2024 Hot Water Extractable/Labile Carbon results (tonnes per hectare), by treatment.

Statistical analyses using one-way ANOVA showed there were no significant differences between the treatments at any depth (Table 3-2).

Table 3-2 Calculated ANOVA p values (alpha = 0.05) comparing the Hot Water Extractable Carbon quantities in each treatment by soil sampling depth

ANOVA p values		Sampling Depth		
Comparison Pairs		**0-150**	**150-300**	**300-600**
Conventional	**Hybrid**	0.569748	0.780935	0.86124
Hybrid	**Regenerative**	0.513217	0.143132	0.974969
Conventional	**Regenerative**	0.283816	0.081231	0.885759

3.3 Visual soil assessment

When Milestone 7 was submitted, the completion of Visual Soil Assessment post-harvest was yet to be completed, as we were waiting for the soil to settle after discing in the autumn. VSA's were completed between the 5th to the 11th of June, when soil was at optimum moisture levels. Data

presented below is for these autumn assessments. Note we use the first edition of the Visual Soil Assessment Guide (2000) by Graham Shepherd. In this version the Ranking Score for Poor Soil Quality is <10, for Moderate 10 – 25, and Good >25.

Table 3-3 Showing Average Weighted Scores for Visual Soil Assessment quality indicators in autumn assessment.

Treatment	Soil Structure	Soil Porosity	Soil Colour	No. + colour mottles	Tillage Pan	Degree Clod Development	Soil Erosion	Earthworm Score	VS Ranking
Conventional	4.31	3.70	2.00	4.00	4.00	1.00	4.00	2.00	25.02
Hybrid	3.19	3.47	1.97	4.00	2.75	1.00	4.00	2.38	22.75
Regenerative	4.83	3.84	2.00	4.00	4.00	1.00	4.00	3.38	27.05

The Conventional and Hybrid treatments scored 'Good' while the Hybrid treatment score was 'Moderate'. The lower score in the Hybrid treatment was largely influenced by the presence of a tillage pan within the top 20cm of the profile. This is likely driven by the strip-till machine used by Wattie's in the planting of tomatoes which was used in above optimum soil moisture conditions.

Pre plant Visual Soil Assessments (VSA) have previously been completed in November (pre-sweetcorn in 2022) or October (pre-tomatoes in 2023) when soil moisture content is closer to optimum for Assessment (VSA). The test should be completed when soil is at a moisture content suitable for grazing or cultivation, supported by the 'worm test' where if soil can be rolled into a worm without cracking it is too wet for a VSA. The spring VSA's will be completed in October to better match the timing of previous analysis and will be reported on as part of Milestone 9.

3.3.1 Earthworm count and biomass

As part of the Visual Soil Assessment earthworms were counted to provide weighted score. Poor Score <4 earthworms, Moderate 4-8 earthworms and Good >8 earthworms.

There was a statistically significant difference between the number of earthworms found in a 20 cm cube of soil in the Regenerative treatment compared to both the Conventional and the Hybrid treatments (p= 0.0038 and p=0.037 respectively). While the Hybrid found more earthworms than the Conventional treatment, there was no statistically significant difference between these two treatments (p= 0.34).

The earthworms found in the VSA's were collected and weighed. There is no statistically significant difference between any of the treatments for earthworm biomass.

Table 3-4 Showing average number of earthworms counted and average biomass per from 20cm spade spit of soil (VSA), by treatment.

Treatment	Average Earthworm Number	Average Earthworm Biomass (grams)
Conventional	6.25	2.03
Hybrid	7.44	2.34
Regenerative	10.88	3.17

3.4 Soil infiltration rate

To be completed by our summer intern this year.

3.5 Soil moisture release curve

This has still not been completed by our contractor. At this stage because there has been significant delay in getting this done, we don't have baseline data. Once completed we will look to compare treatment differences where possible. Similarly, we had issues with the data retrieval from the GroPoint sensors which were installed last season, these have been modified by Crop Tide and will be redeployed in the plots. Hopefully at the end of this season we will have some data to analyse.

3.6 Soil penetration resistance

To be completed as soon as possible, once fully staffed in October (two person job).

4 Cover Crop Monitoring

4.1 Canopy development

Canopy development was measured using the Canopeo phone app which measures fractional green canopy cover (FGCC) which can be used to estimate canopy development and light interception. Canopy cover has been measured weekly since emergence of the cover crop in early April. Figure 4-1 shows canopy cover over the season, where the Conventional treatment (annual ryegrass) almost reaches over 95% canopy cover in mid-May, before decreasing to 35% cover in mid-July after grazing (some of this due to lambs trampling grass into the mud). The grass was allowed to grow for a short period ahead of spraying out. Once sprayed, the canopy cover appears to increase, however this will likely be due to rain washing residual mud off the leaves. There is a sharp decline in canopy cover from early August as the grass dies off. While cover appears to be almost 0%, this measure only considers the green cover and doesn't factor the residual material that is still covering the soil surface.

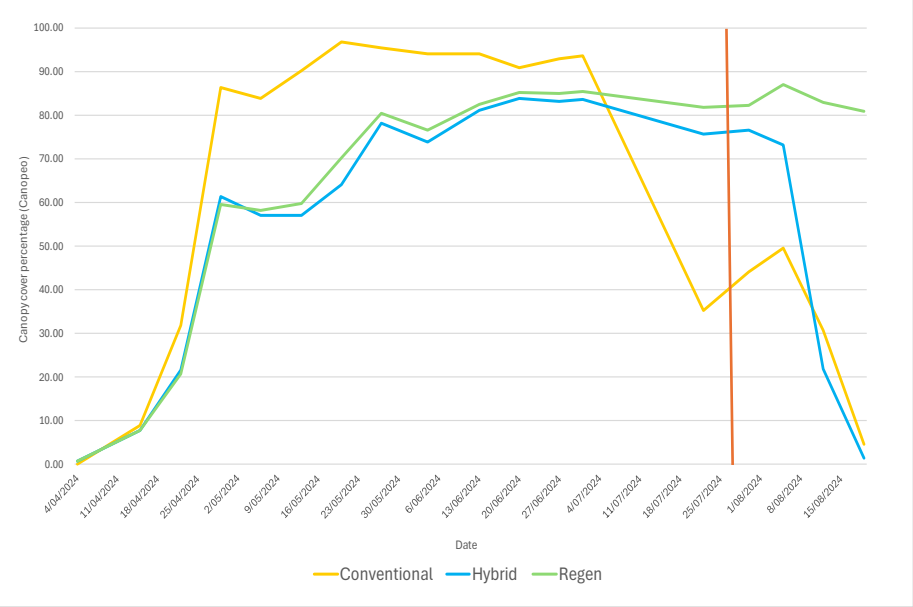

Figure 4-1 Line chart of canopy cover percentage by treatment over time, using the Canopeo App. Orange line indicates date that Conventional and Hybrid treatments were sprayed out.

Both the Hybrid and Regenerative treatment were planted in the same diverse cover crop mix. Given the composition of the mix, being predominantly oats, the Hybrid did not reach full canopy cover, and the Regen treatment is yet to reach this stage. Both treatments followed the same pattern of

growth until the Hybrid treatment was sprayed out, and canopy cover (green cover) declined sharply. Similar to the Conventional treatment, the Hybrid has residual material covering the soil surface. The Regenerative treatment will remain in cover crop until it is terminated ahead of planting beans.

Figure 4-2 Showing winter cover crops. Conventional and Hybrid treatments had been sprayed, with Regenerative treatment still growing.

4.2 Soil moisture

Soil moisture has been measured weekly to 20cm using the Hydrosense II handheld soil moisture sensor (volumetric water content). Two measurements were recorded per subplot (eight per plot). Since planting of the cover crop, the Regenerative treatment has remained slightly drier than the

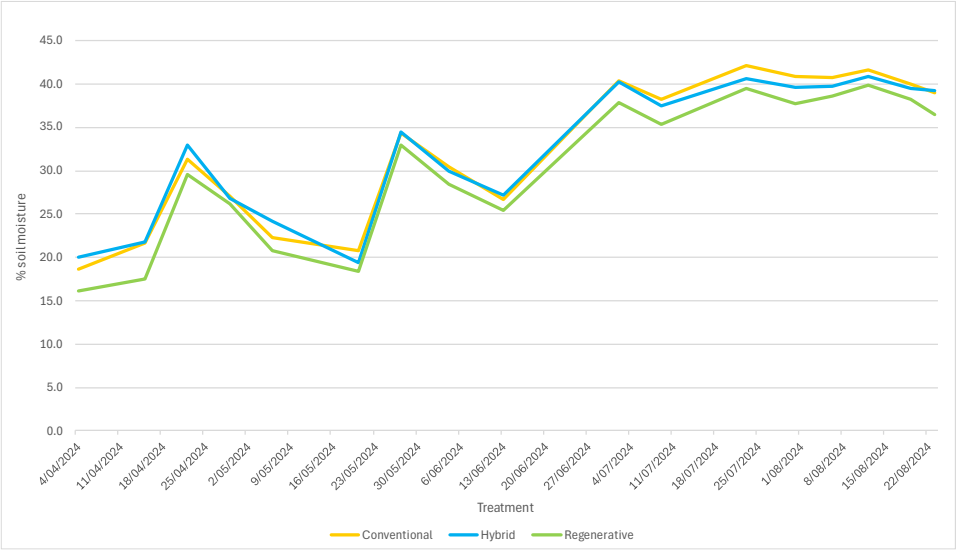

Figure 4-3 Line chart of soil moisture to 20cm (Hydrosense II) for winter cover crops, by treatment.

other two treatments. At the time of planting peas soil moisture was considered wetter than optimum, however was typical of early planting peas on heavier soils. The majority of the McCain early pea programme is on more free draining soils (i.e., near Crownthorpe) and typically doesn't cause too many issues.

The Conventional treatment was ploughed on the 23rd of August, when the Volumetric Water Content (VWC) was 39%.

Soil moisture will continue to be measured throughout the season using both the handheld Hydrosense II (20 cm) and GroPoint sensors to 90 cm.

4.3 Soil temperature

Soil temperature was measured from two weeks prior to planting using a standard 12 cm thermometer. Two measurements were taken per plot (in sub-plot 2 and 4), as close to 9 am as possible. Soil temperature fluctuated daily depending on air temperatures, and soil temperatures dropped significantly on frosty mornings (to be expected).

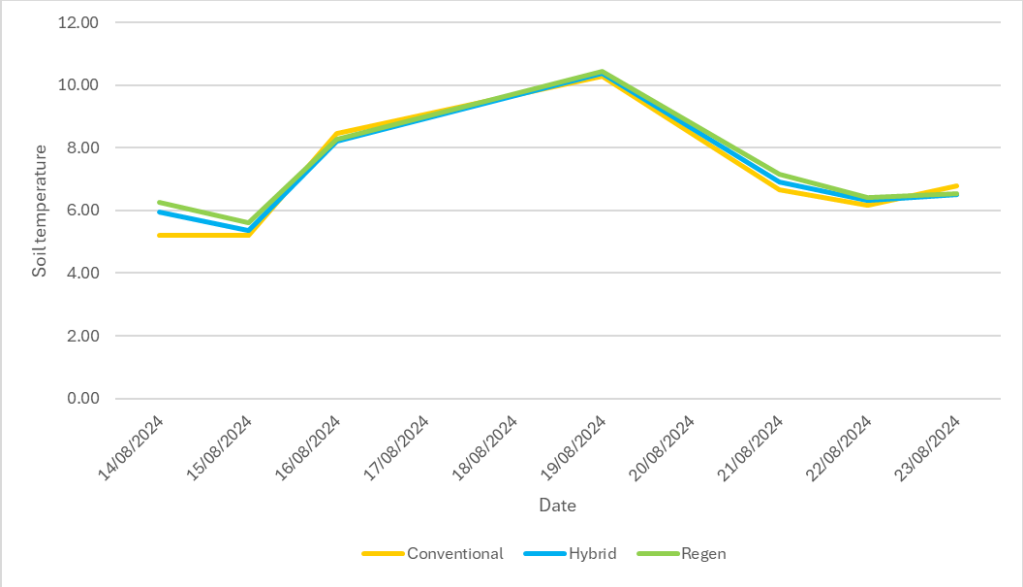

Figure 4-4 Line chart of soil temperature measured prior to pea planting, to 12cm, by treatment.

4.4 Soil Nitrate Quick Test

Soil Nitrate Quick Tests have been completed regularly since planting cover crops in March. Nitrate tests have been completed to 30 cm in two depth increments, 0 – 15 cm and 15 – 30 cm. Eight cores per plot were collected along the existing sampling transect and combined for each measured depth. Soil nitrate-N levels were low at planting, spiked shortly after planting (in the absence of fertiliser), and then dropped off and remained low for the rest of the winter. Figure 4-5 shows results for the total 0 – 30 cm depth over the winter months, all treatments follow a similar trend.

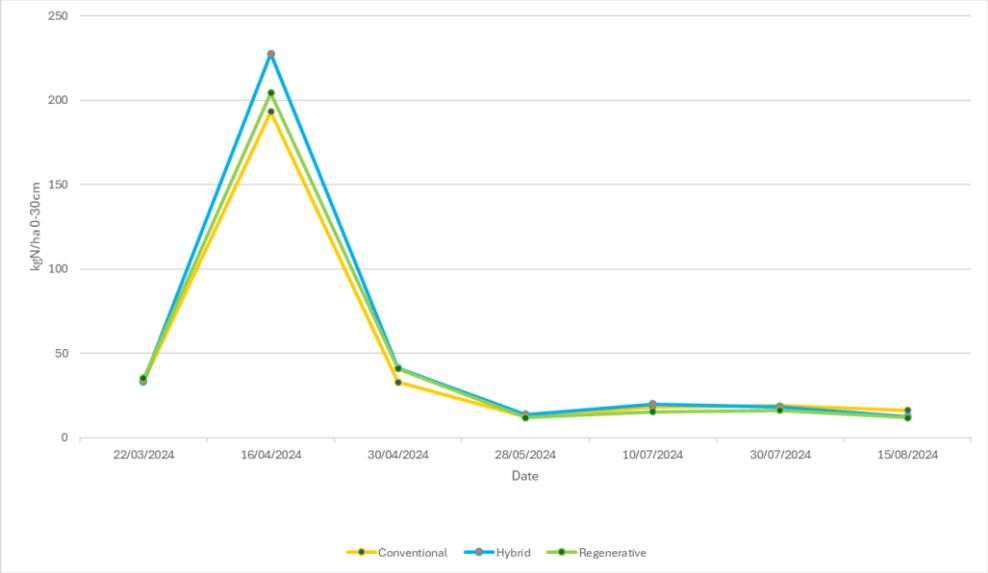

Figure 4-5 Line chart of soil nitrate levels (kg N/ha) by treatment over time in the top 30 cm of soil as determined using the Nitrate Quick Test Method.

4.5 Cover crop biomass

Cover crop biomass was measured for the Conventional treatment ahead of grazing, and the Hybrid treatment ahead of termination (spraying out). The Regenerative treatment will have biomass measurements determined ahead of termination towards the end of the year.

Biomass is determined by taking cuts from a 0.5 m x 0.5 m quadrat (0.25 m^2), four cuts are taken per plot. Sample fresh mass is weighed, and a subsample dried to determine kilograms of dry matter grown per hectare.

The Conventional treatment on average grew 3,222 kgDM/ha (range 2,972 – 3,446 kgDM/ha), planted end of March and grazed in mid – July. The Hybrid treatment on average grew 3,795 kgDM/ha (range 3,493 – 4,300 kgDM/ha), planted end of March and sprayed out end of July. Figure 4-6 shows a comparison of the amount of dry matter grown ahead of termination for both treatments.

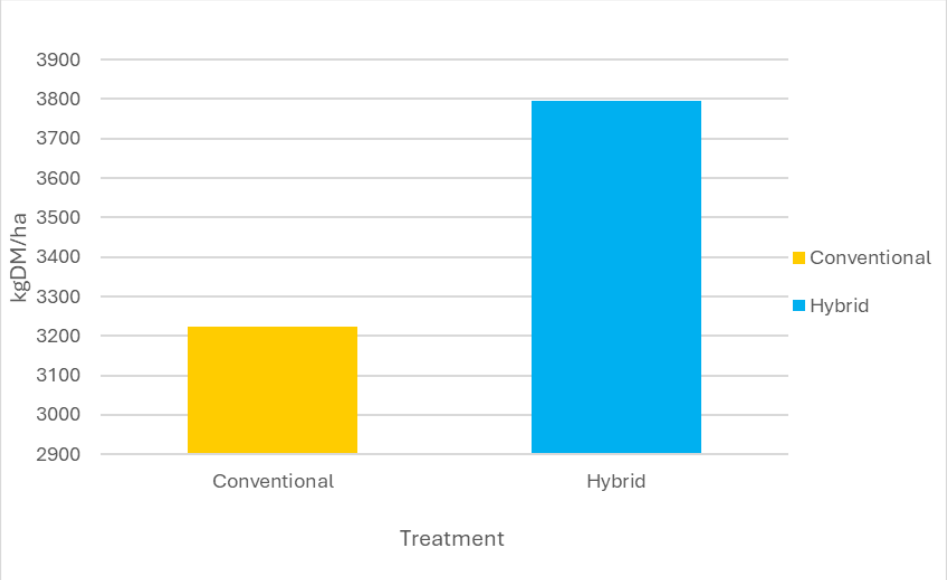

Figure 4-6 Clustered column chart showing winter cover crop biomass (kgDM/ha), by treatment.

5 Year 3 Spring Process Crop Established

5.1 Pre plant soil preparation

Decisions related to the soil preparation ahead of pea planting were largely made in the weeks before planting, with the support of the OAG, particularly McCain and our contractor Mike Kettle.

Both the Conventional and Hybrid treatments were sprayed out four weeks ahead of the planned planting date to give adequate time for the cover crop to start to die and start to break down. We had intended to spray out with a drone to minimise traffic on wet soil, however we experienced several days of wet and windy weather which did not allow for aerial application. Plots were sprayed out with Glyphosate and Sharpen using the tractor mounted spray boom.

Slug bait was flown on with the drone to reduce the slug population as there was a lot of residue in the treatments, which made for a good environment for slugs. Slug bait was flown over all treatments, including the Regen treatment. Even though peas aren't being planted here, the uncultivated ground covered in cover crop may be a host area for slugs and therefore needs to be managed.

The Conventional treatment was ploughed the week before planting and left to dry for a couple of days. The plots were then disced twice to break up clods and level the surface, followed by a pass with the power harrow. The Hybrid treatment was direct drilled so no cultivation was required. As the Regenerative treatment was not being planted in peas, there was no disturbance of this treatment at this time.

It was proposed that the Conventional treatment have one more pass with a rotary hoe or powerharrow to break up some of the hard clods, however due to the lower margins of peas, and their large seed size, it was determined that the seed bed was suitable with only one powered pass.

Table 5-1 Spring pre-pea planting ground preparation details by treatment

	Conventional	Hybrid	Regenerative
Spraying out- Glyphosate + Sharpen	30/7/2024	30/7/2024	Nil
Slug bait (pre-plant)	29/7/2024	29/7/2024	29/7/2024
Cultivation	Ploughing – 23/8/2024 Discing x 2 – 26/8/2024 Powerharrow – 30/8/2024	Nil	Nil

5.2 Spring crop planting

Our first crop of the season was planted on the 3rd of September, which was slightly behind schedule.

Planting was delayed due to above optimum moisture content in the Hybrid treatment. In 'conventional' systems cultivation can be used to dry soil out by exposing more of the soil surface, this is useful when planting early on heavier soils, as was the situation we were dealing with. Additionally, when a crop is actively growing, moisture is removed from the soil through evapotranspiration, which can also aid in drying soil. In the Hybrid treatment, the cover crop had been dead for three weeks, which meant that there was no evapotranspiration occurring. Both of these factors meant that soil was slow to dry, particularly after a shower of rain.

On the planned planting date, the Conventional treatment was ready for planting after cultivating had dried the soil, however the Hybrid remained wet. The issues we faced with planting into wet soil were that there wouldn't be enough tilth created by the drill reducing seed to soil contact, a defined channel would be created which can be a good home for slugs, and exposed seed may be predated by birds.

We met with McCain and Mike Kettle contracting over several days discussing how much leeway we had in terms of planting date, and what options we might have to speed up drying if we had to. McCain wanted to ensure we were set up for success in our direct drilling and gave us an extended window of two weeks to plant, so we could target better soil conditions.

To speed up drying we discussed mulching the cover crop, or aerating to minimize disturbance (preferred), and if all else failed we would disc and power harrow (least preferred). In a small trial area, we experimented with mulching the cover crop to see if this allowed for better airflow and increased drying. We left the mulch on the surface for two days and saw no change in soil moisture and decided against mulching before planting. It was preferred that we didn't mulch ahead of planting as the detached reside would cause issues with blocking the drill or sticking to the press wheels.

We had two short dry runs with the planter, one ahead of the target planting date and one ahead of the actual planting date, to determine how much of a slot/channel would be left by the planter. As we closely watched the forecast, we had rain predicted so decided to make the most of four days of good drying weather and plant on the afternoon of the 3rd of September.

Trichoderma (TrichoStart) was applied to the Hybrid treatment, in batches of 25kg of seed (as advised by growers who use the product). We decided to use Trichoderma in the Hybrid based on trial data that Wattie's have in the South Island, where they found there can be potential increases in yield, and possibly disease protection from the use of this product. As the Hybrid was being direct drilled, slug bait was applied in the planting slot (separate box on the drill). Slug bait was not used in the Conventional as most growers would expect low slug pressure when soil is cultivated. We will monitor, as slugs may move between treatments, and we may apply slug bait to the margins of the plots to prevent transfer between treatments.

The cover crop was mulched immediately after planting. It was discussed that perhaps this wasn't necessary, however as the tillage radish was popping up to 10cm out of the ground McCain were worried about large pieces of radish ending up in the harvester and contaminating the factory intake. As a precaution, the cover crop was mulched to level the radishes and break them up into smaller pieces in the hope they will break down faster or be low enough to the ground that the harvester won't pick them up.

Figure 5-1 Images showing tillage radish popping out of the ground.

Table 5-2 Spring pea planting details by treatment

	Conventional	Hybrid	Regenerative
Peas planted			Nil
Mulching	Nil	CC mulched – 3/9/2024	Nil
Planting rate	210kg/ha	210kg/ha	
Seed treatment	Wakil	Wakil Trichoderma	Nil
Slug bait	TBC. If required, around plot edges	Whole plot – 3/9/2024 7kg/ha	Nil
Rolling	6/9/2024	6/9/2024	Nil

5.3 Calibrate irrigator

Will be completed ahead of first irrigation event- due to a dry start to spring this could be as early as the first week of October.

6 Year 3 Spring Crop Monitoring

6.1 Establishment percentage

At the crop walk with McCain on the 19th of September, it was advised that population/establishment counts Tuesday the following week. A 1 m^2 quadrat was use and seedlings which had unfurled and had flat leaves showing were counted. Those shoots that were still curled up were not yet counted. The target is 90 – 100 plants/m^2.

The first count was completed on the 24th of September and will be completed daily until full emergence. Figure 6-1shows the total number of plants counted in 1 m^2 each day (average per treatment). The Box and Whisker shows that the Hybrid treatment has a lower plant population to start with and there is considerable variation in the number of plants that have emerged.

The operations field walk on the 26th of September discussed the reasons for this and potential implications, as emergence has been slow and there is possibly more variation than is ideal.

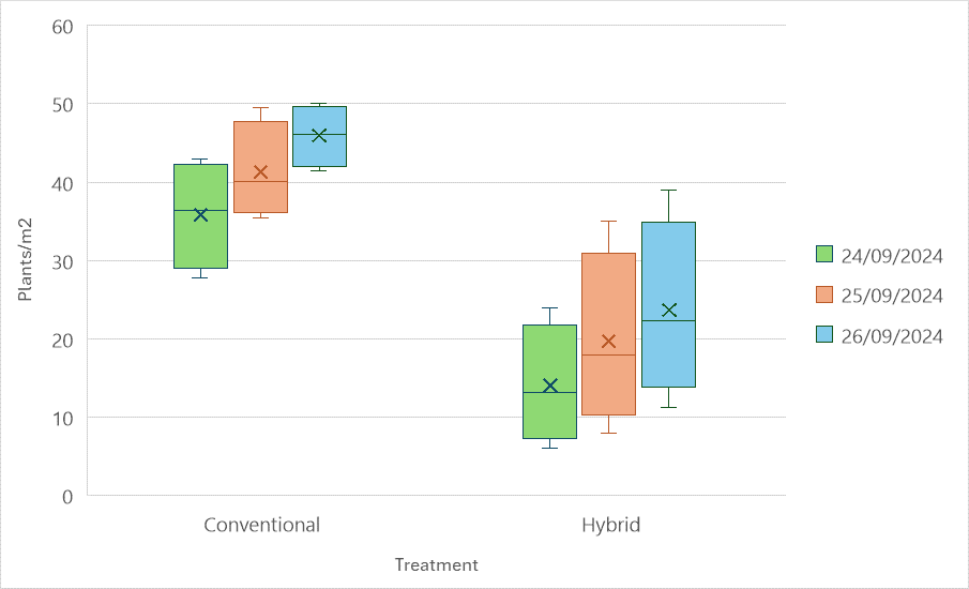

Figure 6-1 Box and Whisker chart sowing average number of fully emerged plants per m2 each day, by treatment

6.2 Canopy development

At the time of reporting canopy development has been measured for three weeks. includes canopy development for all three treatments, including the Regen treatment which is still planted in cover crop. The peas are only just emerging so canopy cover percentage is low. In the Hybrid treatment, where radishes have not been completely snapped, there is some regrowth of green shoots which may impact results moving forward. Additionally, weed pressure may also impact this.

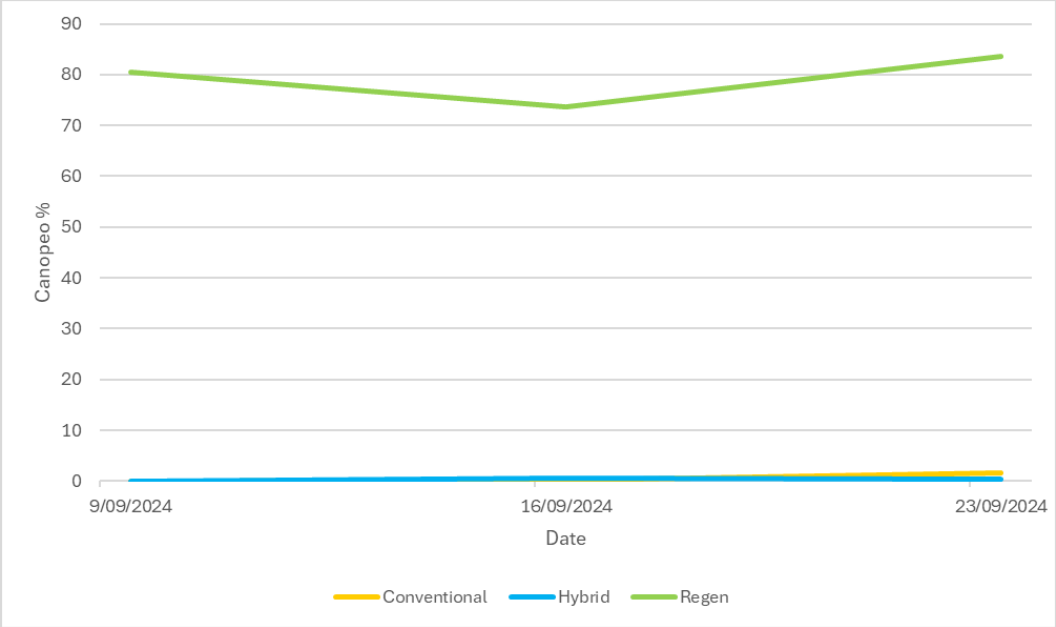

Figure 6-2 Line chart of canopy development using Canopeo App, measured weekly, by treatment.

6.3 Agronomic observations

At the time of reporting three weekly crop walks attended by both McCain and Wattie's field staff have been held. At this point in late September, the peas are only just emerging and there are few actions, however we have had valuable discussions on crop management and monitoring at each meeting.

Figure 6-4 Weekly field walk inspecting peas 19-9-2024.

Figure 6-5 Weekly field walk inspecting peas 25-9-2024

6.4 Soil Nitrate Quick Test

Soil Nitrate Quick Tests have been completed in two increments 0 – 15 cm and 15 – 30 cm twice since planting (two weeks apart). Figure 6-6 Line chart showing Nitrate Quick Test (kgN/ha) 0 – 30cm from July to September 2024, by treatment shows the combined nitrate nitrogen in the two depths

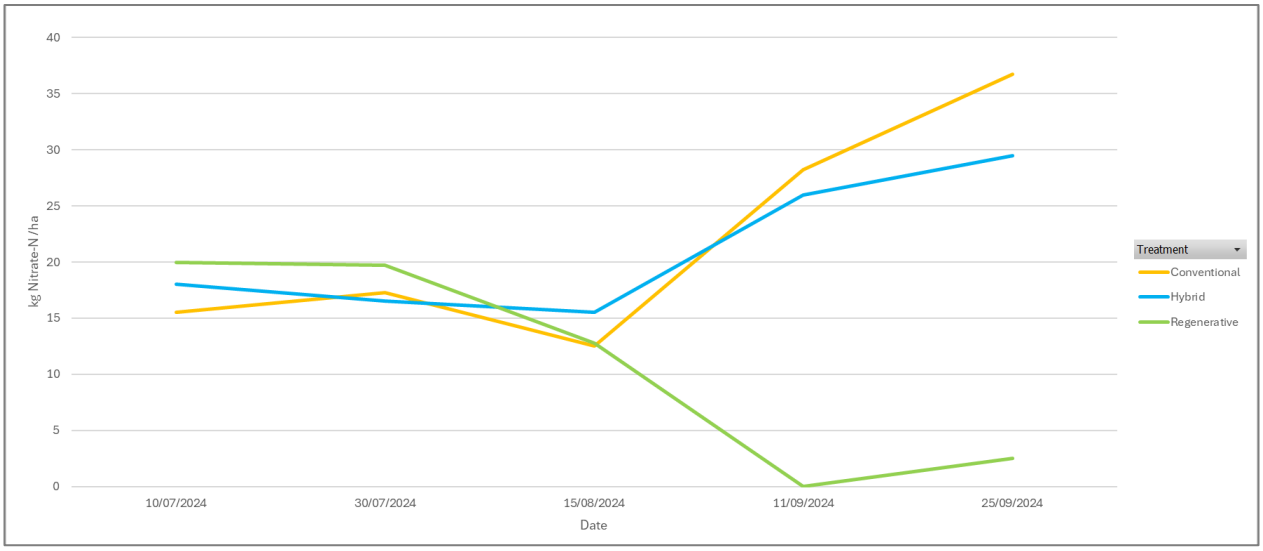

Figure 6-6 Line chart showing Nitrate Quick Test (kgN/ha) 0 – 30cm from July to September 2024, by treatment

(0 – 30 cm), over time from July to September, to show nitrate trends over time.

6.5 Observable deficiencies

At the time of report submission, the seeds are only just germinating. No observable deficiencies to date,

6.6 Tissue testing

McCain are of the view there are only two timings that will be useful for tissue testing peas: pre-flowering and post-harvest. Tissue tests will be completed and reported on as part of Milestone 9.

6.7 Pest and disease presence

The main pest problem experienced is due to damage from pukeko and rabbits. Pukeko pull out newly germinated seedlings to eat the seed underneath, and rabbits have been digging holes in plots. Our pest control programme has ramped up to manage these pests, particularly up until plants are big enough to withstand a pukeko pulling it out of the ground.

No other pest or disease issues identified yet.

6.8 Maturity

Not relevant to this milestone, given growth stage of the pea crop. Maturity will be reported on in Milestone 9.

6.9 Inputs

Peas are one of the lower input crops we will grow in this trial. All inputs are being recorded.

6.9.1 Nutrients

Peas have been found to have little response to applied nutrients. No nutrients have been applied to this crop, and we likely won't apply any nutrients to the peas. We will be using conventional fertilisers for growing the bean crop.

6.9.2 Agrichem

All agrichemical applications have recorded. To date this includes the slug bait (molluscicide) applied to all treatment's pre-plant, the spraying out of the Conventional and Hybrid treatments, and the use of slug bait in the hybrid at planting. Typically, a pre-emerge herbicide is applied to peas, however conditions after planting were too dry (need 15 mm rain after application) so this application has been excluded from the programme.

6.9.3 Biological products

The only biological product applied to date is the Trichoderma applied to the seed for the Hybrid treatment. This is a powdered product that is compatible with the standard seed treatment used by McCain. This is applied at 1g/kg of seed. Given the rudimentary way of applying to a small volume of seed (hand mixed in a wheel barrow), extra product was applied to ensure even coating.

6.9.4 Irrigation

No irrigation to date.

6.10 Soil moisture

Soil moisture has continued to be measured weekly using the Hydrosense II. Soil moisture was measured the day before planting (2nd Sept), where the Regenerative and Conventional treatments had similar moisture contents, and the Hybrid was much wetter. The Regen treatment where the cover crop is still actively growing remains drier than the other two treatments. The Hybrid, where the soil remains undisturbed, with cover crop residue on the surface, is the wettest treatment.

We are interested in the relationship between soil moisture and soil temperature, as wetter soils will likely be cooler as it takes more energy to heat them up.

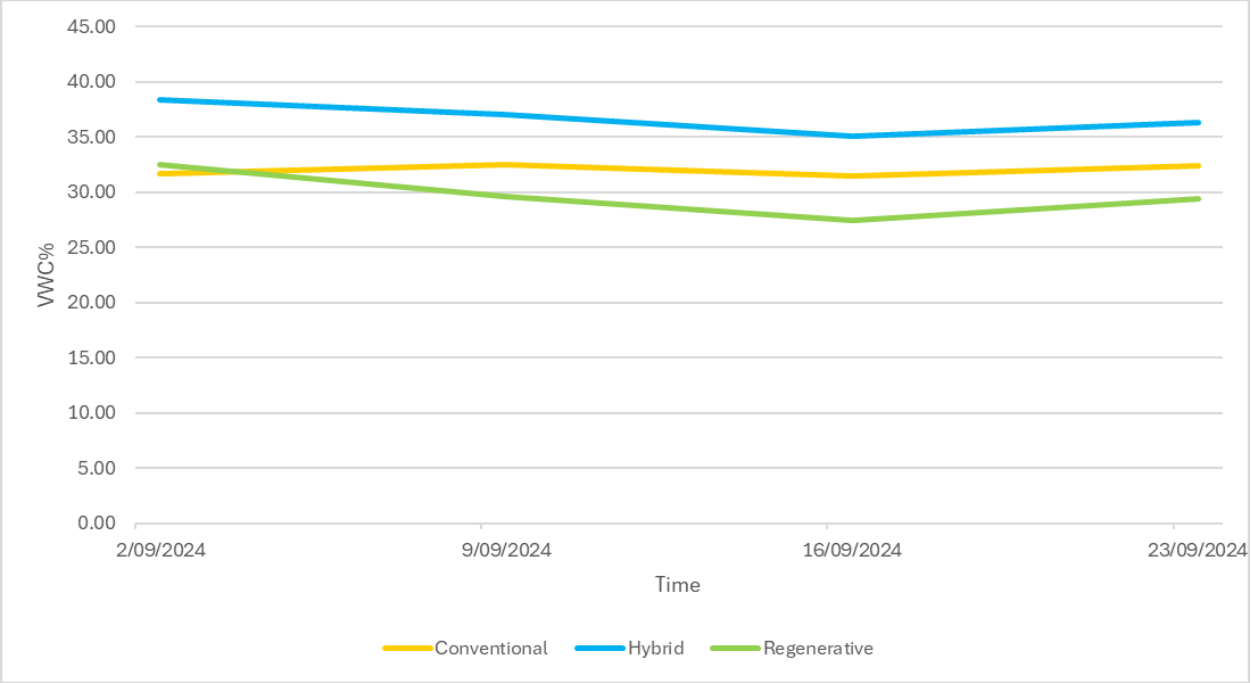

Figure 6-7 Line chart showing soil moisture since pea planting, by treatment.

6.11 Soil temperature

HortPlus iButton Micro-loggers were buried in the planting line (next to a seed) on the 6th of September and retrieved on the 27th of September. The purpose of measuring temperature in the planting line is to determine the temperature of the soil near the emerging seed, particularly to gauge any differences between treatments, as the soil had been treated differently at planting. Soil temperature can impact germination rate of the seed. Loggers were also buried in the Regenerative treatment, to approximately the same depth for completeness of the data set. Soil temperature was recorded at 15 minute intervals.

For ease of interpretation, average daily temperatures, by treatment are displayed in Figure 6-8 Line chart showing average daily soil temperatures at seed sowing depth (post planting) by treatment. . The Conventional treatment, cultivated with no residue, has the highest soil temperatures, which likely relates to the bare soil surface and lower soil moisture content. In comparison the Hybrid treatment has lower soil temperatures, and higher soil moisture content (Figure 6-7 Line chart showing soil moisture since pea planting, by treatment.), a difference which could explain the lower initial emergence number in the Hybrid vs the Conventional treatments. The Regen treatment as the lowest soil temperature, likely due to the shading of the soil by the actively growing cover crop. More interpretation of this data will be completed.

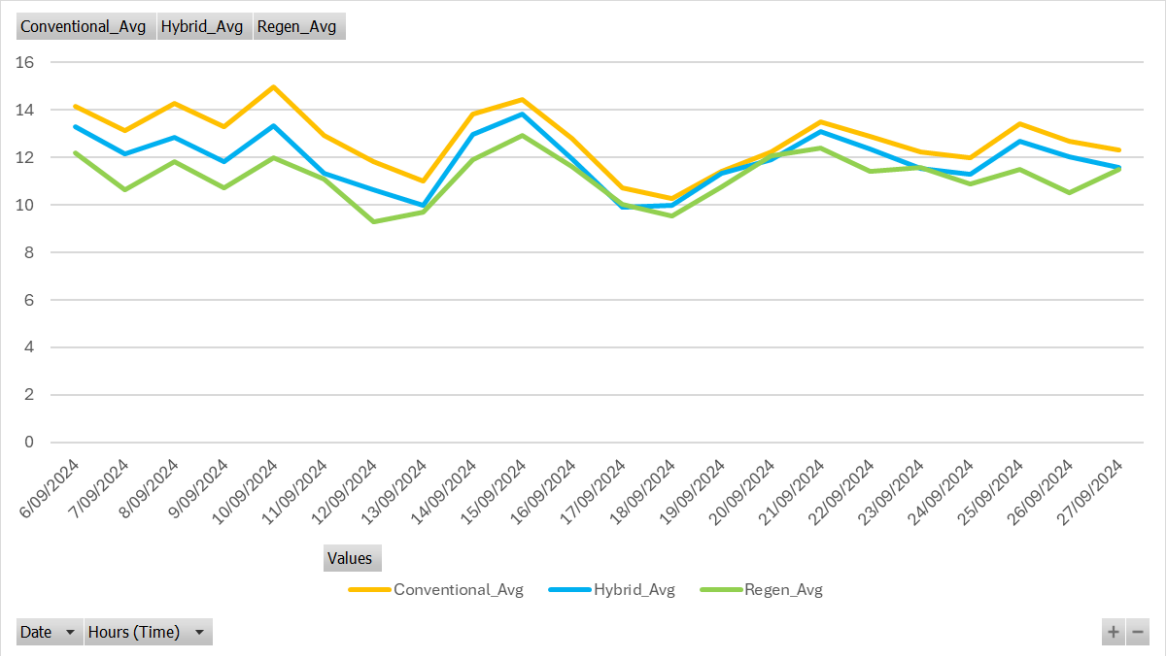

Figure 6-8 Line chart showing average daily soil temperatures at seed sowing depth (post planting) by treatment.

6.12 EIQ

The EIQ values have been updated to reflect current and available information for pesticides. There have also been amendments made to the formula to better reflect available information. These changes came into effect on the EIQ website on the 5th of September, and on this basis EIQ calculated for treatments to date will need to be updated, this will happen in time. EIQ calculations for the 2024 – 2025 season will be calculated using the new formula.

The herbicides applied to date were for spraying out (glyphosate + Sharpen).

The fungicides applied to date are in the seed treatment for the peas (Wakil) which is applied at 2 kg/ T of seed. We sowed the peas at 210 kg/ha; therefore 0.42 kg/ha of Wakil was applied. Based on this we can calculate the EIQ of this seed treatment.

Table 6-1 Treatment Field Use and Ecological EIQ Values to date

	Conventional	Hybrid	Regen
Herbicide Field Use EIQ /ha	193.5	193.5	0
Fungicide Field Use EIQ /ha	10.6	10.6	0
Insecticide Field Use EIQ /ha	0	0	0
Total	204.1	204.1	

**Note that the slug bait product used (IronMax – Iron present as iron phosphate anhydrous) is not registered on the EIQ database.

7 Outreach

7.1 On-site field day

On the 17th of September an on-site field walk was held, the first monthly field walk of the 2024-2025 cropping season. The weather was particularly terrible that afternoon, however we modified the agenda and provided a project overview inside, and those who wanted could go for a walk around the crops. Attendees included processors, contractors, regional council, Ministry for Primary Industries, technical field representatives and researchers, which made for good discussion.

Figure 7-1 September Field Walk

7.2 Magazine article

Magazine article on plans for the 2024 season was submitted to the NZ Grower on the 23rd of August. Article will appear in the October edition of the magazine. The article discusses some of the conundrums we are working through with the OAG and TAG around cover crop termination, as well as a general update of where we are up to at the start of year three. A copy of this article can be found in Appendix 2: Upcoming NZ Grower Article.

7.3 Website updated

Monthly newsletters have been sent out providing updates on project progress.

8 Appendix

8.1 Appendix 1: Soil Test Results Comparison 2023 vs 2024

Basic soil test comparison for key nutrients 2023 to 2024. In 2024 column:

- Green cells indicate an increase in level from previous year
- Yellow cells indicate no change from previous year
- Red cells indicated decrease in level from previous year.

	pH		Olsen Phosphorus		Sulphate Sulphur		Potassium		Potentially Available Nitrogen (15cm Depth)		Boron		Potentially Mineralisable Nitrogen	
Plot No.	**17/08/2023**	**1/08/2024**	**17/08/2023**	**1/08/2024**	**17/08/2023**	**1/08/2024**	**17/08/2023**	**1/08/2024**	**17/08/2023**	**1/08/2024**	**17/08/2023**	**1/08/2024**	**17/08/2023**	**1/08/2024**
Plot 1	6.3	6.3	62	64	2	3	30	29	114	105	0.9	1.1	104	193
Plot 2	6.5	6.6	82	80	5	2	27	28	82	100	1	1.1	95	95
Plot 3	6.5	6.5	73	69	3	2	29	25	118	76	1.3	1.2	89	85
Plot 4	6.3	6.3	52	51	5	2	27	23	97	96	0.9	1	96	87
Plot 5	6.3	6.5	54	49	4	3	31	24	127	101	1.4	1.3	100	93
Plot 6	6.2	6.2	43	41	2	3	25	23	80	102	1	1.1	95	86
Plot 7	6.6	6.6	46	44	3	2	32	27	95	94	1.5	1.4	107	98
Plot 8	5.9	6.3	61	52	4	2	27	22	112	92	1	1.1	94	89
Plot 9	6.3	6.3	54	52	3	2	26	25	124	99	0.9	1	98	96
Plot 10	6.7	6.8	37	40	4	2	29	24	128	87	1.3	1.3	100	87
Plot 11	6.3	6.3	41	46	3	3	25	25	118	87	0.9	1.1	92	153
Plot 12	6.2	6.3	39	36	2	3	30	27	128	94	0.8	1.1	99	89

8.2 Appendix 2: Upcoming NZ Grower Article

Conventional versus Regen: gearing up for a Carbon Positive summer

Dan Bloomer and Alex Dickson – LandWISE

Applying regenerative agriculture principles to an intensive vegetable production system presents a number of apparent conflicts. The conventional system that typifies most Heretaunga Plains growers' practices has evolved to meet factory-determined planting dates and get most profitable production off expensive land. How do we adapt that, or replace it, to meet the ill-defined definition of regenerative cropping?

In conventional growing, almost everyone re-grasses over winter, most graze lambs, and normal practice is to spray out some weeks before soil preparation and planting. Most paddocks are fully cultivated, although there is some strip-tillage on lighter soils. Onions, beetroot and carrots get most cultivation to achieve the desired tilth for sowing fine seed. Yield is king and disease pressure can be high, so crops get the full fertiliser and crop protection package. A range of crops and winter covers is grown over several years, with rotations reflecting economics, disease cycles and timing. Growers may double crop, perhaps peas and corn, to get best annual returns. Then in autumn, it's back into grass and the cycle repeats.

While regenerative farming is loosely defined, possibly one of its strong points, there are five common principles. The first is to minimise soil disturbance. That generally means avoiding cultivation and minimising the effects of applied chemistries including mineral fertilisers and agrichemicals. But regen is not organics – indeed there is a separate but related regenerative-organic movement in some areas.

A second principle is maintaining living roots in the soil as much as possible. Of the total photosynthate a plant creates, as much as 20% goes into the soil to support the soil microbiome – the fungi, bacteria and others – and aid decomposition, nutrient capture and cycling, and stabilise soil structure. Thus, there is a link between the amount of plant growth and soil health and in turn, more productive plants. Associated with this is the principle of protecting the soil surface. Bare soil is easily damaged or eroded by rain and wind. The microbiome continues to respire, burning away the organic matter and there is no photosynthesis restocking supplies. Many studies have shown that long fallow periods can be the biggest cause of soil carbon loss. Overseas research often presents soil cover as avoiding excessive heat, but in an early Hawke's Bay spring, more soil heat is exactly what growers are wanting!

The fourth guiding principle is maximising biodiversity. We see plant biodiversity, but that underpins the above and below ground ecosystem including insects, earthworms and beetles, millipedes and the like, and of course to essential micro-organisms. In general, a more diverse ecosystem is more stable, better able to withstand shocks including application of chemicals, adverse weather events and plagues.

The fifth principle is having animals, ideally cattle, in the system. This seems to stem from observations of bison on the natural prairies of North America, but there are reports that bovine saliva has gut microbes that contribute to soil functioning. Certainly, research is showing there are strong correlations between the soil microbiome and the human gut microbiome – it seems we are indeed what we eat.

So how is our Carbon Positive project stacking up against those principles? The conventional treatments are going great! Our wider team has many decades of experience optimising practices to maximise production. We cultivate, fertilise, spray and to date have achieved well above average yields. Nobody has much experience of regenerative intensive vegetable production, and especially not at the intensity of places like the Heretaunga Plains or Poverty Bay Flats, or the fresh vegetable areas of Pukekohe and Levin. We are building it as we fly, so to speak. And we have our "hybrid" system, where we pick practices from either of the others.

Our regenerative farming advisory group has put emphasis on biodiversity, keeping the soil covered and maintaining living roots as much as possible. So our winter cover crop has a mix of oats and tillage radish, with some vetch and clovers. Buck wheat in the mix was zapped by early frosts and sunflowers lasted longer but didn't get a lot of growth before more recent frost finished most of them. We have extra biodiversity where weeds emerged in the gaps; the regenerative plots are noticeably weedier than the annual ryegrass in the conventional ones. The same mix was planted in the hybrid plots.

The summer cropping programme is kicking off, with peas for McCain Foods to be planted by the end of August. They will be followed about Christmas time by green beans. At time of writing, the conventional plots have just been ploughed and will next week be harrowed and drilled. They will get both pre-emergence and post-emergence herbicides. The hybrid plots are brown with sprayed out cover crop, and our plan is to direct drill the peas, with beneficial Trichoderma as a seed dressing. Depending on results, we may mulch to residues after planting to both roll the soil to close planting slots and encourage residue breakdown before harvest. The pre-emergence herbicide will be dropped with no-till and the retained residue providing some weed control. We expect to use post-emergence herbicides.

The regenerative plots are green and growing. The advisory group decided to forego the pea crop in favour of less disruption and more time for the cover mix to grow leaving the soil in a 'restorative phase' for longer. The thinking is that the extra root exudates and less soil disturbance may "yield" more value than the pea crop through enhanced soil health, especially in the longer-term. There may also be an advantage to soil condition by not driving heavy machinery while the soil is wet. We don't have conclusive evidence either way, but this is after all, a research project. Our big question is, "How and when do we terminate the cover crop?"

Before we grew process tomatoes with Heinz-Wattie's last year, we had a similar cover crop. We planned to mulch, plant through, and retain it on the surface for soil protection and weed management. In the event, we had trouble terminating the oats, and the whole lot was hoed multiple times just before the scheduled planting date. The extra water used by the cover crop meant the soil was very dry and the tomatoes struggled relative to their mates in the conventional and hybrid plots.

This year, by dropping the peas, we have a much later planting date. The termination option of choice is crimper-rolling which has least soil disturbance. This method of termination was borne out of the Rodale Institute in the US and is successfully used in arable cropping systems in single species cover crops like rye-corn, tick beans or oats once they reach maturity. We do not know how successful it will be in our trial. Last year the oats were not sufficiently mature when we tried to terminate them, and they quickly regrew. Maybe this year they will have reached to prescribed flowering to milky dough seed stage and we'll see success. If we don't, what then? Will crimper-rolling kill the remaining tillage-radish? We think it might, because a recent trial run with the direct drill snapped their tops off in the hybrid plots, although we note that cover had been sprayed out a month earlier so plants were already dying. What about the vetch and underlying clovers and weeds?

If crimper-rolling is not enough, what should Plan B be - cultivate or herbicide? We burnt a lot of diesel and did a lot of soil disruption incorporating about 11T/ha of biomass last year, and this year it could be even greater given it will have had an extra three or four months growing. Is it OK to use herbicide instead? Is glyphosate a best option?

The Carbon Positive project is a collaboration between LandWISE and the Hawke's Bay Future Farming Trust. It is funded by MPI, HB Regional Council, McCain Foods, Heinz-Wattie's and BASF with strong support from Hill Laboratories and the local growing community.