LandWISE INCORPORATED

HAWKE'S BAY FUTURE FARMING
TE MATAU A MĀUI AHU WHENUA-HĪKINA TAIAO

Carbon Positive Project

Milestone Five Operational Report

Due 10 November 2023

Contents

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Milestone 5: Year 2 Begins

Date: 10 Nov 23	**Milestone 5**
Milestone description	Year 2 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 2 spring process crops established, soil and crop monitoring. On site Field Day. Magazine article and websites updated. Annual Project Plan Year 2 approved. 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) Year 2 trial site prepared Trial results, copies of all extension material. 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	$173,469
Co-Funding contribution	$74,344

Science Plan Activities

Activity	**Completion Date**	**Details**
PSG reviews progress and plans	10/11/2023	Discussion at PSG meeting
TAG reviews science plans	10/11/2023	Reviewed in 3 stages; 1st review by Plant and Food, 2nd review by OAG, 3rd review by TAG. Change made as required.
Year 2 process crop operational plan completed	29/9/2023	Joint planning between processors, growers, consultants, technical experts etc. to develop operational plan for the 2023-2024 crop
Soil monitoring		
Basic soil testing	1/09/23	Standard soil test suite to 15 cm (Commercial Labs)
Hot water extractable carbon (intermediate sampling)		0 – 15 cm, 15 – 30 cm & 30 – 60 cm, 10 x 30 cores per plot. Combine East and West ends 5 cores each) at each depth and send composite sample for lab testing
Visual soil assessment	Before planting	4 samples per plot, before crop planted
Earthworm counts	Before planting	4 samples per plot, group by worm type, count, weigh
Soil infiltration rate		In-situ test-ring or disc permeameter
Soil moisture release curve		Neutron probe

Soil penetration resistance	After planting	5 transects/plot @ 10 readings x 20 cm apart across bed to 60 cm depth.
Cover Crop monitoring		
Canopy development	15/09/23	Eight images taken per plot (10-12 paces between).
Weed survey	25/7/2023	4 x 0.25m^2 quadrat. Identify species in quadrat, and score amount of that weed (1 = few, 2 = some, 3 = many)
Slug pressure	15/9/2023	Relative Slug Activity using Oregon State University Method. Four flowerpot bases per plot. Slug numbers recorded (from soil and on lid) and biomass weighed.
Soil Nitrate Quick Test	Ongoing	3 depth increments 0 – 15 cm, 15 – 30 cm, 30 – 45 cm. Completed mid-winter, 1 month pre-plant, 1 week pre-planting, and then fortnightly through growing season
Residue Biomass	30/10/23	Recorded before grazing or crop termination. 4 x 0.25 m^2 quadrats cut and dried to determine kg DM/ha.
Tissue N and C	1/09/23	Subsample taken from biomass cuts - commercial lab testing
Year 2 Spring process crop established		Estimated planting date for tomatoes 27 Oct – 1 Nov
Soil prepared as agreed to by OAG	Before planting	Prepared as per operational plan
Planting managed as agreed to by OAG	At planting	Prepared as per operational plan
Calibrate Irrigator	After planting	Irrig8 lite bucket test – single transect
On Site Field Day	Ongoing	Monthly field walk starting 6 Sept
Magazine article and website updated	Ongoing	Monthly newsletter with updates

Activities Completed

Key activities completed as part of Milestone 5 were winter cover crops being grown and terminated, and the planting of a tomato crop for Heinz-Watties.

The operations programme for the 2023-2024 planting of tomatoes has been developed over the last five months. The plan has been developed in conjunction with Heinz-Watties, McCain Foods, regenerative consultants, and advisors, interested local growers, organic vegetable producers, international process tomato growers, technical field representatives and contractors. The planning and consultation for this crop has been more extensive than for the previous year's sweetcorn crop, as the inputs for process tomatoes are considerably higher. There have been several iterations of the operational plan and there is now a 'final' version, however this is subject to change depending on the season.

Despite predictions of an El Nino summer, soil conditions remained wet over the early-mid spring, which meant that cultivation activities were delayed. Additional passes with aerators and rotary hoes were required to achieve the mechanical tilth required to transplant tomatoes. Just before planting it was found that the soil in the regenerative treatment plots was too compacted for adequate root development, so the cover crop was incorporated and the Watties conventional planter used to transplant seedlings. This was a major deviation from the operations plan and the Operations Advisory group are discussing how we manage the regenerative crop through the season. Figure 1 below shows soil moisture (red line) and rainfall (blue bars) from 1st of June 2023 to 29th October 2023.

Soil Monitoring

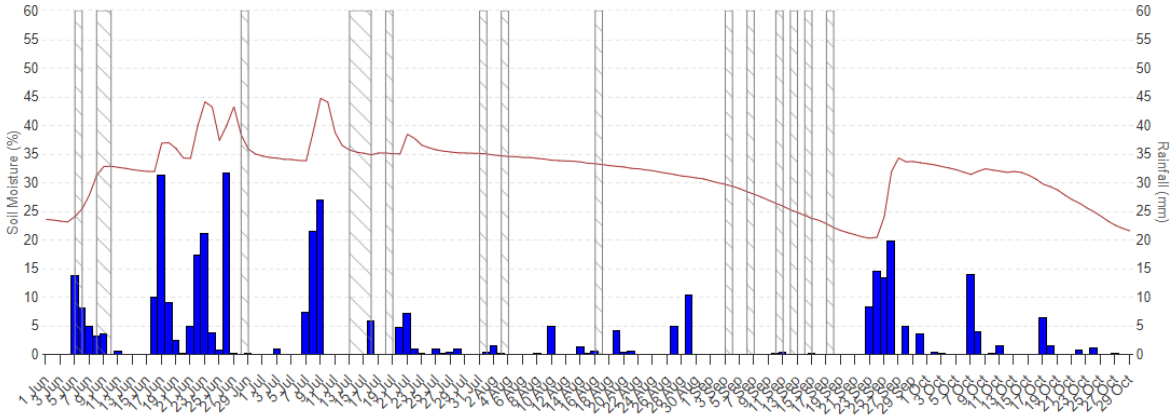

Figure 1 Soil Moisture and Rainfall data (Ruahapia Road Weather Station 1st June-29th Oct retrieved from HortPlus MetWatch)

Basic soil testing

Samples for basic soil testing were taken from plots on the 16th of August. One soil test was submitted per plot for nutrient tests (different to last year where one soil test was submitted per quadrant). There is variation between plots with pH ranging from 5.9 to 6.7, Olsen P 39 – 82 mg/L, Potassium 25 – 32 MAF, Potentially Available N 80 – 128 kgN/ha and Boron 0.9 – 1.5 mg/kg. Sulphate Sulphur and Extractable Organic Sulphur have less variation between plots. The results from these tests were used in the development of crop nutrition plans for the tomato crop. Nutrient plans were completed by Mark Redshaw from Yara Crop Nutrition, who completes plans for the majority of tomato growers in Hawke's Bay.

Hot water extractable carbon (intermediate sampling)

Soil cores for Hot Water Extractable Carbon (HWEC) have been collected and sent to the lab for submission, and we are awaiting results. Ten cores were taken along the already established

transect in each plot using a 30mm diameter corer. Plots were split into two, with five cores taken from the West End and five cores taken from the East End. Cores were split into three depths (0 – 15 cm, 15 – 30 cm and 30 – 60cm), therefore each plot had six samples sent for laboratory analysis (72 samples total).

Visual Soil Assessment

Visual Soil Assessment (VSA) was delayed due to high soil moisture conditions. VSA was completed over several days (within the same week) before groundwork commenced. Most VSAs were done in the field, however some samples were dug out to ensure soil wasn't disturbed by cultivation activities and completed out of field.

Figure 2 Showing examples of pre-planting Visual Soil Assessments from (left) a conventional treatment plot and (right) a regenerative treatment plot.

VSA ranking is <10 Poor, 10-25 Moderate, >25 Good [1]. All VSA results across all plots ranked as 'Moderate', with total scores ranging from 15.5 – 20.6.

An observation from the VSA scoring was that soil under the regenerative treatment (oats) appeared to be drier in comparison to the other treatments. Soil structure was blockier and harder to break up than in the conventional treatment plots. This may be due to historical compaction issues (worsened by a wet season) or due to the oats taking up more moisture from the soil. The conventional plots were cultivated before ryegrass was sown after the previous sweetcorn crop, whereas the regenerative plots were direct drilled in oats, vetch and lupins. Ryegrass plots were terminated by glyphosate in September, whereas the regenerative cover crop was allowed to grow until the end of October.

Earthworm counts

As part of the VSA, earthworms are counted, collected, and total earthworm biomass (in one spade spit) weighed.

[1] Using Visual Soil Assessment Volume 1 *Field guide for cropping and pastoral grazing on flat to rolling country* (Graham Shepherd) https://www.landcareresearch.co.nz/assets/Publications/VSA-Field-Guide-/VSA_Volume1.pdf

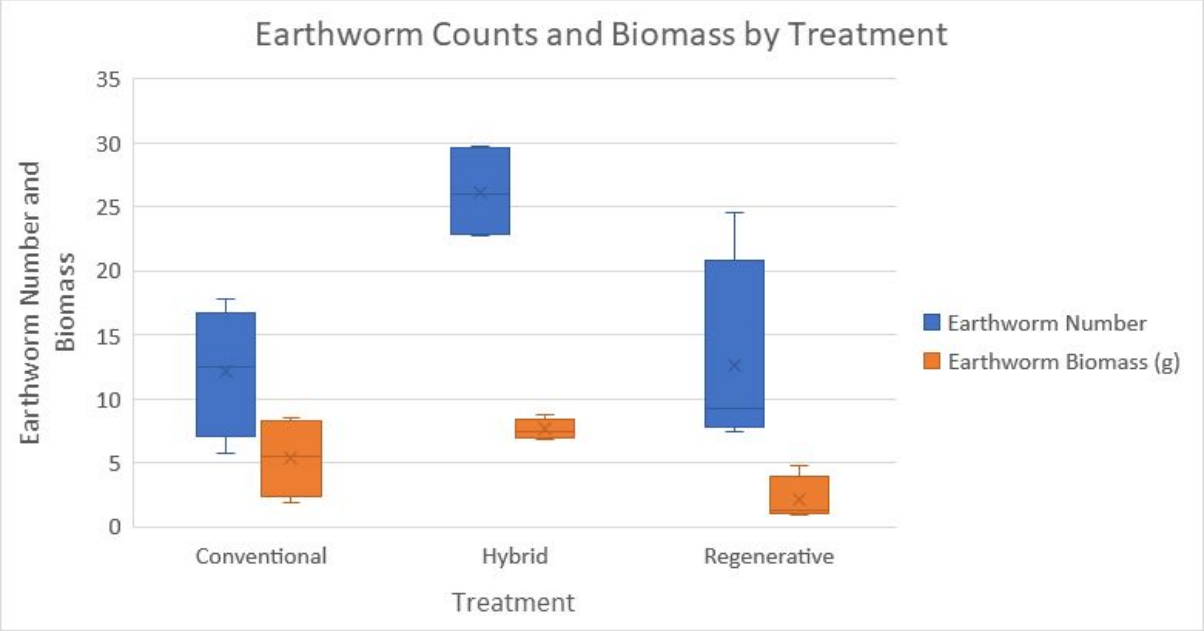

Figure 3 Boxplot of average earthwork number and biomass found in 20 cm VSA sample by treatment

Soil infiltration rate

To be completed when soil has settled after planting (to be reported in MS6).

Soil moisture release curve

To be completed by Tipu Services (previously Aqualinc) when soil is dry enough (to be reported in MS6).

Soil penetration resistance

To be completed when soil is settled after planting (to be reported in MS6).

Cover Crop Monitoring

Winter cover crops were planted on the 30th of April. This was relatively late in the season, due to the late planting and harvest of the sweetcorn.

Figure 4 Winter cover crops August

The cover crops planted, and winter management of them, differed between treatments. Details for each treatment are outlined below in Table 1.

Table 1 Winter cover crop management 2023

Treatment	Approach	Cover Crop	Management Practices
Conventional Treatment	Heretaunga Plains typical system	Annual ryegrass (Moata), grazed.	Sweetcorn stubble mulched, aerated, rotary hoed, rolled, planted with 100kg/ha DAP
Hybrid Treatment	'Cherry picking" Approach	Annual ryegrass, not grazed.	Sweetcorn stubble mulched, aerated, direct drilled with 100kg/ha DAP
Regenerative Treatment	Beyond status quo	Oats/vetch/blue lupins, not grazed	Sweetcorn stubble mulched, aerated, direct drilled. Lime/humates applied pre plant + inoculum sprayed on.

Conventional Treatment

The conventional treatment was grazed by lambs. Lambs were supplied and managed through a local grazier and arrived on the 18th of August. They were stocked at 44 lambs/plot, which is approximately 440 lambs per hectare. Lambs were rotated around each of the conventional plots. Typically, the grazier would have 100 lambs/ha on for 2-3 weeks and rotate around. There was

limited time for grazing as plots needed to be sprayed out, so lambs were stocked at a higher rate for 3-4 days.

Once each plot was grazed once, the lambs were split into two mobs of 22 lambs and left to graze the plots that were grazed first (plot 1 and 6) and then moved onto the plots grazed last (plot 9 and 11). This allowed for plots to be grazed down more evenly prior to spraying out. Lambs departed on the 21st of September. This gave time for the grass to regrow for two weeks before it was sprayed out. Lambs were shifted based on a visual observation of cover and were in plots for between 9 and 13 days in total.

The conventional treatment was sprayed out on the 5th of October.

Figure 5 Lambs grazing the conventional treatment (plot 6)

Hybrid Treatment

The hybrid treatment was not grazed by sheep and was instead left to grow biomass until the 7th of September when it was sprayed out to allow grass to breakdown ahead of strip tilling in early October.

Figure 6 Sprayed out hybrid treatment (plot 4)

Regenerative Treatment

The regenerative cover crop of oats, lupins and vetch was left to grow until it was mowed using a hay mower on the 24th of October, and then mulched on the 25th of October.

Figure 7 Regenerative cover crop, lupins flowering (plot 10)

Prior to mulching the cover crop had a 190kg/ha mix of lime, sulphur, boron and humates applied via drone application to minimise damage to the cover crop.

Figure 8 Airborne Solutions large drone used to apply lime, humates and micronutrients

Canopy development

The Canopeo App was used to capture canopy cover of the cover crop. Data were collected from mid-June (approx. 6 weeks post plant) through to full canopy cover, and until the crop was terminated. In the conventional treatment data were collected until the cover crop was grazed.

Eight images were taken per plot, along existing sampling transect, excluding established buffer zones (roughly 10-12 paces between each spot).

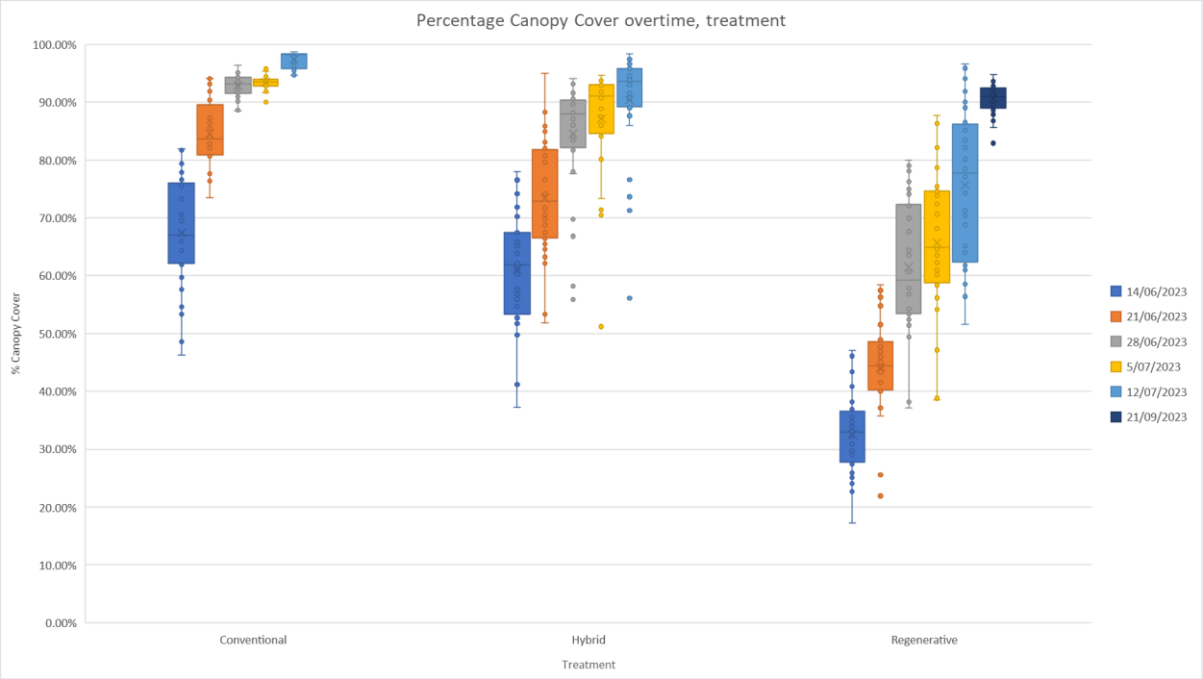

Figure 9 Clustered box plot of canopy cover (%) from sowing through to crop termination, by treatment

Weed survey

A weed survey was completed on the 24th of July. The aim of completing seasonal weed surveys is to collect data to see if the weed spectrum changes over time. Weeds were identified in each plot and the number of each species present was counted. Four sub-replicates were surveyed per plot using a

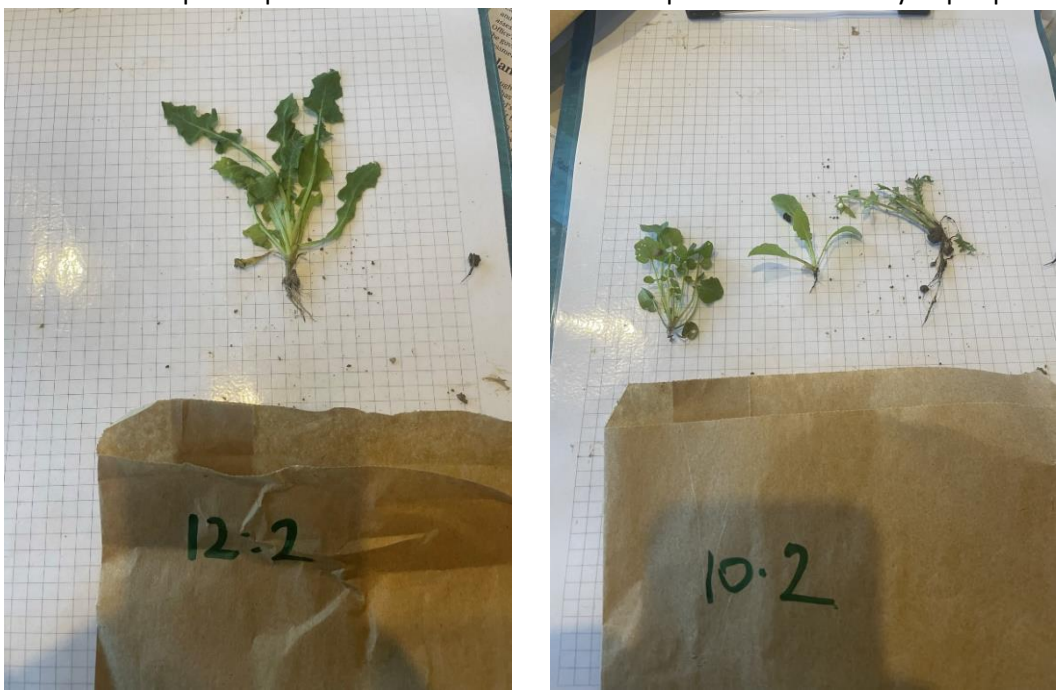

Figure 10 examples of weeds present in plots from weed survey.

0.5 m x 0.5 m quadrat placed on the south side of the slug trap. The conventional and hybrid treatments had earlier been sprayed with a selective herbicide to remove broadleaf weeds from the ryegrass. The identification of some weeds was challenging as some families of weeds look similar especially at seedling stage. For example, the Asteraceae daisy family and species such as catsear, hawkbit and hawksbeard are difficult to separate. Ideally, the next survey will be completed alongside a weed scientist.

Slug pressure

Slug pressure was measured using the Oregon State University 'Relative Slug Activity'[2] method. Four flowerpot bases were placed in each plot along the existing transect. Lids were left for several days. Slugs on the lid and in the plant matter under the lid were counted and weighed. This measure does not give 'total number of slugs per hectare' but does provide a relative measure of slug pressure. The number of slugs varied from 0 – 10 per lid, and the weight varied from 0 – 7.5 g per lid.

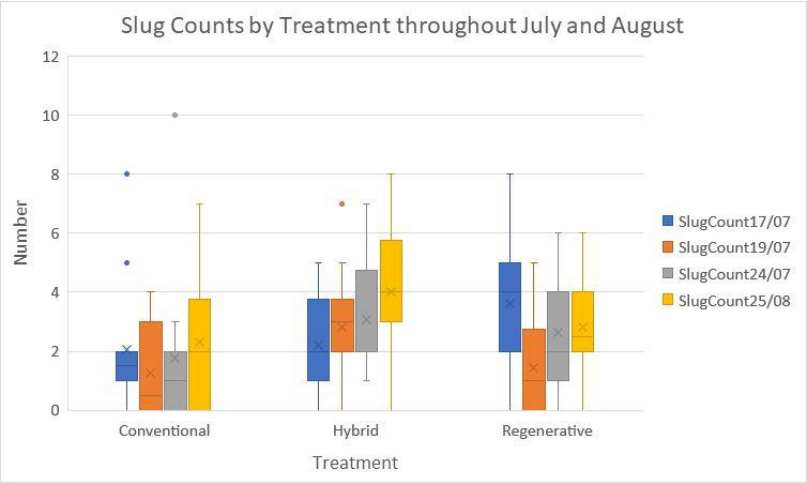

Figure 11 Clustered box plot showing number of slugs found by treatment, by sample.

Figure 12 Slugs found under upturned plant pot saucer

[2]Oregon State University Relative Slug Activity methodology https://agsci.oregonstate.edu/slug-portal/monitoring/measuring-slug-activity-and-density

Soil Nitrate Quick Test

Nitrate Quick Test was completed in July. Nitrate was measured to 3 depths, 0 – 15 cm, 15 – 30 cm and 30 – 45 cm. In general, the concentrations of nitrate – N were low across the treatments. The 0 – 15cm depth nitrate ranged from 0 – 6 kgN/ha, the 15 – 30cm depth ranged from 0 – 12 kgN/ha, and in the 30 – 45 cm depth ranged from 0 – 10 kgN/ha.

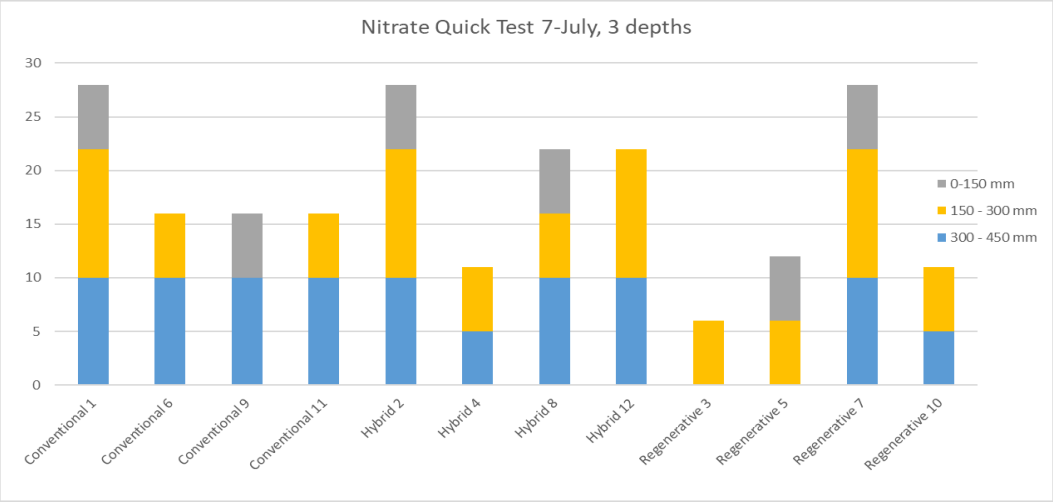

Figure 13 Stacked column graph showing Nitrate Quick Test kgN/ha at three 15cm increments, per sample

Samples were collected for a second Nitrate Quick Test before pre-planting fertiliser was applied but results are not yet available.

Biomass

Biomass was measured before each treatment was terminated. For the conventional treatment this was before grazing, for the hybrid before spraying out and for the regenerative treatment it was before mulching. Four subsamples were cut using a 0.5 m x 0.5 m quadrat. Wet mass was weighed, and samples dried at 65 degrees Celsius for 2-3 days, until the dry down curve flattened off.

The second cut from the regenerative treatment used a standardised 15% dry matter, as samples overloaded the oven and did not dry down evenly.

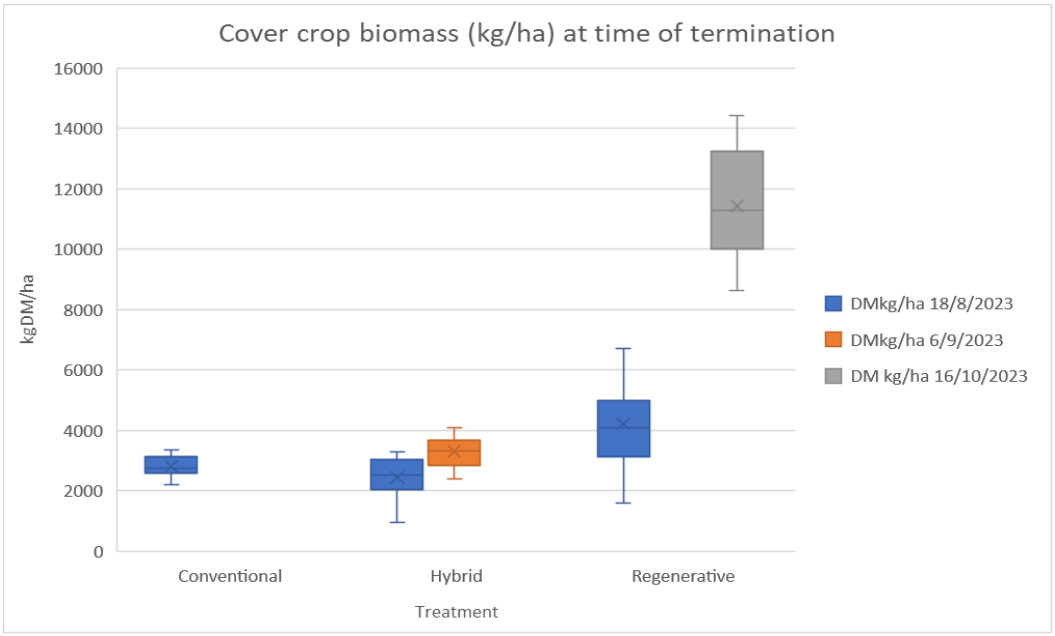

Figure 14 Clustered boxplot of cover crop biomass (kg/ha) for each treatment.

Tissue N and C

Plant matter subsamples were submitted to Hill Laboratories for nitrogen and carbon analyses.

A subsample from the final cut of the regenerative treatment (oats) was submitted to repeat nitrogen and carbon analysis and other basic nutrients to try to explain the differences in biomass production between plots.

Plot 3, which produced the least amount of biomass over the winter had comparatively lower nitrogen, phosphorus, potassium, sulphur, calcium and magnesium, when compared to the other three plots.

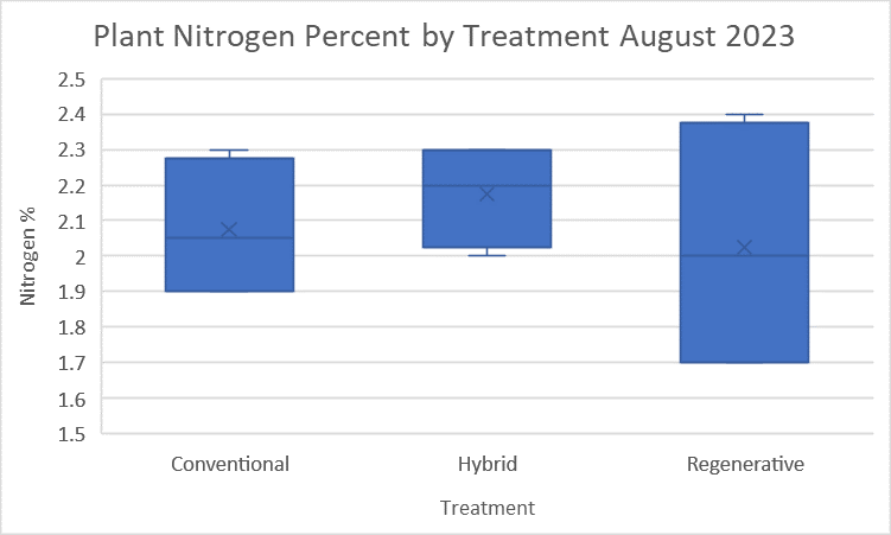

Figure 16 Boxplot of plant nitrogen percentage by treatment

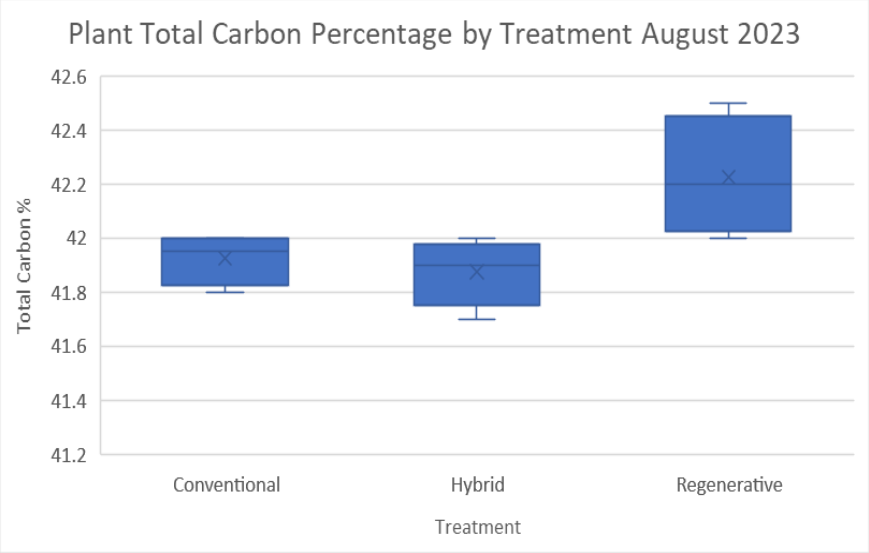

Figure 15 Boxplot of plant carbon percentage by treatment

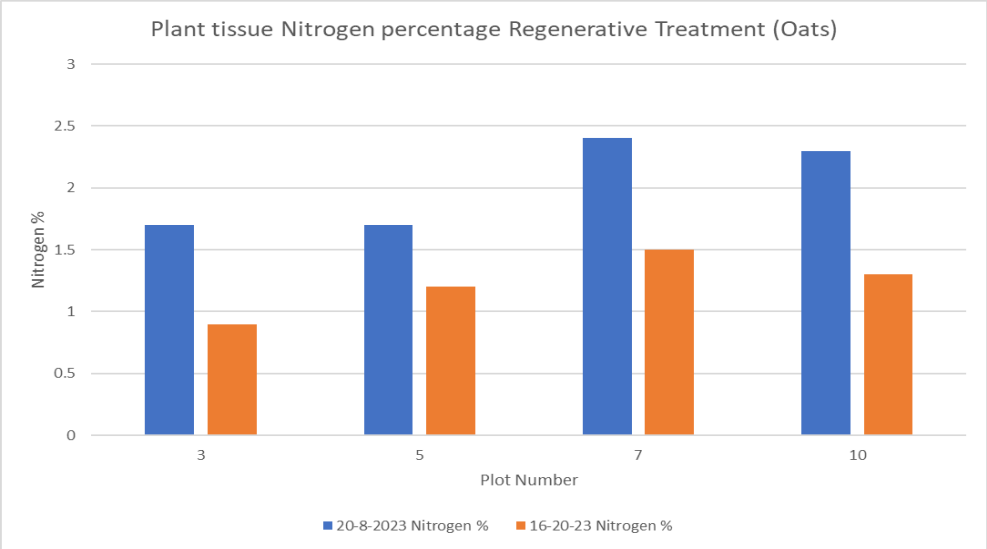

Figure 17 Clustered column graph of plant tissue nitrogen percentage in regenerative treatment plots in August and October

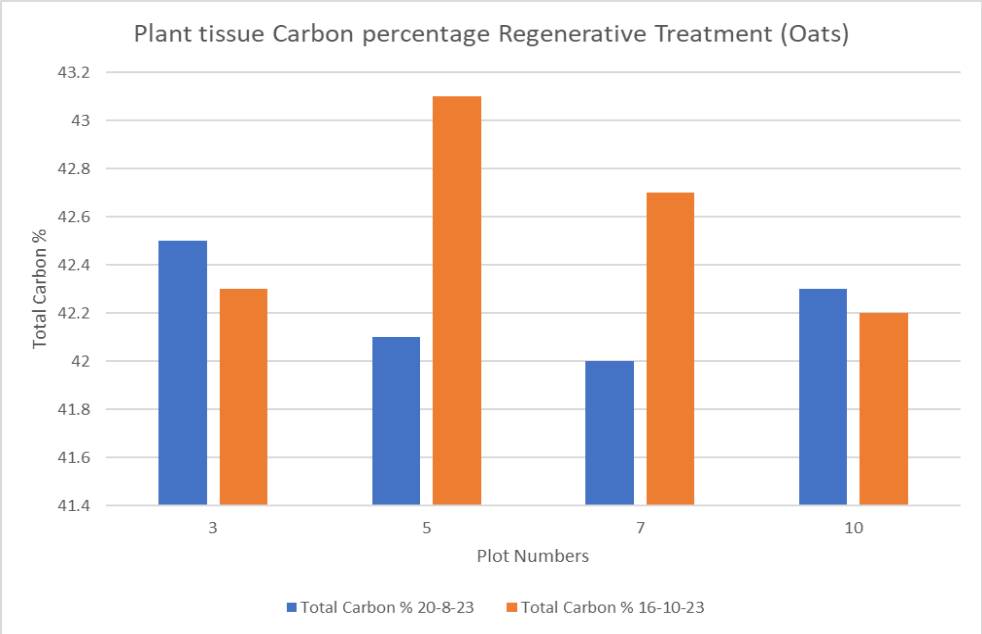

Figure 18 Clustered column graph of plant tissue carbon percentage in regenerative treatment plots in August and October

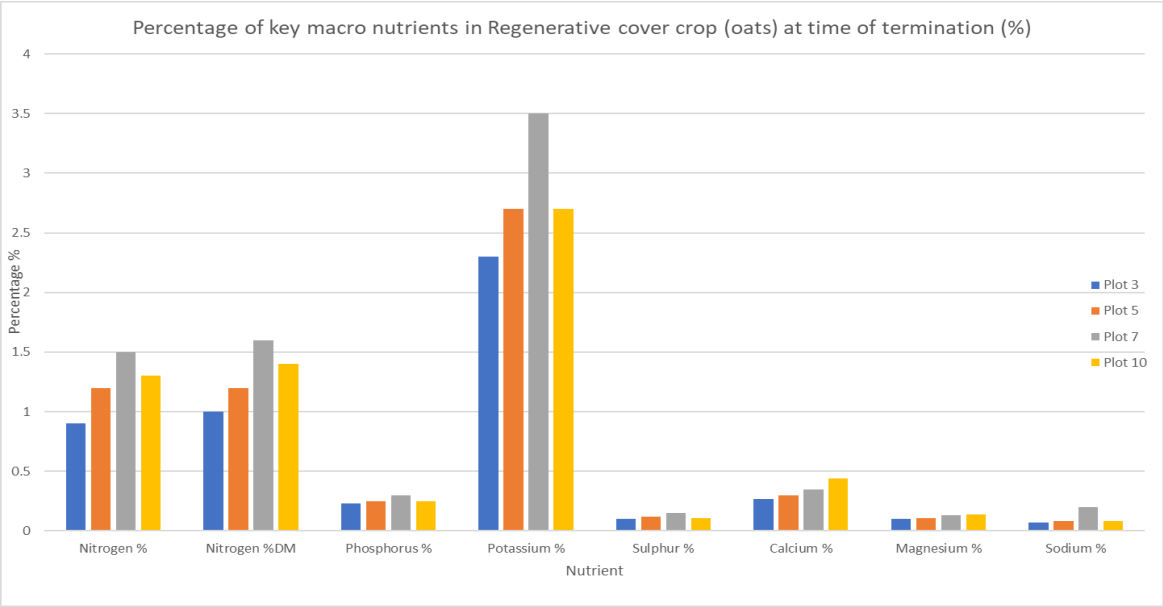

Figure 19 Clustered column graph showing percentage of key macro nutrients in tissue at time of termination.

Year 2 Spring Crop Established

Soil prepared as agreed to by OAG.

The Operational Advisory Group formally agreed to an Operational Plan with the understanding that this plan was likely to change based on seasonal factors. The plan included ground preparation, nutrients, and agrichemicals chosen for plant protection. Members of the OAG were consulted with almost every day in the lead up to planting to ensure that groundwork was completed on time and would achieve the desired soil conditions for transplanting tomatoes. The aim was to have satisfactory soil moisture, minimise large clods of soil, and avoid cultivating too early ahead of planting which can create crusting and large, hard clods on heavier soils.

As slugs were present, all plots had 7kg/ha IronMax organic slug bait applied as a preventative treatment. Slug bait was applied mainly as there were concerns that the regenerative treatment could have a greater degree of slug pressure as no cultivation was planned, and there would be an organic layer on top of the soil which would be an ideal habitat for slugs. Slug bait was applied via drone to reduce tractor passes and avoid damaging the oat cover crop.

Conventional Treatment

After the conventional treatment was sprayed out on the 5th of October, the plots were left to die down for three weeks. Heinz-Watties agronomists and contractor Mike Kettle were consulted with to determine how to prepare plots. The plots were chip-hoed to bury the remaining turf (shallow rotary hoe) and then aerated over labour weekend (22nd of October). This left large chunks of soil on the surface and pulled up a considerable amount of moisture. To break up chunks and dry soil for

Figure 21 Soil in conventional treatment after aerating pass.

planting a second aerator-incorporator pass was completed, with the aim of breaking up the below 'tillage pan'. Following this, the plots were rotary hoed and rolled twice to leave a soil tilth appropriate for transplanting. Images below show some of the process to prepare the ground for the conventional treatment.

Figure 20 Ripper and incorporator used for conventional treatment.

Figure 22 Conventional treatment rotary hoeing (first pass)

Hybrid Treatment

The hybrid treatment was sprayed out early with the plan being to strip till, get a weed strike and then spray out to create a stale seed bed to reduce the impact of weeds later on. Strip tilling was completed by Watties Ag team, and agronomists and contractors were consulted for ground preparation. The first pass with the strip till machine was a strip chip-hoe (shallow rotary hoe) on the 10th of October (five weeks after spraying out) to break up the turf on the surface. While the soil appeared dry on the surface, this pass showed that the soil was too plastic to continue working and

Figure 23 Soil rolled into a ball to demonstrate it was too plastic (wet) to be cultivated.

further drying was required before more passes were done, to avoid further soil damage.

Further passes with the strip till machine were required to break down the large lumps of soil into smaller, more manageable sizes. After it was identified in the conventional treatment that aerating was required, the hybrid treatment was ripped to 400 mm. In total there were four strip till passes (including the chip hoe) to prepare for planting. Watties already use the strip till machine in some paddocks but these tend to be on lighter, pumice soils soil of Hastings. In these areas 1-2 passes of the strip till machine is required to achieve tilth, so there was more work required on the heavier soils used in the trial.

Figure 24 Third strip till pass in hybrid treatment

Regenerative Treatment

The aim for the regenerative treatment was to try something quite different to how Watties typically grow tomatoes. To minimise soil disturbance and agrichemical use, the plan was to plant with a modified transplanter which transplanted seedlings into a mulched cover crop. This approach requires zero cultivation (soil disturbance) and creates a protective mulch layer on the soil surface which supresses weeds, minimising if not eliminating the use of herbicides, buffering the use of insecticides and fungicides, retaining moisture, and cooling the soil over the summer.

In the week leading up to planting Tobi Euerl and Robert Hall from live2give (MulchTec Planter owner/operators) visited the site to assess the cover crop and decide on the best ways to mulch the cover crop. Key concerns were a) mulch not being thick enough b) how to mulch the cover crop without turning it into a powder and c) some concerns were raised about how compacted the soil was in this area. Through discussion with MulchTec, Watties, and Mike Kettle (contractor), a solution was found to mulching the cover crop (mowed by Mike Kettle's hay mower and then mulched using the LandWISE mulcher).

Figure 25 Infield discussions about best ways to manage the regenerative cover crop for mulch planting.

In the week of planting, VSA showed that the soil under the regenerative treatment was in poorer condition than expected, and too compacted for roots to grow into, which would impede plant performance through the season. A meeting was held on the 25th of October with wider OAG including Watties field staff, Mike Kettle Contracting, Phil Schofield (regen consultant) and Gareth Holder (grower) to work through options. It was decided that the best course of action would be to work in the cover crop, aerate the soil, and rotary hoe to create soil conditions suitable for growing tomatoes.

To aid in the breakdown of the cover crop, a biological digestor (BioStart Digestor) and Calcinit were sprayed over the residue. The regenerative treatment was aerated (same as the conventional treatment), rotary hoed twice, a spader was used to bury the remaining residue to a target depth to 300mm the day before planting (25th October).

Figure 26 Second pass with rotary hoe on mulched cover crop

Planting managed as agreed to by OAG.

All treatments were planted using the Watties planter, which plants three double rows of tomato seedlings at a time. All treatments were planted on the same day. Prior to the planter pass, a strip incorporator (Badalini) passes over the area to be planted, incorporating a pre-emerge herbicide (MAGNETO and BoxerGold) and part of the fertiliser requirements (varies per treatment). The day of planting was around 27 degrees and windy, so the rate of water applied with the planter was increased.

Figure 27 Incorporating starter fertiliser and pre-emergent herbicide prior to transplanting

Conventional Treatment

The conventional treatment was planted with 400kg YaraMila 8-11-20, split between the planter and the incorporator.

Figure 28 Transplanting tomatoes into a conventionally managed plot

Hybrid Treatment

The hybrid treatment was planted with 300kg YaraMila Complex, split between the planter and the incorporator. The planter water was dosed with two biological products, MultiKraft Soil NRG and MultiKraft Microlife.

Figure 29 Transplanting tomoates into a hybrid treatment plot

Regenerative Treatment

The regenerative treatment was planted with 300kg YaraMila Complex, split between the planter and the incorporator. As with the hybrid treatment, the regenerative treatment also had the planter water dosed with MultiKraft Soil NRG and MultiKraft Microlife.

Figure 30 Transplanting tomatoes into a regenerative management plot

Treatment summary

Below is a summary of operations for each treatment, up until planting.

Treatment	Conventional	Hybrid	Regenerative
Slug Bait	7kg/ha Iron Max Slug bait	7kg/ha Iron Max Slug bait	7kg/ha Iron Max Slug bait
Pre plant nutrition	Nil	Nil	190kg/ha mix lime, sulphur, boron, humates
Groundwork	Chip hoe Aerator x 2 Rotary hoe x 2 Badalini (strip incorporator)	Chip hoe Strip till x 2 Aerator Strip till x 1 Badalini (strip incorporator)	Aerator Rotary hoe x 2 Spader Badalini (strip incorporator)
Herbicide	Pre emerge MAGNETO + BoxerGold	Pre emerge MAGNETO + BoxerGold	Pre emerge MAGNETO + BoxerGold
Fertiliser	400kg/ha YaraMila 8-11-20 32kg N, 42kg P, 80kg K, 10.4kg S (per ha)	300kg/ha YaraMila Complex 36kg N, 15kg P, 45kg K, 24kg S, 4.8kg Mg, 7.5 kg Ca (per ha)	300kg/ha YaraMila Complex 36kg N, 15kg P, 45kg K, 24kg S, 4.8kg Mg, 7.5 kg Ca (per ha)
Biologicals (planting)	Nil	MultiKraft Microlife MultiKraft Soil NRG	MultiKraft Microlife MultiKraft Soil NRG
Biologicals (residue)	Nil	Nil	BioStart Digestor 4L/ha

Calibrate Irrigator

Irrigator will be calibrated at first irrigation event.

On Site Field Day

Figure 31 First monthly field walk, held 6th September.

Magazine article and website updated

The website continues to be updated and items included in the regular LandWISE News emails. An article has been prepared for the December issue of NZ Grower magazine.

Planning Ahead: Milestone 6 - Due 1 Feb 2024

Date: 1 Feb 2024	**Milestone 6**
Milestone description	Year 2 Progress as per planned milestones
Target Outcome	Showcasing growing mixed crops under alternative management systems
Activities undertaken	PSG Meeting to review milestone reports, Year2 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. 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	$83,303.55
Co-Funding contribution	$35,701.52
Total	$119,005.07