Carbon Positive Milestone 7

Operational Report Prepared by LandWISE Inc.

Due 1st June 2024

Table of Contents

Table of Tables

Table of Figures

Milestone 7

Date:1 Jun 2024	**Milestone 7**
Milestone description	Year 2 Completed
Target Outcome	Increased understanding of regenerative cropping and effects of transition
Activities undertaken	OAG team meeting, harvest, crop and soil analyses completed, winter crops established, magazine article, Outreach presentations at 1 conference. 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	$83,303.55
Co-Funding contribution	$35,701.52
Total	$119,005.07

Milestone 7 Science Plan

Activity	Completion Date	Details
OAG Team meeting		Year 2 Progress as per planned milestones
Agronomic observations/ crop health monitoring	Weekly	Agronomic observations leading up to harvest
Harvest		
Harvestable yield	4/3/2024	Hand harvest 1.25 m x 2 m (2.5m^2) plots - 2 sub-reps (East and West End). More sub-reps if significant variation in crop dev.
Watties harvestable yield	6/3/2024	Each plot harvested into separate bin to be delivered to factory
Non harvested yield	6/3/2024	Hand harvest residue.
Crop analysis		
Factory quality assessments	15/3/2024	- % dirt (related to harvesting)- Factory - % EVM (extraneous vegetative matter)- Factory - % green tomatoes- Factory + hand harvest - % breakers- Factory + hand harvest - % damaged- Factory + hand harvest - % rots- Factory + hand harvest - % diseased- Factory + hand harvest - Colour- not measured. - Firmness- not measured. - Uniform maturity - Field hold - Brix- Factory + hand harvest
Crop tissue N, C and DM%	1/04/24	Commercial lab assessment
Residue biomass	1/04/24	LandWISE harvest and weighed
Residue N, C and DM%	1/04/24	Commercial lab assessment
Post harvest soil analysis		
Visual soil assessment	1/06/24	4 samples per plot, before winter crop established
Hot water extractable carbon (intermediate sampling)	1/06/24	0 – 15 cm and 15 – 30 cm, 10 x 30 cores per plot. Combine & send composite sample for lab testing
Winter cover crops established	1/06/24	Groundwork completed, seed drilled and plants growing.
Magazine article	1/06/24	Newsletters by LandWISE and HBFFT
Outreach presentation at 1 conference	13/2/2024	Presentation at Annual FLRC Workshop at Massey University February 2024 + LandWISE Conference May 2024.

1 Overview of Tomato Production

The Carbon Positive tomato crop was harvested by Heinz-Watties on 6th March, and winter cover crops planted on 22nd March, wrapping up what has been an exciting season at the LandWISE MicroFarm. This was the second commercial crop to be grown as part of this project, following sweetcorn in year one. In comparison to the sweetcorn crop, this year's tomatoes were far more intensive to grow, with a higher demand for nutrients, and a more complex crop protection programme.

After a cool, wet start to the season we were eventually treated to a warm summer. There have been regular rain events, with a total of 287 mm of rainfall between 26th of October (planting) and 6th of March (harvest) (Figure 1). Weekly soil moisture measurements have been completed and the irrigator has been run regularly between rainfall events to make up for any soil moisture deficits (Section 4 Irrigation).

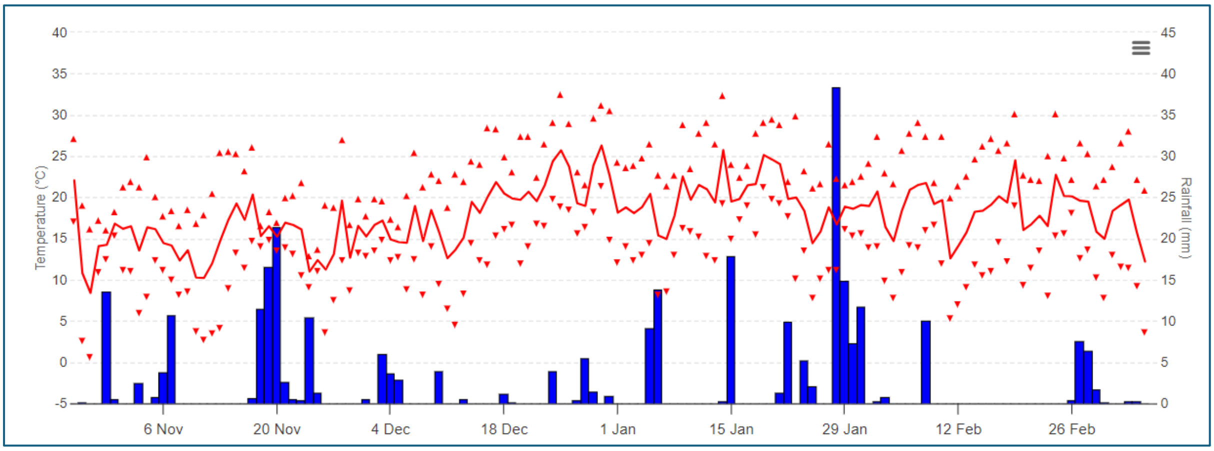


Figure 1 Soil Moisture and Rainfall data (Ruahapia Road Weather Station 26th Oct – 6th March retrieved from HortPlus MetWatch)

Weekly "Thursday 9am" crop monitoring meetings with Wattie's and the Operations Advisory Group (OAG) were held to walk the crop, make plans for each treatment for the upcoming week, determine nutrient, water and crop protection requirements, and determine when to harvest the crop. Weekly progress photos are provided in Figure 2. The meetings were essential for crop success. The engagement from the wider OAG was invaluable, and we hope to maintain this level of engagement over the next four years.

Alongside the OAG, we continue to learn what growing a regenerative vegetable crop might entail, how we can implement the philosophies of regenerative farming to intensive cropping, what future opportunities and limitations may be, and better understand what this means for soil health and soil carbon. The group understands that we are only two years into the project, and we are very much in a transition phase for the Regenerative and Hybrid treatments.

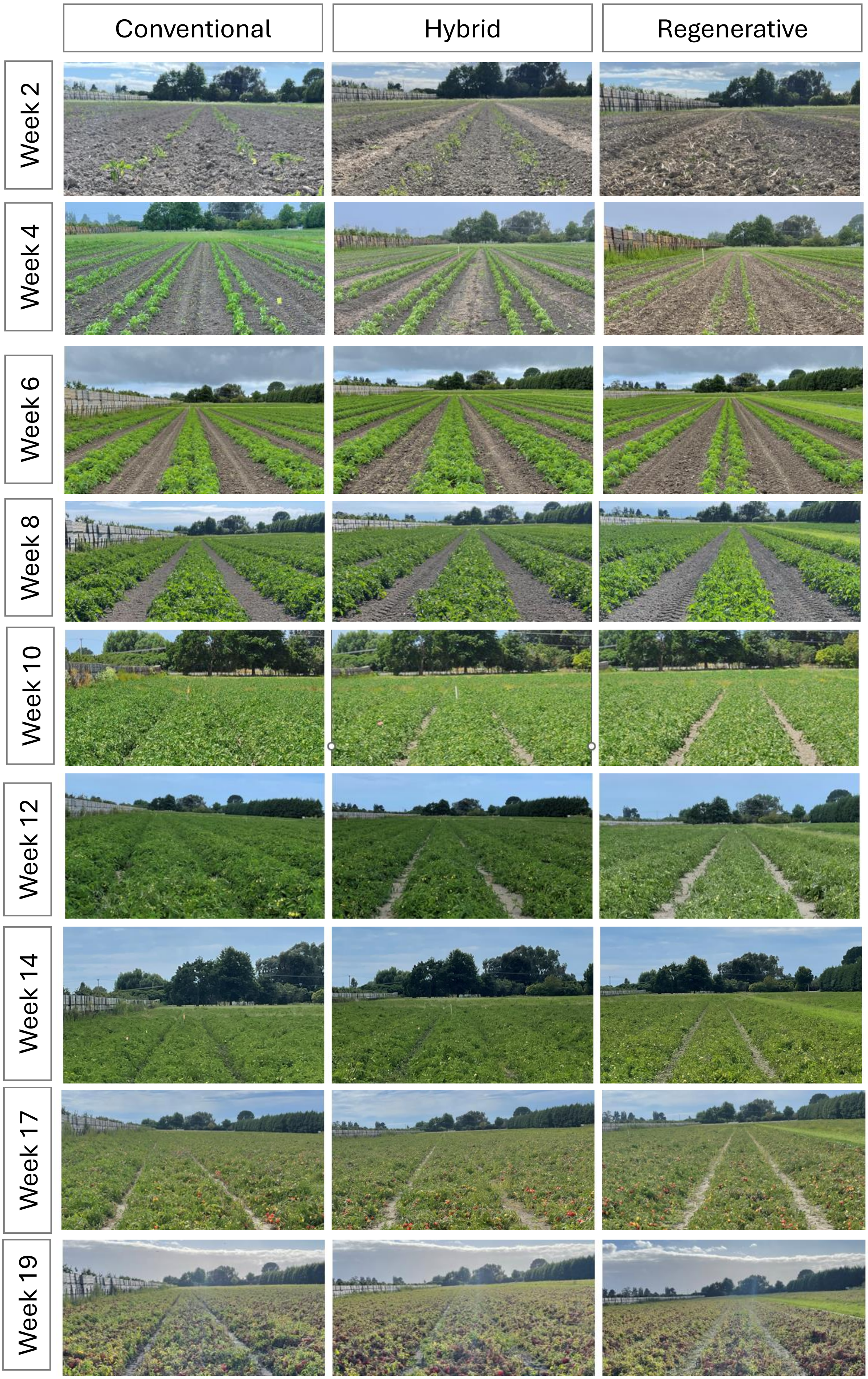


Figure 2 Visual progress of three treatments week on week.

2 Agronomic Observations and Crop Health Monitoring

Weekly OAG crop walks with Bruce Mackay and Caleb Burbury (Heinz-Wattie's), alongside Phil Schofield and other members were held to determine plans for the following week. Conversations and observations were recorded in a diary format to capture key information related to crop management and inputs (planned and actual). The crop protection programme developed prior to planting was used as a guide for the season, however this was reviewed regularly and amended where needed. To support decision making, the following information was collected:

- Insect pressure
- Disease pressure
- Weed pressure.
- Soil moisture
- Soil nitrate
- Plant nutrient concentration.

2.1.1 Insect Pressure

Tomato Potato Psyllid (*Bactericera cockerelli*, TPP) was monitored using yellow sticky traps. Throughout the season no TPP was positively identified, although it will have been present. Some native psyllid was identified. TPP are a sucking pest and a major threat to the production of solanaceous species as they spread Zebra Chip Virus *(Candidatus Liberibacter solanacearum*, haplotype A) which in tomatoes causes yellowing and purpling of leaves, leaf rolling, stunted plant growth and soft fruit. The chemical and biological control mechanisms used to control TPP varied across treatments.

Other pests including thrips and green peach aphids (Figure 3). While found in the crop, they were never in high numbers, and were controlled by the TPP management.

In mid-January an increasing population of corn ear worm/tomato fruit worm (Figure 4) was found in all treatments. These were not targeted as part of the planned crop protection programme. A targeted insecticide was used to control these caterpillars as they were causing damage to fruit.

Figure 3 Image of green peach aphid.

Figure 4 Image of tomato fruit worm.

2.1.2 Disease Pressure

The main disease risks included bacterial speck, late blight (typically occurs under cool conditions in the spring), early blight (typically occurs late in the season) and sclerotinia (in the later part of the season).

We tried to implement a formal disease monitoring programme but the identification was challenging without the support of outside experts. Disease pressure was monitored through crop walks, which was representative of how a grower or agronomist would assess and address an issue.

Bacterial speck was present from early December but became more prevalent in the Hybrid and Conventional treatments in late January (Figure 5). Infection was predominantly in the spray rows, where the top of plants had been damaged, creating a disease entry point. It seemed to be less of an issue in the regenerative treatment plots, possibly because of the lower canopy.

A run of overcast, dull days in late November increased the risk of late blight, so a precautionary fungicide was applied to all treatments. Blight can very quickly spread and destroy a crop and is important to control early. In late January to early February, blight was found in the paddock (Figure 6). Because it could worsen if the weather remained overcast, fungicides were applied in each treatment.

Figure 5 Bacterial speck on tomato leaf (Week 13)

Figure 6 Late blight on tomato leaf (Week 12)

Choice of fungicides and bactericides used to control disease were determined by Heinz-Watties and the OAG, working within the philosophies of each treatment.

2.1.3 Weed Pressure

A pre-emerge herbicide was applied to all treatments at planting. In Week 3, a further herbicide application applied spray between plants, rather than over the top. The soil was dry so the residual action took some time to work, and after two days after weed cotyledons were looking healthier than expected. A second directed herbicide intended to be applied 7-10 days after the first application was held up by a run of wet weather and the tomato plants got too big, as did the weeds. The Wattie's interrow weeder (standard practice) and a specialised weeder that mechanically weeds between the double row of tomatoes was used, and the Wattie's side dressing machine (Badalini) cultivated the interrow and applied a pre-emerge herbicide to the interrow (Conventional and Hybrid treatment only). The weeds in the interrow of the Regenerative treatment grew large, but not expected to reduce yield, so no further control was completed.

The main weed species identified were thorn apple (*Datura stramonium*), wire weed (*Polygonum aviculare*), black night shade (*Solanum nigrum*), green nightshade (*Solanum nitidibaccatum*), redroot amaranth (*Amaranthus retroflexus*), fleabane (most likely broad-leaved fleabane *Conyza sumatrensis*).

All plots had some hand weeding at the end of the season, targeting the nightshade species and thorn apple to minimise the amount of weed seed that would enter the weed seed bank. This was done casually by LandWISE staff and has not been included in gross margins, as the weed pressure would not justify a response in a commercial setting.

2.1.4 Soil Moisture

Irrigation requirement was determined by soil moisture monitoring using several technologies. A handheld Hydrosense probe measured moisture in the top 200 mm and gave good information for the new seedlings. This showed that the regenerative plots were very dry, but the other two treatments were very wet. Industry practice is to avoid irrigation in the first three or four weeks after planting, but this showed to be inadequate as the regenerative plants did not grow until rain provided a significant water input. An array of Gropoint sensors was installed as the crop developed, but after repeated problems accessing the data, weekly neutron probe monitoring was contracted through Tipu Services Ltd. Measurements to 800 mm depth provided information of available soil moisture and activity in the root zone.

Immediately before planting, the Regenerative treatment was significantly drier than the other two treatments which were sprayed out four weeks (Conventional) and seven weeks (Hybrid) earlier and retained moisture. In comparison the oats, vetch, and lupin mix in the Regen treatment was left growing until two days before planting, so continued to suck moisture out of the soil. As the other two treatments had sufficient water, and we had no ability to apply differential irrigation, we decided to hold off irrigating as per Wattie's advice. Unfortunately, this meant that the tomato plants in the Regenerative treatment were stressed from the start of the season, and never fully recovered. See also Section 4.3 Water budgets.

2.1.5 Soil Nitrate

Soil nitrate was measured fortnightly using the Nitrate Quick Test both manually and using the Nitrachek 404 device. Samples were taken in two 15 cm increments to 30 cm, and if conditions allowed, to 45 cm.

Soil nitrate levels in the Regenerative Treatment were very low at planting, driven by the cover crop management (late termination) and incorporation of residue into the soil (Figure 7). Nitrate levels increased following fertiliser applications at planting, side dressing, but were only maintained by a late application 6 weeks before harvest.

Regenerative treatment soil nitrate was consistently much lower than the other treatments. Nitrate levels were expected to lift as the cover crop was broken down, but no evidence of that was found. It is thought to be due to the amount of dry matter incorporated into the Regenerative treatment. Residues were 9.95 - 12.65 t DM/ha and had a Total Carbon percentage between 42.3 - 43.1%, so a significant amount of carbon has been added to the soil. If nitrogen was being made available by the cover crop breaking down, the plant demand exceeded soil availability.

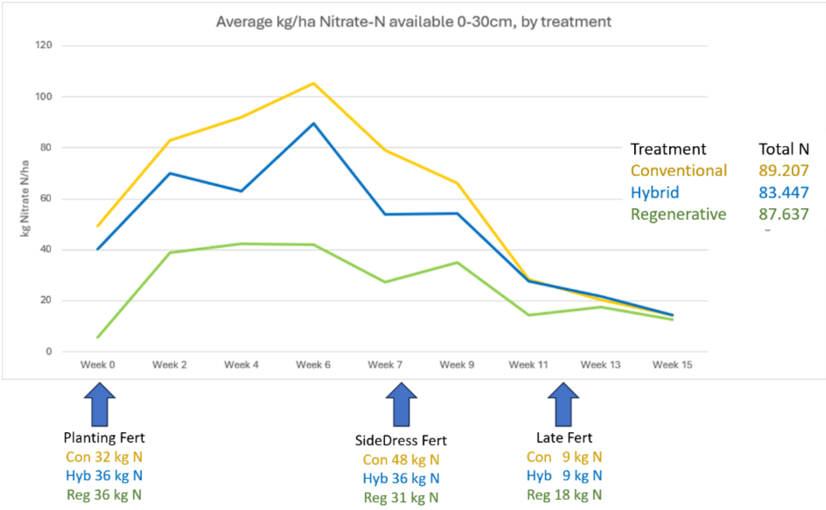


Figure 7 Line chart of soil nitrate levels over time as determined using the Nitrate Quick Test method

Soil nitrate levels lifted after planting fertiliser was applied, however did not appear to increase significantly after side dressing, again this is likely because this will have been during a substantial period of canopy growth where N supply exceeded demand.

Regular nitrate monitoring highlighted that nitrate levels were steadily declining in all plots from Week 6. By Week 10 levels were getting very low and Mark Redshaw (Yara Crop Nutrition) stated that any application later than six weeks ahead of harvest would be unlikely to have any significant benefit to the crop. The OAG decided to apply a small amount of nitrogen with the aim of keeping the canopy healthy, maintaining its ability to ripen the fruit that had been set.

2.1.6 Plant tissue tests.

Leaf samples were submitted to Hill Laboratories for analysis in December, January and February. This data was used to inform nutrient management decisions, both for granular and foliar nutrient applications. Figure 8 shows an example of monthly data captured for leaf nitrogen percentage. The brown band in Figure 8 is the normally expected range for nitrate during the season.

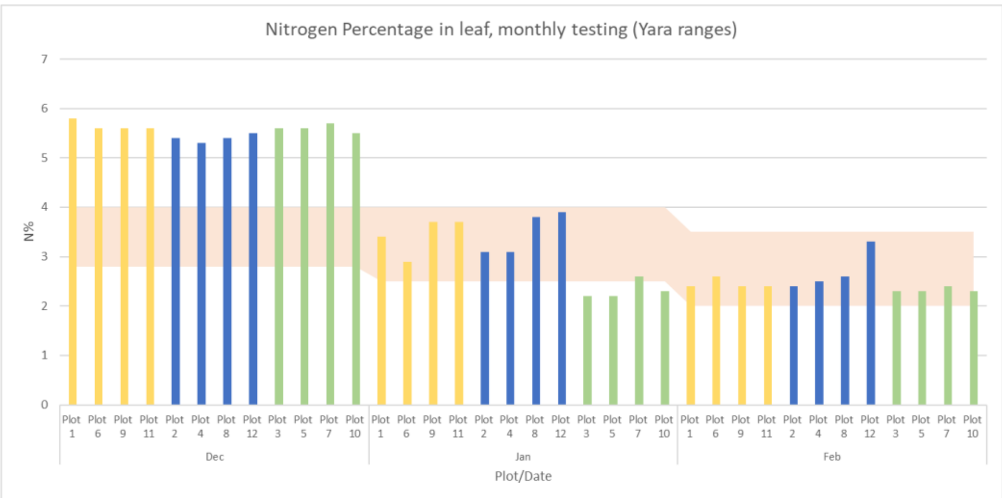


Figure 8 Monthly nitrogen leaf concentration (Yara Crop Nutrition USA target ranges).

3 Inputs

The main crop inputs included crop protection products (herbicides, insecticides and fungicides), crop nutrition products (solid and foliar fertilisers), stickers and adjuvants, and biostimulants. All inputs were recorded using ProductionWise and submitted to Heinz-Wattie's for approval ahead of harvest.

All input decisions were made by the Operations Advisory Group and aimed to align with the frameworks/philosophies of each treatment. This section includes commentary on decision making and lessons related to each type of input, as well as a more detailed discussion of the Environmental Impact Quotient (EIQ) used to quantify crop protection programmes. Full programmes can be found in Appendix 2.

3.1 Crop Protection

Crop protection is a critical component of tomato production. Heinz-Wattie's provided an example of a crop protection plan which included 15 spray applications over a 135 day period, each application had at least one active ingredient but could include up to four. The standard plan is weather dependent but provided a platform for discussion as to what to expect through the season.

The standard programme was developed over a number of years, if not decades. We initially found it difficult to determine which products had the 'highest risks', particularly environmental risks, and should therefore be at the top of the list for minimising or eliminating. The language used in discussion was somewhat vague and included words like 'harsh' and 'soft'. A full breakdown of crop protection applications for each treatment can be found in Appendix 2.

3.1.1 EIQ

McCain Foods staff recommended using the Environmental Impact Quotient as a more robust way of quantifying the 'harm' crop protection programmes. The Environmental Impact Quotient is an online tool available from Cornell University and is:

> *"a formula created to provide growers with data regarding the environmental and health impacts of their pesticide options so they can make better-informed decisions regarding their pesticide selection"*. https://cals.cornell.edu/new-york-state-integrated-pest-management/risk-assessment/eiq/eiq-calculator

The formula includes a range of environmental effects of pesticides, combined to give an EIQ score for a pesticide active ingredient (Kovach et al., 1992). A diagram of the equation breakdown can be found in Appendix 1.

EIQ={C[(DT*5) + (DT*P)] + [(C*((S+P)/2) * SY) + (L)] + [(F*R) + (D*((S+P)/ 2) *3) +(Z*P*3) +(B*P*5)]}/3

(Farmworker Risk) + (Consumer Component) + (Ecological Component)

- DT = dermal toxicity
- C = chronic toxicity
- SY = systemicity
- F = fish toxicity
- L = leaching potential
- R = surface loss potential
- D = bird toxicity
- S = soil half-life
- Z = bee toxicity
- B = beneficial arthropod toxicity
- P = plant surface half-life

This score is used to calculate a Field Use Rating (FUR) which factors the percentage active ingredient and the application rate or the 'dose' of the active ingredient. It is this value that can be used to compare products. The formular for FUR is:

EIQ Field Use Rating= EIQ x % active ingredient x Rate

The calculator also calculates the Consumer, Worker and Ecological impact of the Field Use Rate, which can be compared across products and programmes. For the purpose of this project, Ecological EIQ is of most interest.

The Field Use EIQ score and the Ecological EIQ score for each the three treatments is presented below. Figure 9 shows the contribution of each product type (fungicide, herbicide, insecticide, other) to the total score for the tomato crop. The graph shows that fungicides have the highest contribution across all treatments, followed by herbicides. Insecticides contribute only a small percentage of the total score.

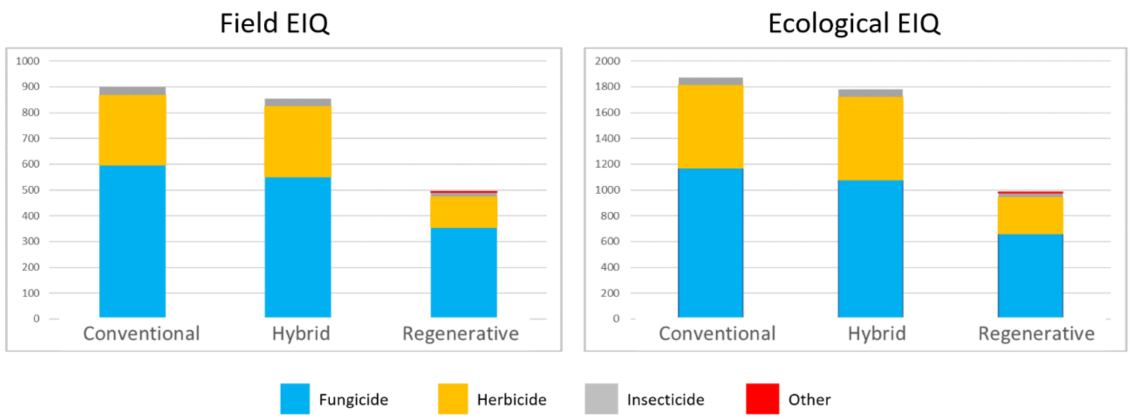


Figure 9 Environmental Impact Quotient (EIQ) scores by treatment.

We supplemented the EIQ data with the University of Hertfordshire Pesticide Properties Database to gather more specific information on different products https://sitem.herts.ac.uk/aeru/ppdb/en/.

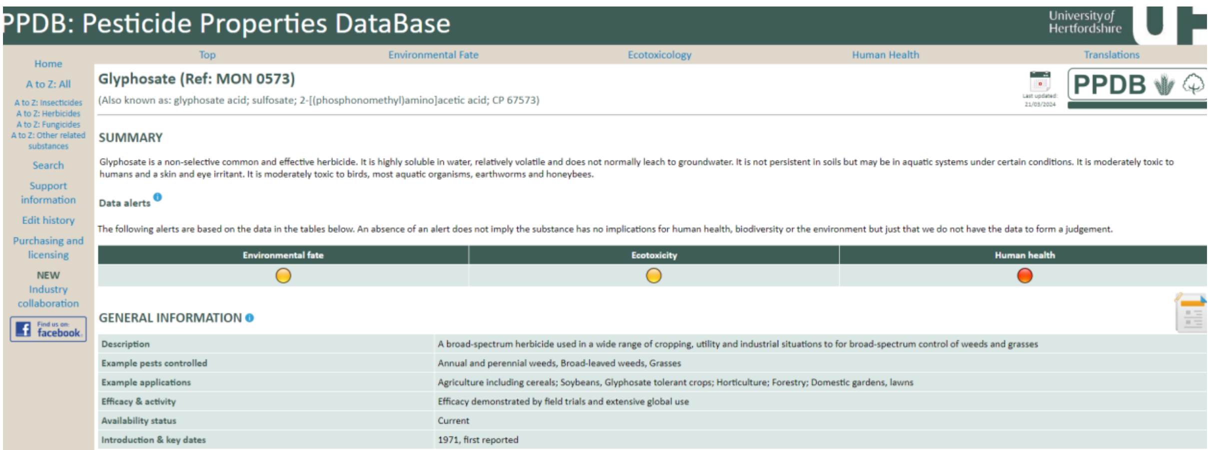


Figure 10 Example of the University of Hertfordshire Pesticide Properties Database PPDB

3.1.2 Fungicides

A range of conventional systemic and contact fungicide products were used across all treatments to prevent infection and treat infection. Some alternative products were used in the Regenerative treatment.

A key component of current management for tomatoes is copper hydroxide (Kocide Opti) to prevent bacterial infection. One of the only options available to protect against bacterial speck, it is believed to have reducing efficacy over time. Copper can accumulate in soils (Morgan & Taylor, 2004), and elevated levels of copper in soils can have a detrimental impact on soil microbial communities and functionality (Dewey et al., 2012). A single application of 0.8kg 30% copper hydroxide has a Field Use EIQ of 17.5/ha and Ecological Score of 35.1. While this is low compared to some of the other fungicides, growers often apply it many times throughout the season, making it a more environmentally 'harmful' product.

We excluded copper from the Regenerative treatment and instead successfully used a bio-bactericide, Aureo Gold (*Aureobasidium pullulans)*. However, we note that the season had relatively low disease pressure, and results in a season with higher disease pressure may differ. There was no notable difference in the level of bacterial speck between treatments at the end of the season. Heinz-Wattie's is planning to take this further next season and based on these results, aims to have a whole paddock where they significantly reduce or exclude copper. The Regenerative treatment also had less mancozeb, and no fluazinam applied, being replaced by phosphorus acid and organic fungicides.

The Hybrid treatment had the Conventional crop protection applied, with small adjustments made towards the end of the season including a reduction in copper hydroxide and mancozeb use.

3.1.3 Herbicides

Failing to get weed management right can cause economic losses to yield and issues at harvest. Early weed management is critical as there are limited chemical controls for some species, particularly the nightshades which are in the same family as tomatoes. The main aim was to keep the crop and interrow weed free until the plants reached in-row closure. All treatments had a combination of chemical and mechanical management practices used to control weeds, which is standard practice among process tomato growers.

In the Regenerative treatment, the aim was to minimize the use of herbicides where possible. We mechanically terminated the cover crop which eliminated the first herbicide, where glyphosate was used for the other treatments.

In all treatments we used BoxerGold (Prosulfocarb + S-Metolachlor) at planting, which is a residual, pre-emergent herbicide. The Ecological impact EIQ score for BoxerGold was the highest of all the products used in the program; a single application accounts for 10% of the total score in the Conventional treatment.

The Conventional and Hybrid treatments had two applications of BoxerGold; one at planting in the 1 m wide strip cultivated by the Badalini, and one at side dressing in the 1 m wide interrow. The side dressing application was excluded from the Regenerative treatment, and no herbicide was used in the interrow. The weeds in the interrow did take reach a point that would have a significant impact on crop yield.

The other key herbicide used in tomato production is Sencor (metribuzin) which is a selective pre- and post-emergent herbicide that provides a residual effect in the soil, as well as a knockdown effect on some weeds. Growers typical apply two applications of Sencor 7 - 10 days apart, the first application to damage emerging weeds, the second to kill them. Sencor is applied between the tomato plants to minimise contacting them as Sencor can cause leaf burn, creating disease entry points on the leaf. Each treatment had a single application of Sencor as, due to a run of wet weather delaying the subsequent application, the second application would have been applied too late to achieve the desired knockdown, the tomato plants had grown too large, and the risk of spraying leaves was too high.

The rest of the weed control was completed using mechanical weeding, firstly with Wattie's Rototiller that weeded the interrow and secondly with a modified weeder that weeded between the double row of tomatoes. A third mechanical pass was the Badalini used at side dressing.

Some hand weeding was completed towards the end of the season. This was to manage the weed seed bank, rather than the pursuit of higher yield, and therefore has not been factored into gross margins.

3.1.4 Insecticides

Prior to tomato potato psyllid arriving in New Zealand in the mid 2000's, insecticide use in field tomatoes was minimal. A range of insecticides are now used to manage TPP (which transmits zebra chip virus- ZCV). We used both chemical and biological control measures.

We released a range of biological control agents into the trial area, including *Tamarixia triozae* (small parasitic wasp), Tasman lace wings (*Micromus tasmaniae*, a predatory insect) and pirate bugs (*Orius vicinus*- small predatory insect*)*. It is beyond the scope of this project to monitor these insects but we did try to look after them by using selective insecticides that target pest insects like psyllids, aphids and thrips and leave beneficial insects/predators alone. We excluded one possible insecticide that is particularly 'harsh' to predators and non-target insects.

TPP was monitored using yellow sticky traps. While we did not confirm TPP was present in the trial area, we expect it was. We found some native psyllid which does not spread ZCV. Three different insecticides, with different modes of action, were used in the Conventional and Hybrid treatment. Products were alternated as part of best management practice for resistance management. The Regenerative treatment received only two insecticide applications as one was not needed in Week 11.

Tomato fruit worm/corn ear worm was found at significant levels six-weeks prior to harvest. Caterpillars eating the inside of small green fruit and impact crop yield and quality. Wattie's tried to source an IPM friendly insecticide but could not so control required the use of a less selective alternative insecticide across all treatments (Uphold - *spinetoram*).

As noted in the EIQ section, insecticides made up a very small fraction of the total score.

3.2 Crop Nutrition

Nutrient application decisions were made using expertise from Heinz-Wattie's staff, technical experts, Regenerative consultants, and growers. Soil and plant tissue tests were used to inform decision making, as well as visual observations. All three treatments relied on 'conventional' granular fertiliser to meet crop nutrient demands, with varying amounts of foliar nutrition applied in each treatment. Figure 11 shows the total nutrient delivered by foliar versus granular fertiliser in each treatment.

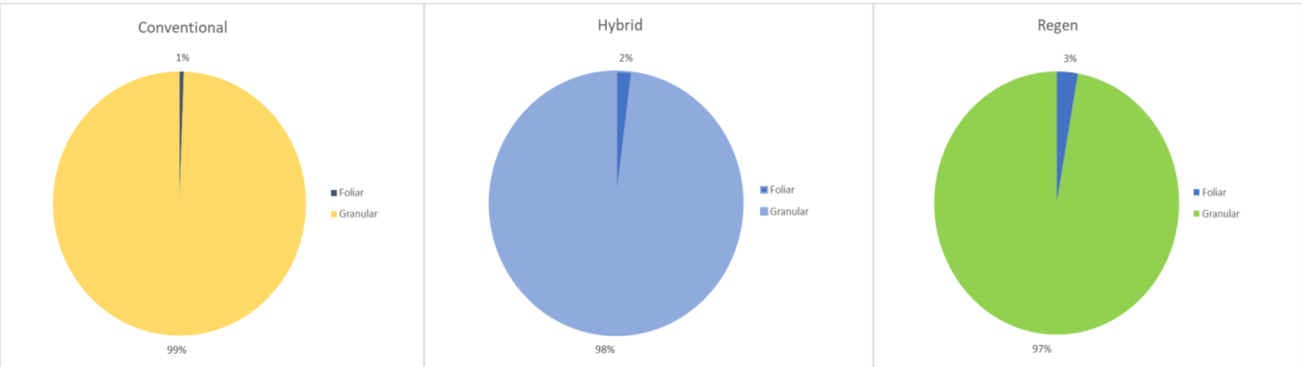


Figure 11 Pie charts showing the percentage of total nutrient delivered by granular and foliar fertiliser.

Error! Reference source not found. shows the breakdown of macro-nutrients applied to each treatment (kg/ha). Each treatment had a similar amount of nitrogen applied, however there were significant differences in the amount of phosphorus and potassium applied between treatments. Note the total kilograms of applied nutrient for the Regen treatment is higher than the other treatments, this is due to the light application of lime ahead of planting.

A full breakdown of each treatment's nutrient applications can be found in Appendix 2.

Table 1 Breakdown of nutrients applied to each treatment.

	Applied N kg/ha	Applied P kg/ha	Applied K kg/ha	Applied S kg/ha	Mg kg/ha	Applied Ca kg/ha	Total Kg Nutrient Applied per HA
Conventional	**89.4**	**62.1**	**168.4**	**42.5**	**6.9**	**10.1**	**379.4**
Foliar	0.4	0.1	0.9	0.1	0.5	0.1	2.1
Granular	89.0	62.0	167.5	42.4	6.4	10.0	377.3
Hybrid	**83.6**	**30.3**	**119.7**	**48.3**	**10.1**	**15.3**	**307.2**
Foliar	2.6	0.3	2.2	0.3	0.5	0.3	6.1
Granular	81.0	30.0	117.5	48.0	9.6	15.0	301.1
Regen	**88.5**	**15.8**	**103.9**	**35.4**	**24.3**	**114.5**	**382.4**
Foliar	3.7	0.8	3.9	0.6	0.3	1.4	10.7
Granular	84.8	15.0	100.0	34.8	24.0	113.1	371.7

3.2.1 Granular Fertilisers

There are typically 2 - 3 key timings for fertiliser application in tomatoes- first at planting, second approximately 6 - 7 weeks after planting (AP/side dressing), and if the crop requires it a third application, no less than 6 - weeks ahead of harvest. Typically, growers would use prilled or compound fertilisers that delivers the full NPKS suite of nutrients e.g., YaraMila Complex (12-5-15-8) or YaraMila 8-11-20 (8-10.5-20.2.6).

Planting fertiliser is delivered by both the Badalini incorporator (Figure 12) and the planter (Figure 13), approximately a 50:50 split. The Conventional treatment used a standard rate (400kg/ha) of YaraMila 8-11-20. Both the Hybrid and the Regenerative treatment used a reduced rate (300kg/ha) of YaraMila Complex.

Figure 12 Badalini pre planting.

Figure 13 Tomato planter.

At side dressing the Badalini (Figure 14) completed another pass, applying 400kg YaraMila Complex (standard rate) to the Conventional treatment, and 300kg/ha Complex (reduced rate) to the Hybrid treatment. Pre-plant soil tests and tissue tests in December indicated that all key tissue nutrient levels were sufficient including N, however soil nitrate levels were decreasing. The approach taken for these treatments was to make a decision in line with what Wattie's or a 'conventional grower' would do. This meant applying some surplus nutrient as insurance to ensure the risk of limiting production through nutrient deficiency was minimised. The reduced rate in the Hybrid treatment reflected a more 'rational' amount surplus nutrient applied.

Figure 14 Badalini at side dressing.

At this time, it was decided that a more conservative approach would be taken for the Regenerative Treatment. Pre-plant soil tests and leaf analysis in December showed that nutrients were within the optimum range for all key nutrients. Soil nitrate levels were low in the Regenerative treatment and were still declining so it was decided that YaraLiva Nitrabor (calcium nitrate 15.4-0-0-0) would be applied at 200kg/ha. It was expected that some of the nitrogen in the incorporated cover crop would become available to the plant, this was not seen at this point of the season, hence nitrogen 'from a bag' was applied to meet plant demand. Humates were added to this application to 'soften' the impact of the synthetic fertiliser.

In Week 11 the Regenerative treatment started to appear yellow and was described as looking 'hungry'. A leaf test was sent off in early January and showed low nitrogen and potassium levels in the Regen treatment. The other two treatments were within optimum range. Several options were discussed- Mark Redshaw (Yara) suggested that we just target the Regen treatment with a late application, however Caleb Burbury (Heinz-Wattie's) wanted to see an application of nitrogen to all treatments as soil nitrate levels were low across the board. The risk of limiting nutrients, particularly nitrogen and potassium at this late stage was that there would not be enough energy in the canopy to mature the fruit that had been set. It was decided a late application of N and K would be applied to all treatments (YaraRega 9-0-27.5-0); however, a higher rate would be applied to the Regenerative treatment as there were visual signs of deficiency as well as in tissue testing.

Figure 15 Drone used for aerial spreading.

In a grower setting this late application would be applied by a tractor mounted fertiliser spreader, which can spread to 20 - 32 m. We could not apply fertiliser in this way, as our plots are only 12 m wide. We instead used a large drone to fly the fertiliser on (Figure 15). The drone has a 40 kg payload and can spread to 12 m.

3.2.2 Foliar Fertilisers & Biostimulants

Foliar fertilisers and biostimulants are increasingly being integrated into growing systems as a way of delivering nutrients to plants. Foliar fertilisers are often a preferred way of delivering nutrient within the regenerative agricultural community as they are understood to have a lesser effect on soil biology, target plants directly, can be applied more uniformly and are rapidly plant available. There is a multitude of different products available on the market from full NPKS products, specific trace element blends, biostimulants, soil conditioners etc.

Heinz-Wattie's have been trialling a range of foliar and biostimulants products and their efficacy over the past few years which provided some direction for what products might be suitable for the different treatments. The advice given to us by Phil Schofield, our Regenerative Consultant, was to incorporate a bio-stimulant each time a foliar nutrient product was used, and to alternate products where possible.

To start, all seedlings were treated with streptomycin (an antibiotic) at the nursery to kill any unwanted bacteria ahead of planting. The approach was to plant clean seedlings, and target plants directly, to minimise the use of fungicides later on which would be applied across the whole plant and soil surface. Seedlings were then drenched with a biostimulant (Mycorrcin) which is used by some growers to minimise transplant shock.

At planting the Regenerative and Hybrid treatments had two soil conditioners added to the planter water; the first product included a range of probiotic microbes aiming to improve soil structure and nutrient availability, the second product was a mix of beneficial microbes, humic acids and microorganisms and aims to improve plant nutrition, activate soil life and improve the uptake of other soil nutrition. This combination of products is being used by Wattie's in target areas where soil quality is not optimum and was easy to add into the planter water tank, therefore did not require an additional application. This mix was excluded from the conventional treatment.

Through the season different combinations of foliar nutrients and biostimulants were applied to each treatment, the Regenerative treatment had 9 applications, the Hybrid 6 applications, and the Conventional 2 applications. In the early part of the season the Regen treatment had an application of calcium nitrate and Megafol in an attempt to assist the plants in overcoming the moisture stress they were under. Most of the foliars were added to the spray tank when crop protection products were being applied, which minimised additional passes being made. The exception to this is when there was a potential compatibility risk between the crop protection products and the foliar product.

Products were selected on the basis that they a) had been trialled by Heinz-Wattie's in New Zealand or b) the product had published trial data as to its efficacy. Where needed, we worked with technical sales staff from suppliers to ensure that the products we were using were appropriate through the different tomato growth stages i.e., vegetative growth, flowering, fruit set.

4 Irrigation

4.1 Calibration

A "bucket test" was performed to check the depth and uniformity of irrigation. The test identified incorrect sprinklers had been fitted after a recent alternative nozzle demonstration so had to be replaced.

4.2 Water Budgets

Water budgets prepared from moisture monitoring data, the on-site Ruahapia weather station and estimates of canopy-driven crop factor are shown below for the conventional and hybrid (**Error! Reference source not found.**) and the regenerative treatment (**Error! Reference source not found.**) plots. These illustrate that the tomato seedlings in the regenerative treatment suffered significant water stress for the first several weeks, a conclusion supported by observed lack of growth until rain provided moisture.

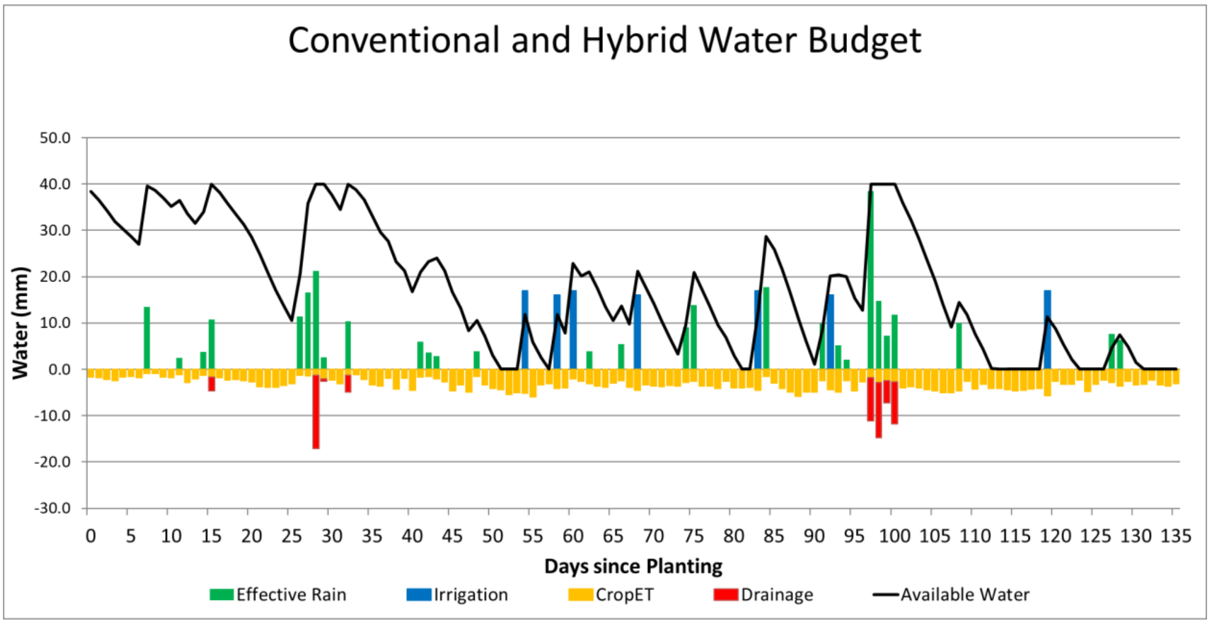


Figure 17 Water budget prepared for the conventional and hybrid treatment plots.

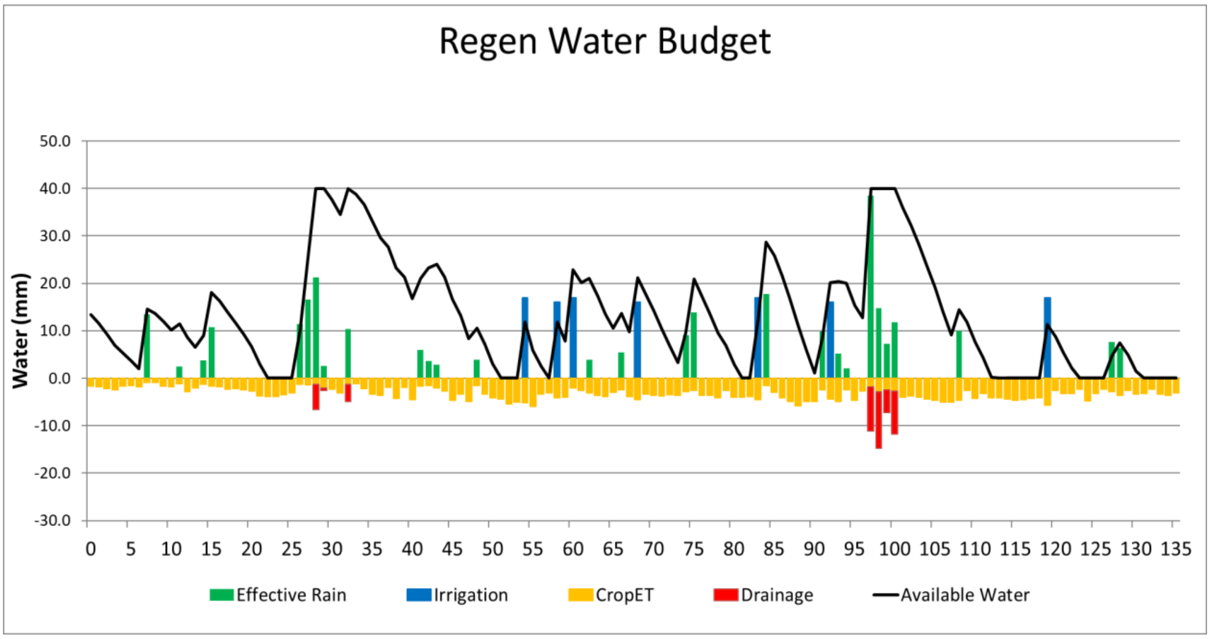


Figure 16 Water budget prepared for the regenerative treatment plots.

4.3 Application

Irrigation began when all plots were nearing refill point as determined by the neutron probe monitoring. A target depth of 16 mm per application was used to ensure adequate depth of Moisture but to minimise runoff. Ideally the regenerative treatment plots would have received irrigation immediately after planting and until soil moisture was satisfactory. However, the other plots were already very moist and further irrigation was undesirable. In May we refitted the irrigator with a completely new system which will allow us to provide each plot (or even each bed) will an independent irrigation application, avoiding this problem in future (Figure 18).

Figure 18 Newly fitted LEPA irrigation system allowing individual plot control.

5 Harvest

Yield data was measured in two ways; first by hand, then using Wattie's harvester. Some fruit quality measurements were completed in field; however, the most representative data comes from the factory intake harvest measurements. A breakdown of each method is described in this section. The factory pays for both red fruit and breaker fruit (fruit with some colour) so these categories are grouped when calculating total yield. Green fruit and rotten fruit are not paid for, deductions are also made for extraneous vegetative material and dirt in the intake sample.

Figure 19 Team of hard working volunteers helping with hand harvesting.

5.1 Harvestable Yield- Hand Harvest

Hand harvest yield measurements were taken from four spots along the established transect in each plot. The sample size from each spot was 0.5 m x 2 m (bed width) = 1 m^2. Harvest material was sorted/graded into factory categories:

- Red tomatoes
- Green tomatoes
- Breakers tomatoes (not red or green)
- Rotten tomatoes
- Remaining plant material- vine

Each bucket was weighed and recorded. Subsamples were collected for further analysis.

Figure 20 shows the relative yield differences in paid weight (T/ha) between each treatment. Table 2 shows the grading breakdown of each treatment. Hand harvests showed the Hybrid treatment had the highest mean saleable yield, although this was not significantly different to the Conventional treatment (p=0.226). Both the Conventional and Hybrid treatments had a statistically higher yield than the Regenerative treatment (p<0.001).

The Regenerative treatment had a higher proportion of green fruit. In a commercial crop, we may have been able to delay harvest to ripen some of this fruit but this was not possible at our plot scale. he Regen treatment also had a lower percentage of rots, similarly this likely relates to maturity as there was less overripe fruit.

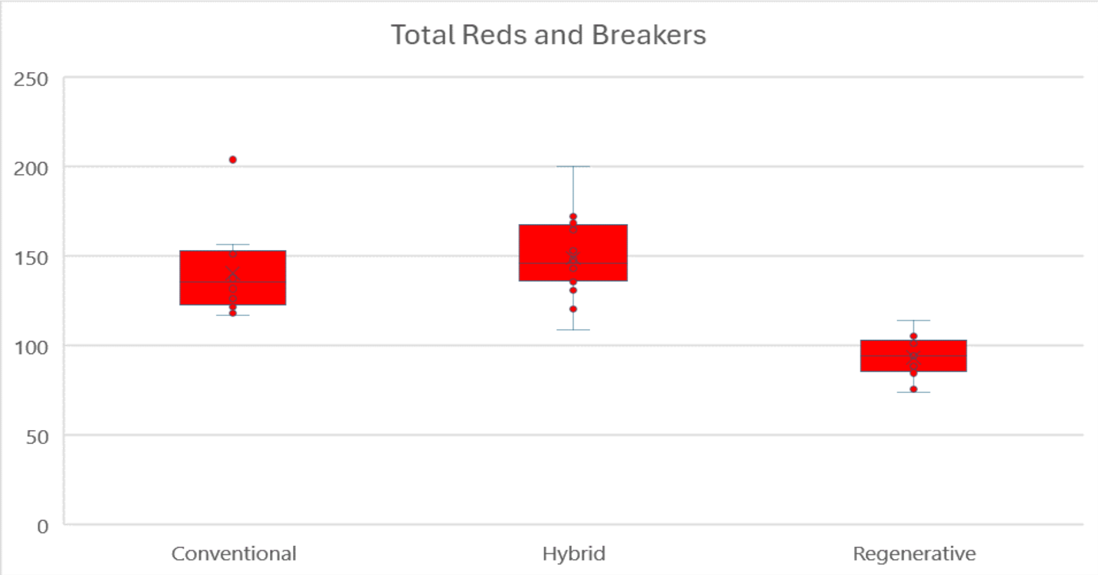


Figure 20 Hand Harvest total T/ha paid weight (red and breaker fruit) by treatment.

Table 2 Hand harvest fruit grading breakdown by treatment.

	Red & Breaks t/ha	Green Fruit t/ha	%Green Fruit	Total Fruit t/ha	Rots t/ha
Conventional	141[a]	3.3[a]	2.3[a]	144[a]	3.4
Hybrid	149[a]	4.4[a]	2.9[a]	153[a]	3.9
Regenerative	93[b]	9.3[b]	9.1[b]	103[b]	2.5
Average	128	5.7	4.8	133	3.3

Values with the same lettering are not significantly different.

5.2 Vine Residue

The Conventional treatment had significantly more vine remaining than both the Hybrid and Regenerative treatments (p= 0.009 and p<0.001 respectively). There was no significant difference between the amount of vine residue in Hybrid and the Regenerative treatment (p=0.09).

Table 3 Vine residue by treatment (hand harvest)

Treatment	Average Vine Residue t/ha
Conventional	26.03[a]
Hybrid	21.68[b]
Regenerative	18.54[b]

Values with the same lettering are not significantly different.

5.3 Total biomass

Total biomass grown is the sum of the paid weight, non-paid weight and the amount of residue left in the field. While the Hybrid yielded the highest total biomass, there was no significant difference (a) to the Conventional treatment. The Regenerative treatment yielded significantly less biomass than the other two treatments (b).

Table 4 Total biomass produced per treatment.

Treatment	Average of Total Red & Breakers t/ha	Average of Green Fruit t/ha	Average of Rots t/ha	Average of Residue t/ha	Average of Total Biomass t/ha
Conventional	140.63	3.34	3.38	26.03	173.38[a]
Hybrid	148.98	4.42	3.85	21.68	178.92[a]
Regenerative	93.42	9.31	2.53	18.54	123.81[b]

Values with the same lettering are not significantly different.

5.4 Machine Yield - Heinz-Wattie's harvester

The machine harvest was completed 2 days after the hand harvest. Each plot was harvested into its own gondola, tipped into its own bin (Figure 21), trucked to the factory and given standard intake quality process inspections. This required intensive management by the Heinz-Wattie's staff and ran seamlessly on the day. The machine yield measurements provide insight into what was harvested from each plot at commercial scale.

Figure 21 Machine harvest of tomatoes into gondola.

Figure 22 Heinz-Watties factory intake core.

At the factory, a large core sample is taken from each unit of tomatoes arriving (Figure 22). The sample is loaded onto a set of reducing scales and weight deductions made for each of the "non-paid" materials (greens/disease or damaged/dirt/EVM). The remainder is the paid fruit (reds and breaker fruit). The percentage of the total sample that is red or breakers is used to calculate the grower paid weight. The factory also measures brix; however, this is a crude measure from the juice of one fruit and is not factored into payments to growers.

Figure 23 shows the paid weight per hectare by treatment, based on the factory intake results.

In contrast to the hand harvested results, the Conventional treatment had the highest mean yield, but it was not significantly different to the Hybrid treatment (p=0.148). The Regenerative treatment had the lowest yield and was significantly lower than the both the Conventional and the Hybrid treatments ($p<0.001$). The percentage of green fruit was lower in the machine harvest samples than in the hand harvest samples, as the hand harvest counted all green fruit, while much of the undersized green fruit falls through grating on the harvester and is not removed from the field.

Table 5 shows the factory grading results by treatment.

	Red & Breaks t/ha	%Green Fruit	%Damage, Rot or Disease	%Dirt	%EVM	%Brix
Conventional	133[a]	1.63[a]	1.51[a]	2.04[a]	0.15	4.89
Hybrid	126[a]	1.49a[a]	1.39[a]	4.91[a]	0.10	4.74
Regenerative	93[b]	3.58[a]	0.90[a]	2.83[a]	0.13	4.08
Average	117	2.23	1.27	3.26	0.13	4.57

Values with the same lettering are not significantly different.

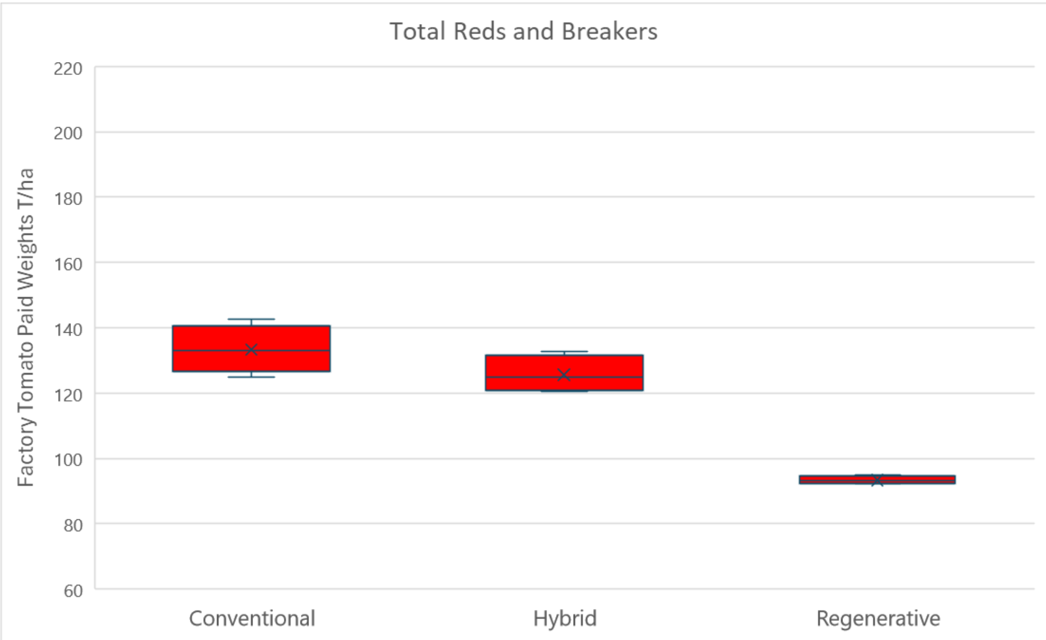


Figure 23 Machine Harvest total T/ha paid weight (red and breaker fruit) by treatment.

6 Crop Analysis

6.1 Factory Quality Assessment

The factory assessment measured the amount of vine/extraneous vegetative material that arrived in the factory as well as the amount of green and red fruit.

The percentage of green fruit, rots, dirt, and EVM% are measured not only to calculate yield but also considered as part of overall fruit quality. Figure 24 shows the quality measurements and EVM% by treatment.

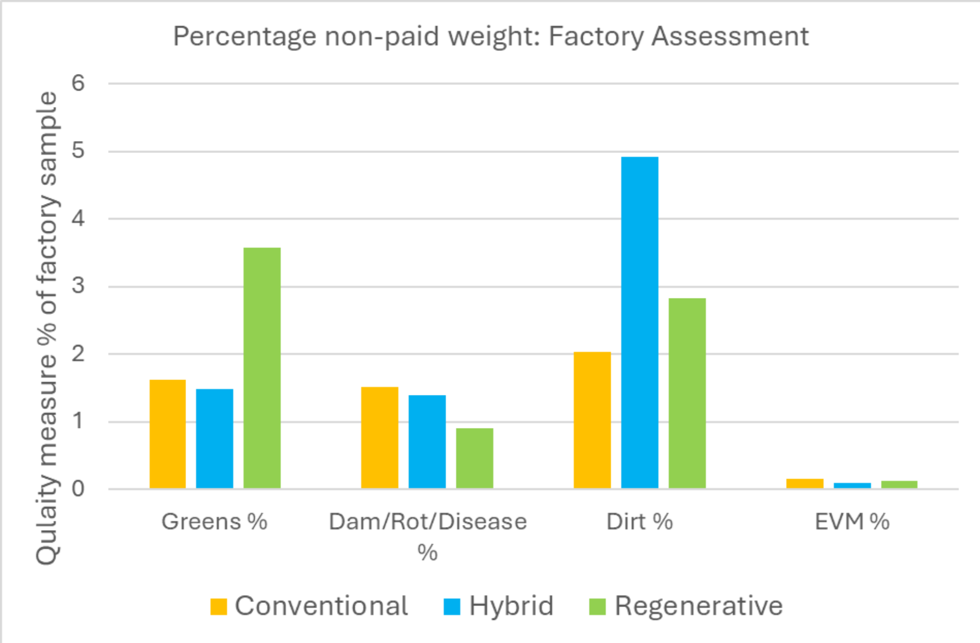


Figure 24 showing the percentage of the factory sample that included non-harvested yield.

6.1.1 Maturity

Maturity is not measured directly, however can be correlated to the percentage of green fruit and the percentage of rotten/diseased fruit. A higher percentage of green fruit indicates a less mature crop, and a higher percentage of rotten fruit indicates a more mature crop. The Conventional treatment had the highest percentage of rots and lowest percentage of green fruit indicating that the crop was more mature. Conversely the Regen treatment had the lowest percentage of rots and the highest percentage of green fruit indicating that the crop was less mature. This aligns with observations made on the treatments throughout the season where the Regenerative treatment seemed to be 2-3 weeks behind the other two treatments. This indicates that Regenerative harvest could have been delayed but this was not possible in our trial set up.

6.1.2 Brix

As well as the intake brix measurements, five-fruit subsamples (4 subplots per plot) were processed by Wattie's on-site laboratory. Samples were blended and brix was measured using the machine used to measure brix in paste.

In contrast to the intake samples, the Regenerative treatment had the highest brix levels, and was statistically higher than the Conventional and Hybrid treatments ($p<0.001$).

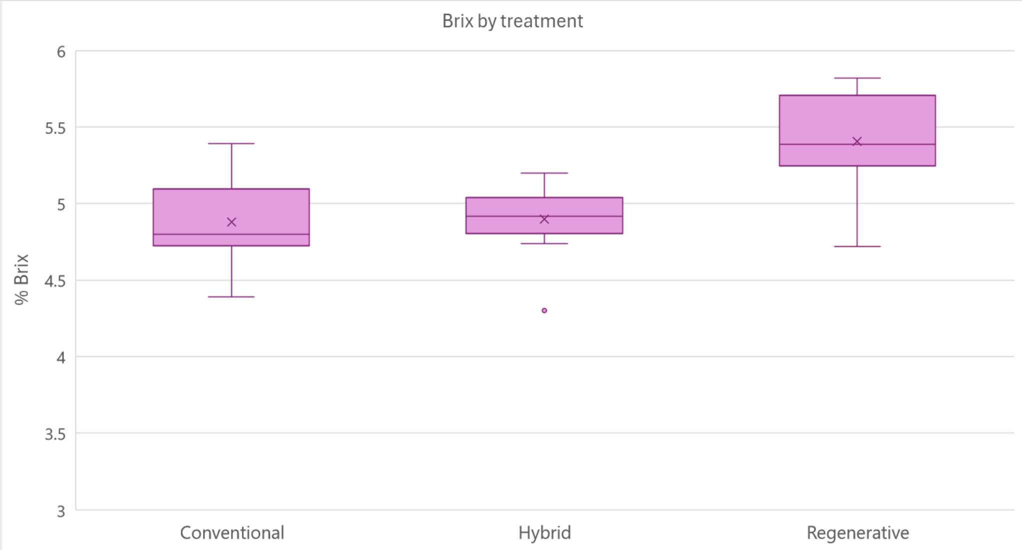


Figure 25 Factory replicated brix laboratory test results by treatment.

6.1.3 Field hold

The variety of tomatoes grown as part of the trial has been selectively bred to have a long field hold, i.e., the fruit will keep on the vine for a long period of time without perishing. The trait allows for issues like delays in crop harvest and can be related to the percentage of rotten fruit in the sample. The Conventional treatment had the highest percentage of rotten fruit at 1.51%.

6.2 Crop Fruit Analysis

A subsample of fruit was submitted to Hill Laboratories for analysis. Analysis included dry matter percentage, nitrogen percentage and carbon percentage. This information can be used to complete nitrogen and carbon balances in future.

6.2.1 Fruit Dry Matter

The Regenerative treatment had a significantly higher dry matter percentage compared with the Conventional and Hybrid treatments ($p<0.001$). There was no significant difference between the Conventional and Hybrid treatments ($p= 0.108$).

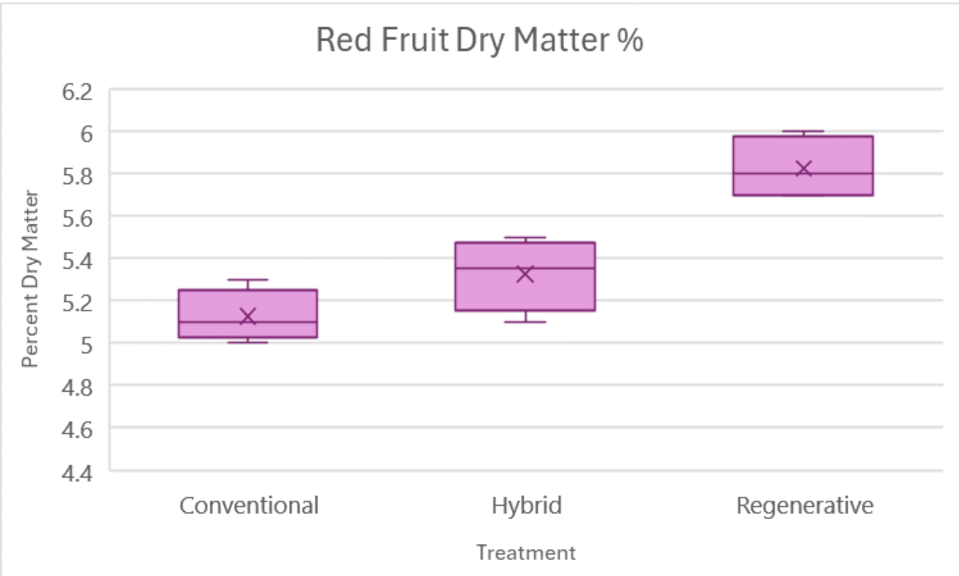


Figure 26 Red fruit dry matter percentage by treatment.

6.2.2 Nitrogen

From the red fruit submitted for sampling there was no significant difference between the Conventional and Hybrid (p=0.642) or Regenerative and Conventional treatments (p=0.084). There was a significant difference between the Regenerative and Hybrid treatments (p=0.018).

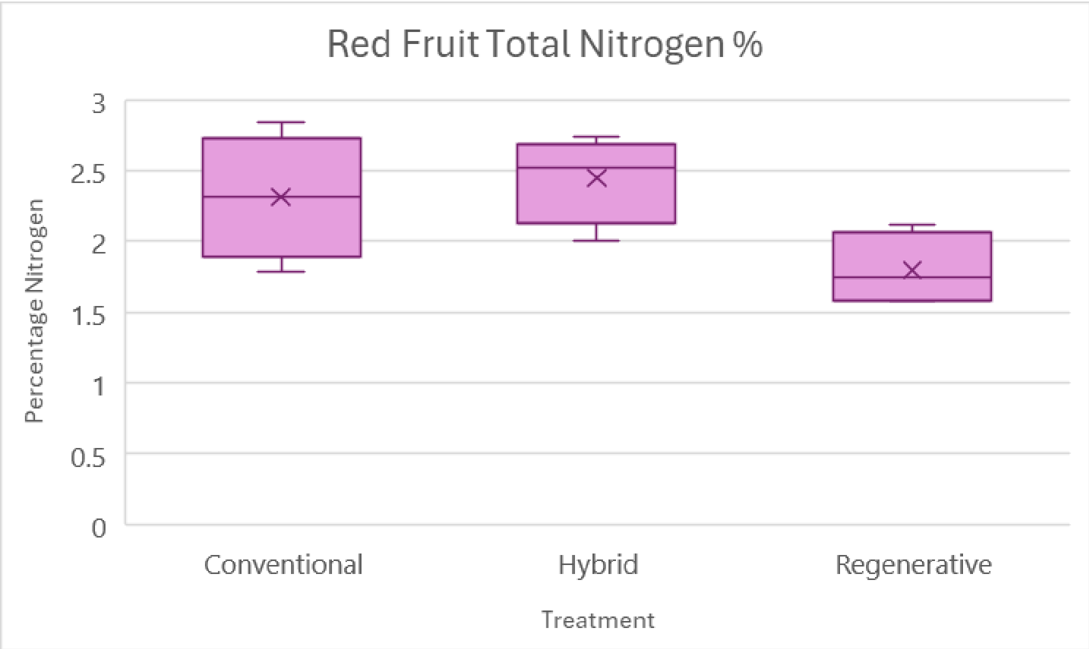


Figure 27 Red fruit percentage nitrogen by treatment.

6.2.3 Carbon

There was no significant difference in the percentage of carbon between any of the three treatments.

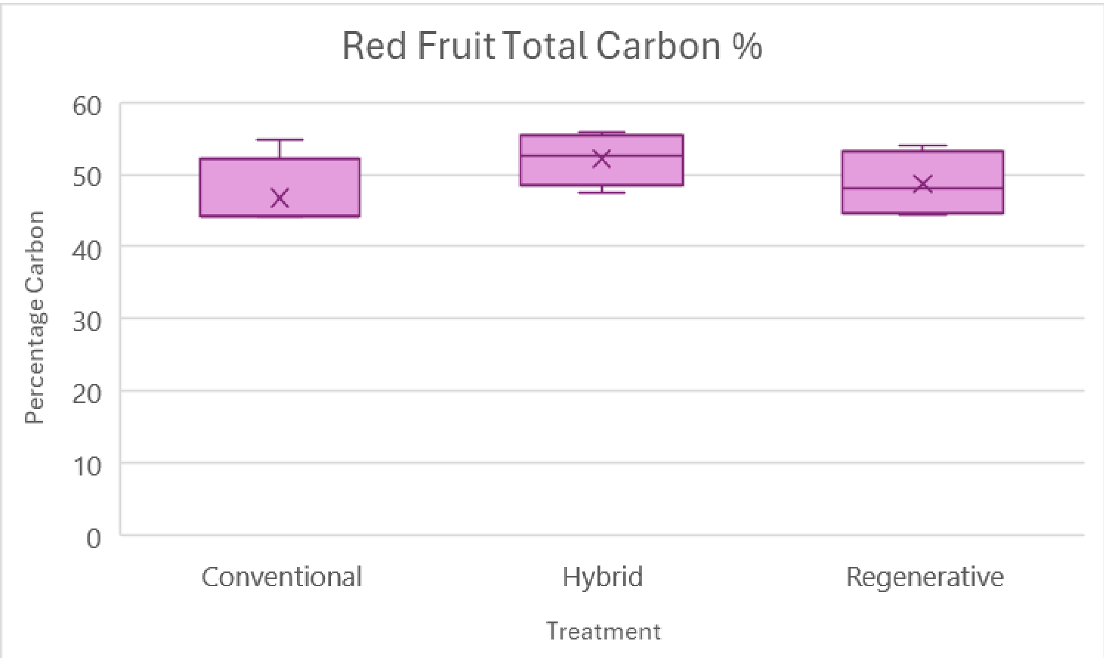


Figure 28 Red fruit percentage carbon by treatment.

6.3 Crop Residue Analysis

While some fruit will be left in the field after a normal machine harvest operation, our laboratory residue analysis was on the vine residue only.

Table 6 Treatment total residue and total dry matter produced.

Treatment	Average Vine Residue t/ha	Vine dry matter %	Total vine dry matter T/ha
Conventional	26.03[a]	31.03%	8.08
Hybrid	21.68[b]	34.38%	7.45
Regenerative	18.54[b]	35.53%	6.59

Values with the same lettering are not significantly different.

6.3.1 Dry Matter

There was no significant difference in vine dry matter between any of the three treatments. The Conventional treatment had 31% dry matter, the Hybrid 34.3% and the Regenerative 35.5%.

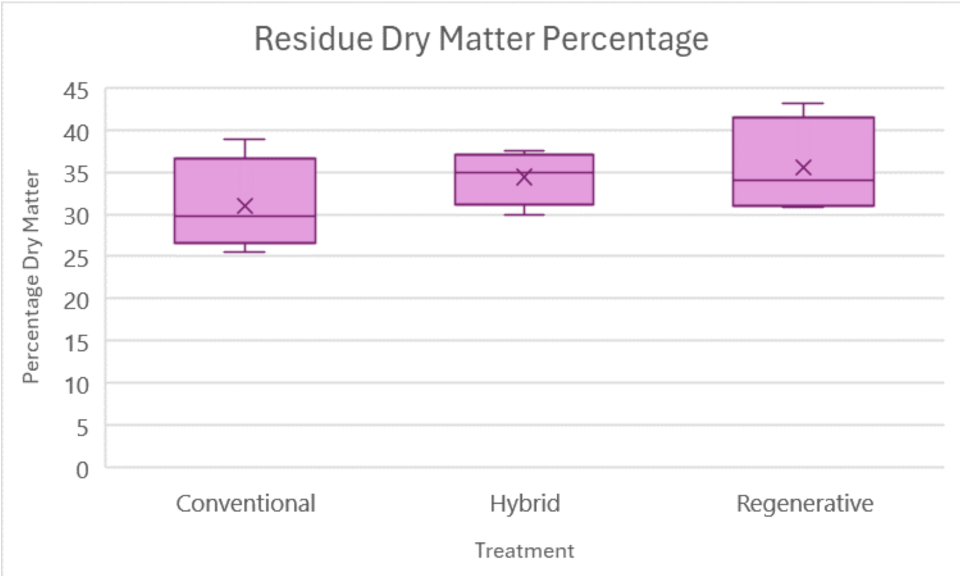


Figure 29 Residue percentage dry matter.

6.3.2 Nitrogen

The residue nitrogen percentage in the Conventional and Hybrid treatments (p=0.414) or between the Hybrid and the Regenerative treatments (p=0.271) were not significantly different, but there was a significant difference between the Conventional and the Regenerative treatments (p=0.050).

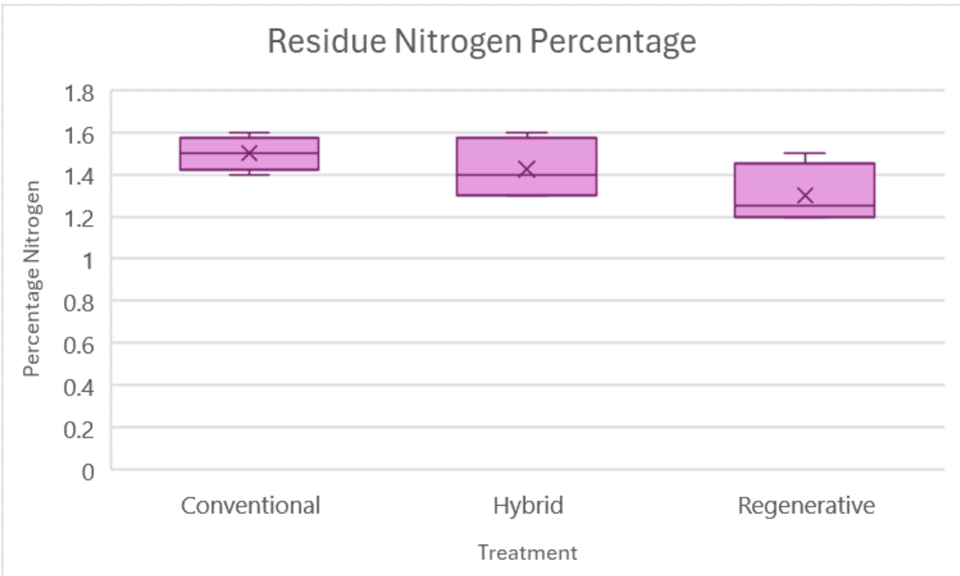


Figure 30 Residue percentage nitrogen by treatment.

6.3.3 Carbon

There was no significant difference between the carbon percentage of the tomato residue any of the treatments.

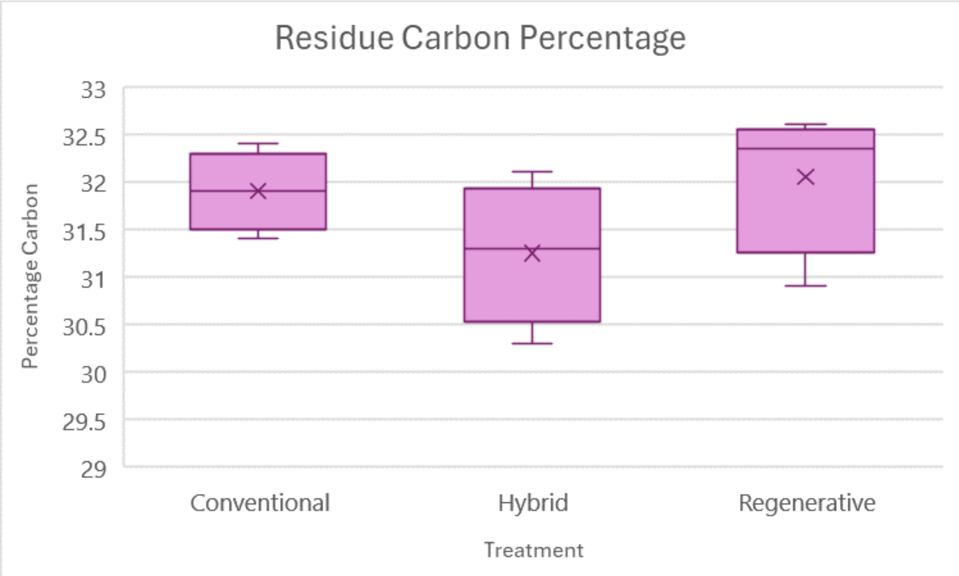


Figure 31 Residue percentage carbon by treatment.

6.3.4 Chemical Residue

In line with factory quality assessment, each treatment had a subsample submitted to AsureQuality to determine if there were any chemical residues on the fruit. Combined subsamples were submitted for each treatment.

One analyte of procymidone (Sumisclex), a fungicide that was applied 19 days before harvest was detected. All treatments had concentrations well below the maximum residue limit (MRL) of 1.0 mg/kg (Conventional 0.053mg/kg, Hybrid 0.12kg/kg, Regenerative 0.11mg/kg). Interestingly the residue was lower in the Conventional treatment. All plots had the same rate applied, but at the time of application the Conventional treatment had a larger canopy, so possibly reduced the amount of chemical contacting the fruit. We note that the withholding period for the product is only 3 days.

7 Post Harvest Soil Analysis

7.1 Nutrient Fertility Analysis

While not within the Science Plan, Heinz-Wattie's encouraged us to complete post-harvest soil nutrient tests to compare nutrients from the start of the season to the end. It is not best practice to compare nutrients at different times of the year as results will be influenced by seasonal factors like temperature and moisture. Results did show that there was a decrease in Potentially Available N and Potentially Mineralisable N, which reflects the high demand for N by the tomatoes. We will compare these results to the pre-plant tests ahead of the 2024 - 2025 crop.

7.2 Visual Soil Assessment

Autumn Visual Soil Assessment has not yet been completed. The window between harvest and discing was small and did not allow us to complete sampling before soil was cultivated. The soil disturbance caused by cultivation and aeration is significant, so we have delayed until the soil has settled. Testing will be completed before the Milestone due date (1st June) and reported in the next milestone report.

7.3 Hot Water Extractable Carbon

Autumn Hot Water Extractable Carbon testing has also been delayed until the soil has settled after cultivation. As part of the HWEC test we will also complete bulk density analysis and need to wait for the soil to settle to get reliable results. Testing will be completed by the Milestone due date (1st June) and reported in the next milestone report.

8 Winter Cover Crop Established

Deciding what winter cover crops to plant was a lengthy process, driven by our sub-optimal first experience of cover crop termination ahead of the tomato crop. The OAG was determined to learn from last year's challenges. The conversation started with what crops we wanted to plant in the spring, and worked back from harvest and the optimal harvest conditions required. The next process crops will be peas planted in August-September followed by beans planted at Christmas. To reduce the intensity of the Regenerative treatment, and extend the winter restorative phase, peas will be excluded and only beans will be planted. This means that the cover crop will grow for approximately eight months, compared to just five months for the other two treatments.

Table 7 showing details of winter cover crops, by treatment.

Management	Conventional	Hybrid	Regenerative
Cover crop preparation/residue management	Heavy disc>light disc>Drilled>Aerated>Rolled	Heavy disc>light disc>Drilled>Aerated>Rolled	Heavy disc>light disc>Drilled>Aerated>Rolled
Cover crop species	Annual ryegrass (Moata)	Black oats, vetch, sunflowers, buckwheat, crimson clover, Persian clover, tillage radish.	Black oats, vetch, sunflowers, buckwheat, crimson clover, Persian clover, tillage radish.
Livestock	Lambs	None	None
Planned cover crop termination	Sprayed out- 1 month before planting	Sprayed out- 1 month before planting	Crimper roller
Spring/Summer crops	Peas>Beans	Peas>Beans	Beans

The Conventional treatment will again be the only area grazed with lambs over the winter. While this is counter to the Regenerative philosophy, the OAG decided to build up a bulk of biomass over the winter and spring, use a roller-crimper to terminate the cover crop, and then direct drill beans into the crimped layer. Weed pressure is one of the biggest issues for beans, so by having a layer of mulch on the surface they hope to minimise herbicide use on the crop.

To harvest beans effectively, the soil surface needs to be 'like a billiard table' so all treatments had tomato residue disced in with a heavy set of discs, followed by a lighter set to create a more even surface. The treatments were then drilled with their respective seed mix (see below), then aerated and rolled to consolidate the soil. The thinking behind aerating after planting was to burst the tillage pan after the heavy traffic had been on the plots and minimise traffic on the newly aerated ground (which could cause further compaction). The winter cover crop was planted on the 22nd of March and has been irrigated twice as conditions have been dry since harvest.

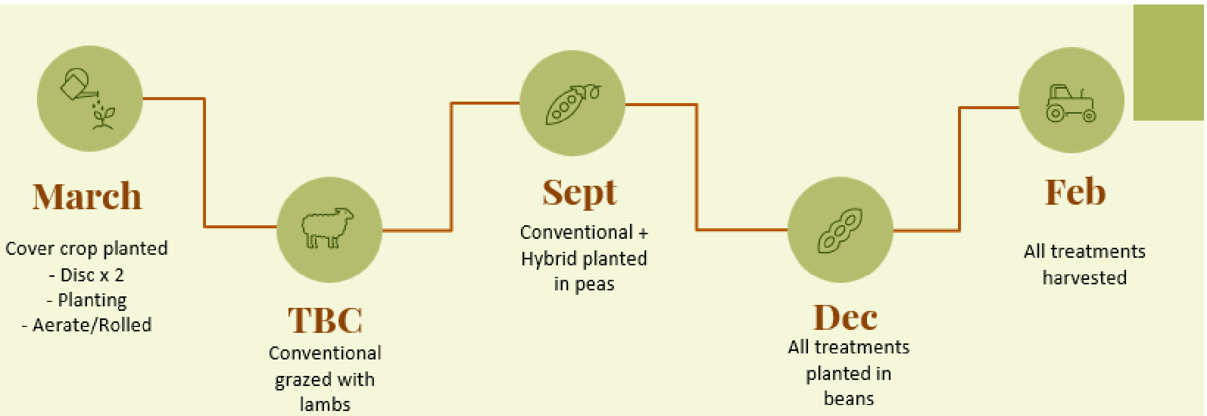


Figure 32 Illustration of winter cover crop and spring crop plans.

9 Gross Margins

The cost of production for each treatment was determined using 'real-world' costs, i.e., standardised grower or contractor rates, rather than the research rates that we are charged. Research costs are much higher due to the scale of the plots and the additional time it takes to complete work. The machine harvest yield was used to determine income from the crop, as it is more closely aligned to the paid yield per hectare (factoring in paddock variation, tracks etc.).

Input costs were similar across treatments, so the main driver of the difference in the margin is the yield achieved in each treatment.

Table 8 showing per hectare gross margins, by treatment.

Stage	Conventional	Hybrid	Regenerative
Harvest	$30,679	$28,902	$21,487
Lease	-$3,500	-$3,500	-$3,500
Pre-plant	-$1,596	-$1,596	-$1,441
Planting	-$3,509	-$3,484	-$3,689
Growing	-$4,387	-$4,540	-$4,812
Grassing down	-$777	-$812	-$812
Grand Total	$16,911	$14,970	$7,233

10 Outreach

10.1 Magazine Article

We have not had an article published in the Grower, but we have published a number of newsletters via the LandWISE and HB Future Farming Trust networks. We also published an article in the proceedings of the 2024 Farmed Landscapes Research Centre Workshop held at Massey University in February. This is available at https://www.massey.ac.nz/~flrc/workshops/24/Manuscripts/Bloomer_Dan.pdf

10.2 Outreach Presentation

The LandWISE conference was held on the 15-16th of May, attended by 99 people from across the primary sector, including farmers, researchers, technical field staff, industry product group representatives, innovators and consultants. Dan and Alex presented on the Carbon Positive project, providing a project overview to those new to the project, a breakdown of operations for the tomato crop, harvest data including gross margins and a look ahead for the next 12 months.

Figure 33 slide cover photo LandWISE Conference presentation.

As part of the conference a field walk/demonstration afternoon was held at the LandWISE MicroFarm on Day 2, where delegates were split into 4 groups and rotated around different stations, seeing a range of agri-tech and bio-tech innovations. One station was showing off the winter cover crop, insectary pods and a roller crimper which we will use to terminate the cover crop. These groups provided thought provoking discussion and engaged a range of different sectors including our planned next steps.

Figure 34 LandWISE Conference field walk.

10.3 Field Walks

We held weekly field walks at 9am every Thursday with Heinz-Watties and other technical advisors throughout the season. In this time, we scouted the crop for pests and diseases, discussed data that had been collected in the past week, looked ahead at the weather, and at how the crop was progressing in each treatment. This allowed us to make informed decisions in line with the philosophies of each of our treatments. Were able to prepare for the week ahead and even look a couple of weeks ahead to get prepared, for example finding small quantities of chemical.

We began monthly field walks in September and continued right through until February, inviting people to visit the site, hear an update on the crop, and discuss any challenges, lessons etc. These field walks were well attended, with many interesting questions asked and discussions had.

Figure 35 Photos showing monthly field walk discussions throughout the season.

10.4 End of Season Discussion

An end of season discussion was held on the 10th of April, inviting interested parties to see interim results and discuss outcomes from this year. The meeting was attended by processors, growers, farmers, and consultants, with presentations taking about one hour, leaving one hour for more in depth discussion. The end of season meeting makes a good bookend for the season and will continue each year.

11 Looking Ahead

Milestone 7 marks the end of Year 2 of the project. Looking ahead to Year 3, the Annual Science Plan and the associated activities will be reviewed and approved. By October 2024 the pea crop will have been established in the Conventional and Hybrid treatments and we will be looking ahead to planting beans in December.

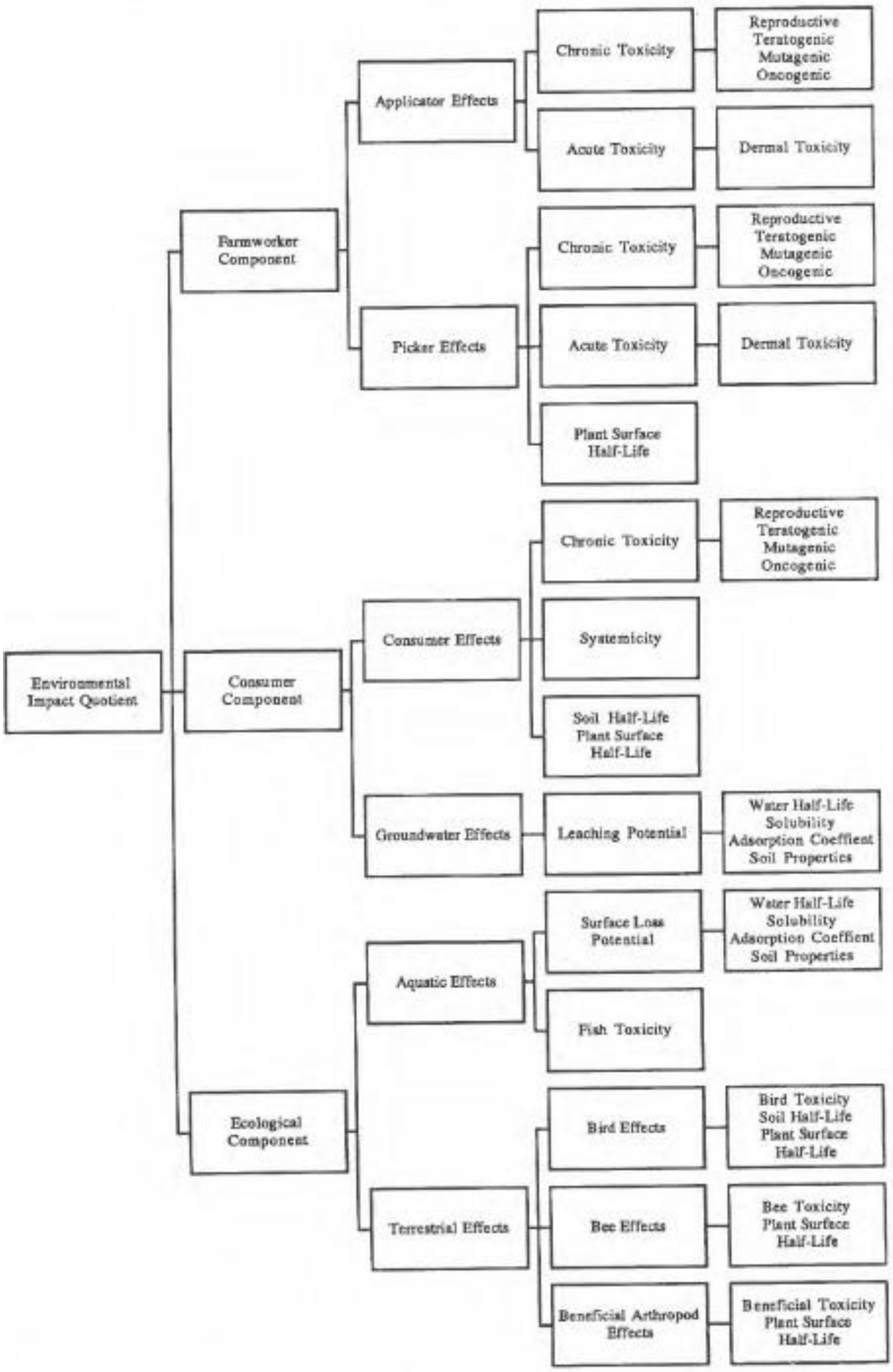
Over the coming months we will be working closely with McCain Foods locally, as well as Heinz-Wattie's in the South Island to plan ahead for the crop management plans for each treatment.

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

12 Appendices

12.1 Appendix 1- Environmental Impact Quotient (Kovach et al., 1992).



12.2 Appendix 2- Crop Protection and Nutrition by Treatment

12.2.1 Conventional Treatment

Application Date	Treatment	Action	Product/Action Type	Rate/Quantity	Unit
5/10/2023	Conventional	Herbicide	Weedmaster TS470	3	L
5/10/2023	Conventional	Sticker/Adjuvant	Li700	0.5	L
18/10/2023	Conventional	Molluscicide	Iron Max	7	kg
26/10/2023	Conventional	Granular Fertiliser	YaraMila 8-11-20	400	kg
26/10/2023	Conventional	Herbicide	BoxerGold	5	L
26/10/2023	Conventional	Herbicide	Magneto	1	L
14/11/2023	Conventional	Directed Herbicide Apr	Sencor Application	1	
14/11/2023	Conventional	Herbicide	Sencor480sc	0.5	kg
28/11/2023	Conventional	Foliar Fertiliser	Yara Bud Builder	3	L
28/11/2023	Conventional	Fungicide	Kocide Opti	0.8	kg
28/11/2023	Conventional	Fungicide	Ridomil Gold MZ	2	L
7/12/2023	Conventional	Fungicide	Kocide Opti	0.8	kg
7/12/2023	Conventional	Fungicide	Ridomil Gold MZ	2.5	L
7/12/2023	Conventional	Insecticide	Benevia	0.5	L
15/12/2023	Conventional	Granular Fertiliser	YaraMila Complex	400	kg
15/12/2023	Conventional	Herbicide	BoxerGold	5	L
15/12/2023	Conventional	Herbicide	Magneto	1	L
22/12/2023	Conventional	Fungicide	Dithane	2	kg
22/12/2023	Conventional	Fungicide	Kocide Opti	0.8	kg
22/12/2023	Conventional	Insecticide	Movento 100 SC	0.8	L
22/12/2023	Conventional	Sticker/Adjuvant	Bond Xtra	0.7	L
4/01/2024	Conventional	Fungicide	Gem	0.75	L
4/01/2024	Conventional	Fungicide	Kocide Opti	0.8	kg
4/01/2024	Conventional	Insecticide	Movento 100 SC	0.8	L
4/01/2024	Conventional	Sticker/Adjuvant	Bond Xtra	0.7	L
13/01/2024	Conventional	Fungicide	Gem	0.75	L
13/01/2024	Conventional	Fungicide	Kocide Opti	0.8	kg
13/01/2024	Conventional	Insecticide	Oberon	0.6	L
13/01/2024	Conventional	Sticker/Adjuvant	Bond Xtra	0.7	L
19/01/2024	Conventional	Granular Fertiliser	YaraRega	100	kg
20/01/2024	Conventional	Fungicide	Dithane	2	kg
20/01/2024	Conventional	Fungicide	Kocide Opti	0.8	kg
20/01/2024	Conventional	Insecticide	Uphold	0.5	L
20/01/2024	Conventional	Sticker/Adjuvant	DuWett	0.3	L
2/02/2024	Conventional	Fungicide	Ridomil Gold MZ	2	kg
2/02/2024	Conventional	Fungicide	Kocide Opti	0.8	kg
2/02/2024	Conventional	Insecticide	Uphold	0.5	L
2/02/2024	Conventional	Sticker/Adjuvant	DuWett	0.3	L
16/02/2024	Conventional	Biostimulant	BioMaris	2	L
16/02/2024	Conventional	Foliar Fertiliser	Croplift K	3	kg
16/02/2024	Conventional	Fungicide	Sumisclex	1.1	L
24/02/2024	Conventional	Growth Regulator	Ethin	2.5	L

12.2.2 Hybrid Treatment

Application Date	Treatment	Action	Product	Rate/Quantity	Unit
7/09/2023	Hybrid	Herbicide	Weedmaster TS470	3	L
7/09/2023	Hybrid	Sticker/Adjuvant	Li700	0.5	L
18/10/2023	Hybrid	Molluscicide	Iron Max	7	kg
26/10/2023	Hybrid	Soil Conditioner	MultiKraft MicroLife	27	L
26/10/2023	Hybrid	Soil Conditioner	MultiKraft Soil NRG	3	L
26/10/2023	Hybrid	Granular Fertiliser	YaraMila Complex	300	kg
26/10/2023	Hybrid	Herbicide	BoxerGold	5	L
26/10/2023	Hybrid	Herbicide	Magneto	1	L
14/11/2023	Hybrid	Directed Herbicide Apr	Sencor application	1	
14/11/2023	Hybrid	Herbicide	Sencor480sc	0.5	L
28/11/2023	Hybrid	Foliar Fertiliser	Yara Bud Builder	3	L
28/11/2023	Hybrid	Fungicide	Kocide Opti	0.8	kg
28/11/2023	Hybrid	Fungicide	Ridomil Gold MZ	2	L
7/12/2023	Hybrid	Fungicide	Kocide Opti	0.8	kg
7/12/2023	Hybrid	Fungicide	Ridomil Gold MZ	2.5	L
7/12/2023	Hybrid	Insecticide	Benevia	0.5	L
15/12/2023	Hybrid	Foliar Fertiliser	Lono	5	L
15/12/2023	Hybrid	Foliar Fertiliser	Foliacin	1	L
15/12/2023	Hybrid	Granular Fertiliser	YaraMila Complex	300	kg
15/12/2023	Hybrid	Herbicide	BoxerGold	5	L
15/12/2023	Hybrid	Herbicide	Magneto	1	L
22/12/2023	Hybrid	Bio Bactericide	Aureo Gold	0.15	kg
22/12/2023	Hybrid	Biostimulant	Yara BioMaris	2	L
22/12/2023	Hybrid	Foliar Fertiliser	Yara Croplift	3	kg
22/12/2023	Hybrid	Fungicide	Dithane	2	kg
22/12/2023	Hybrid	Insecticide	Movento 100 SC	0.8	L
22/12/2023	Hybrid	Sticker/Adjuvant	Bond Xtra	0.7	L
4/01/2024	Hybrid	Fungicide	Gem	0.75	L
4/01/2024	Hybrid	Fungicide	Kocide Opti	0.8	kg
4/01/2024	Hybrid	Insecticide	Movento 100 SC	0.8	L
4/01/2024	Hybrid	Sticker/Adjuvant	Bond Xtra	0.7	L
8/01/2024	Hybrid	Foliar Fertiliser	Lono	5	L
8/01/2024	Hybrid	Foliar Fertiliser	Albina	1	L
13/01/2024	Hybrid	Fungicide	Gem	0.75	L
13/01/2024	Hybrid	Fungicide	Kocide Opti	0.8	kg
13/01/2024	Hybrid	Insecticide	Oberon	0.6	L
13/01/2024	Hybrid	Sticker/Adjuvant	Bond Xtra	0.7	L
19/01/2024	Hybrid	Granular Fertiliser	YaraRega	100	kg
20/01/2024	Hybrid	Fungicide	Dithane	2	kg
20/01/2024	Hybrid	Fungicide	Kocide Opti	0.8	kg
20/01/2024	Hybrid	Insecticide	Uphold	0.5	L
20/01/2024	Hybrid	Sticker/Adjuvant	DuWett	0.3	L
2/02/2024	Hybrid	Bio Bactericide	Aureo Gold	0.15	kg
2/02/2024	Hybrid	Biostimulant	Yara BioMaris	2	L
2/02/2024	Hybrid	Fungicide	Dithane	2	kg
2/02/2024	Hybrid	Insecticide	Uphold	0.5	L
2/02/2024	Hybrid	Sticker/Adjuvant	DuWett	0.3	L
16/02/2024	Hybrid	Biostimulant	Yara BioMaris	2	L
16/02/2024	Hybrid	Fungicide	Sumisclex	1.1	L
16/02/2024	Hybrid	Foliar Fertiliser	Croplift K	3	kg
24/02/2024	Hybrid	Growth Regulator	Ethin	2.5	L

12.2.3 Regenerative Treatment

Application Date	Treatment	Action	Product	Rate/Quantity	Unit
18/10/2023	Regen	Lime	Lime	150	kg
18/10/2023	Regen	Granular Fertiliser	SGP 90	30	kg
18/10/2023	Regen	Granular Fertiliser	Boron	10	kg
18/10/2023	Regen	Humates	Humates	5	kg
18/10/2023	Regen	Molluscicide	Iron Max	7	kg
26/10/2023	Regen	Soil Conditioner	MultiKraft MicroLife	27	L
26/10/2023	Regen	Soil Conditioner	MultiKraft Soil NRG	3	L
26/10/2023	Regen	Granular Fertiliser	YaraMila Complex	300	kg
26/10/2023	Regen	Herbicide	BoxerGold	5	L
26/10/2023	Regen	Herbicide	Magneto	1	L
11/11/2023	Regen	Foliar Fertiliser	Yara Calcinit	6	kg
11/11/2023	Regen	Foliar Fertiliser	Megafol	2	L
14/11/2023	Regen	Directed Herbicide Applica	Sencor application	1	
14/11/2023	Regen	Herbicide	Sencor480sc	0.5	kg
28/11/2023	Regen	Bio Bactericide	Aureo Gold	0.15	kg
28/11/2023	Regen	Foliar Fertiliser	Yara Bud Builder	3	L
28/11/2023	Regen	Fungicide	Phosgard	3	L
7/12/2023	Regen	Bio Bactericide	AureoGold	0.15	kg
7/12/2023	Regen	Fungicide	Ridomil Gold MZ	2.5	L
7/12/2023	Regen	Insecticide	Benevia	0.5	L
15/12/2023	Regen	Foliar Fertiliser	Lono	5	L
15/12/2023	Regen	Foliar Fertiliser	Foliacin	1	L
15/12/2023	Regen	Granular Fertiliser	Nitrabor	200	kg
15/12/2023	Regen	Humates	Humates	3	kg
22/12/2023	Regen	Bio Bactericide	Aureo Gold	0.15	kg
22/12/2023	Regen	Biostimulant	Yara BioMaris	2	L
22/12/2023	Regen	Foliar Fertiliser	Yara Croplift	3	kg
22/12/2023	Regen	Fungicide	Dithane	2	kg
22/12/2023	Regen	Insecticide	Movento 100 SC	0.8	L
4/01/2024	Regen	Bio Bactericide	Aureo Gold	0.15	kg
4/01/2024	Regen	Biostimulant	YaraVita Actisil	0.5	L
4/01/2024	Regen	Fungicide	Triplex	1.5	L
4/01/2024	Regen	Insecticide	Movento 100 SC	0.8	L
4/01/2024	Regen	Plant Illicitor	Actigard	0.04	kg
8/01/2024	Regen	Foliar Fertiliser	Lono	5	L
8/01/2024	Regen	Foliar Fertiliser	Albina	1	L
13/01/2024	Regen	Bio Bactericide	Aureo Gold	0.15	kg
13/01/2024	Regen	Biostimulant	Yara BioMaris	2	L
13/01/2024	Regen	Foliar Fertiliser	Croplift K	3	kg
13/01/2024	Regen	Fungicide	Triplex	1.5	L
19/01/2024	Regen	Granular Fertiliser	YaraRega	200	kg
20/01/2024	Regen	Bio Bactericide	Aureo Gold	0.15	kg
20/01/2024	Regen	Foliar Fertiliser	Phoscare	5	L
20/01/2024	Regen	Fungicide	Dithane	2	kg
20/01/2024	Regen	Insecticide	Uphold	0.5	L
2/02/2024	Regen	Bio Bactericide	Aureo Gold	0.15	kg
2/02/2024	Regen	Biostimulant	Yara BioMaris	2	L
2/02/2024	Regen	Fungicide	Dithane	2	kg
2/02/2024	Regen	Insecticide	Uphold	0.5	L
16/02/2024	Regen	Biostimulant	Yara BioMaris	2	L
16/02/2024	Regen	Foliar Fertiliser	Croplift K	3	kg
16/02/2024	Regen	Fungicide	Sumisclex	1.1	L
24/02/2024	Regen	Growth Regulator	Ethin	2.5	L