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Regenerative agriculture in kiwifruit orchards – barriers to the adoption of these practices

Course 54 – November 2025

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I wish to thank the Kellogg Programme Investing Partners for their continued support.

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Executive Summary

Regenerative agriculture (Regen Ag) is a holistic farming approach that aims to improve the health of the environment, not just sustain it. It focuses on regenerating soil health and biodiversity, which can lead to benefits such as improved water quality, carbon sequestration, and climate change mitigation. This approach uses a variety of practices, such as cover cropping, no-till farming, and biochar applications, and is often seen as working "with the environment, not against it".

Regen Ag has not yet become a mainstream practice due to a rather 'leaky' definition and often perceived as a 'feel good' factor and 'greenwashing'. However, the biggest concern is the lack of scientific data to support its perceived benefits, both globally and within New Zealand.

New Zealand's kiwifruit industry is youthful in comparison to other primary industries - the horticulture sector contributed $8.5b in 2025 to the export revenue and nearly half of this came from kiwifruit exports indicating that growing kiwifruit can be a profitable business.

To date, government and the kiwifruit industry has invested in investigating the benefits of Regen Ag, however, there is almost no publicity of the results by these entities and no extension activities in promoting these practices. Despite the hindrances due to knowledge gaps, Regen Ag in the kiwifruit industry has gained significant attention as a more sustainable option compared to conventional farming. A greater proportion of growers, especially the younger generation, are aiming to become environmentally resilient while remaining profitable. Adoption of Regen Ag practices in kiwifruit, has percolated from other horticultural sectors such as viticulture, and vegetable cropping, due to cross-sector collaborations in the recent times.

Regen Ag in the kiwifruit industry is far from becoming a mainstream practice; the aims of this Kellogg report was to identify which regenerative practices are currently practical and being utilised in kiwifruit orchards. Using a survey approach and thematic analysis of questionnaire responses from industry stakeholders, the report investigates what are the hindrances to the adoption of Regen Ag practices within the kiwifruit industry.

Analysis of the questionnaire responses revealed that,

- Lack of scientific data is one of the biggest hindrances to the adoption of Regen Ag practices. This is in accordance with the diffusion of innovation model, where this report found the biggest proportion of early adopters of Regen Ag practices in kiwifruit, followed by innovators, but because of the knowledge gaps, the adoption falls off, causing a cascading effect on the remaining population.
- Lack of support in promoting the science and extension of Regen Ag from the government and Zespri – is one of the hindrances to Regen Ag adoption.
- The current 'kiwifruit growing model' is highly profitable and growers ask, '*why change if not broken*'. There are no commercial incentives for regeneratively-grown, nutrient-dense kiwifruit. Some primary industries have started claiming premiums for regeneratively grown produce, but there does not seem to be any movement in the kiwifruit space.
- There is currently (and in the near future) no mention of a separate 'regeneratively produced' marketing category of kiwifruit.
- Initial monetary inputs can be higher for cover crop seeds, and soil amendments such as biochar and compost that are proven to improve soil health and organic matter,

across other horticultural sectors. The benefits need to be tested and proved for the wider adoption of these practices (which may bring these initial costs down due to better supply).

- Improving soil health, is one of the pillars of Regen Ag - using cover crops and biochar is a proven concept, but its potential effect on improving kiwifruit quality and marketability has not yet been proven widely. However, improving soil health should be the most obvious and easy-to-achieve option to improve resilience to environmental anomalies, which again, is a parameter that is difficult to quantify.

It is concluded that the industry needs to collectively perform science and extension activities to prove the perceived benefits of Regen Ag and incentivise these practices for a sustainable future of the kiwifruit industry.

The report highlights the following recommendations.

- **Adopting a science-based, data-driven approach:** CRIs, Zespri and key industry experts need to form a committee who can be responsible for scientifically demonstrating the benefits of Regen Ag by conducting experiments, run cost-benefit analyses, thereby demonstrating the economic feasibility of Regen Ag in kiwifruit, and this should be done alongside risk assessments. These committee experts would serve as the key advocates and extension specialists to bring science to growers in the most simplified manner.
- **Collaboration and communication:** A pan sector collaboration and pooled funding stream across various horticultural sectors is critically recommended that will serve as the platform for sharing key learnings and testing the practicality of the successful outcomes.
- **Regulation, certification and potential for incentives:** A certification system for regeneratively-grown kiwifruit must be established, and in order to do so, New Zealand, as a collective, is required to agree upon a 'New Zealand version' of Regen Ag and regulate the practices around it. Kiwifruit growers can then be incentivised for becoming regenerative, and this can drive the kiwifruit industry to become sustainable to remain competitive and profitable in the future.

Acknowledgements

I would like to thank the Rural Leaders team and the Kellogg Rural Leadership program managers for orchestrating an exceptional program that has significantly expanded my perspectives and opened my horizons to the global markets and its challenges. I am particularly grateful to Phil Morrison, Annie Chant, Dr Lyndsey Dance and Lisa Rogers, for their commendable dedication in running this course smoothly.

I am grateful to Zespri International for funding the entirely of this amazing program – I will endeavour to be a responsible brand ambassador in promoting this program to my colleagues and peers across the kiwifruit industry. I would also like to thank my employer Trevelyan Pack and Cool Ltd, who have supported my leadership journey and made this study possible.

I would like to thank all the respondents who gave up their valuable time to participate in the questionnaires, thank you again. The insights, wisdom and honest opinions have been invaluable.

Cohort 54 - you are a fantastic group of incredibly talented people that I am lucky to have met and connected with. I will cherish the long-lasting friendship with you all and look forward to staying connected and celebrating your future successes.

I would like to thank my work mentor, colleague and a great friend - Gordon Skipage (Trevelyan Pack and Cool Ltd), for allowing me to work on this project, alongside full-time work and proactively supporting my work-life balance. A big hug to my lovely kids, wife, parents and my sister, all of whom gave me the patience and inspiration that allowed me to juggle family time, fulltime work and this course.

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Introduction

Regenerative agriculture (Regen Ag) is as an adaptive, ecological approach to managing the agricultural landscape. It has a particular focus on improving the health and function of our soil, plants, animals and people with an expectation of increased profitability. It emphasises the connection between the health of our farms/orchards, and the health and resilience of our communities, waterways, biodiversity and climate.

The concept has immense potential, however, often lacks attention due to being a 'leaky', undefined term across the globe – the term leaks into carbon farming, is a stepping stone to organic farming, and soil carbon sequestration. However, the biggest concern is the lack of scientific data to support its perceived benefits, both globally and within New Zealand. The gap in scientific knowledge is even wider in the case of horticultural systems.

To date, government and the kiwifruit industry has invested in investigating the benefits of Regen Ag, however, there is almost no publicity of the results by these entities and no extension activities in promoting these practices. Despite the hindrances due to knowledge gaps, Regen Ag has taken off as a more sustainable option to conventional farming and a greater proportion of kiwifruit growers, especially the younger generations, are aiming to become environmentally resilient while remaining profitable.

New Zealand grown kiwifruit marketed by Zespri, is one of the most profitable horticultural produce of Aotearoa and Zespri as a brand, has a global reputation of its 'clean-and-green' image. To maintain its reputation and optimum market access, Zespri may need to focus on sustainably grown, nutrient-dense, healthy kiwifruit. This could potentially be achieved using Regen Ag practices as there are overseas studies that has shown indications of improvements in the quality of the produce.

Because of its unique yet intensive way of growing kiwifruit, not all Regen Ag practices seem practical under kiwifruit vines that are shaded during half of its growing cycle.

This Kellogg report attempts to collate some of these practices and identifies the potential reasons for what is stopping kiwifruit growers from adopting Regen Ag practices.

Rationale of the project

Specifically focussed on the kiwifruit production in New Zealand, the rationale of this report is:

- Which regenerative practices are currently practical and being utilised under kiwifruit orchards.
- What benefits are growers/industry leaders expecting from Regen Ag and what are the hindrances to its adoption.
- Understand how these hindrances to the widespread adoption could be averted.

Methodology

Questionnaires and thematic analysis

A questionnaire consisting of 11 questions was emailed to kiwifruit growers, postharvest personnel, technical representatives (postharvest facilities, fertiliser companies), scientific research providers, and industry bodies such as Zespri, Kiwifruit Vine Health (KVH), and Plant and Food Research (see Appendix at the end of this report for the list of questions).

Responses from a total of 24 industry stakeholders were analysed using thematic analysis suggested by Braun & Clarke (2006). Thematic analysis is a method for identifying, analysing, and interpreting patterns of themes in qualitative data. Followed by a detailed analysis of the themes, the commonalities have been discussed for each theme.

Table 1 below shows the questionnaire participants, their industry experience and area of expertise.

	Industry experience (years)	Expertise area	Kiwifruit grower?
1	40	Technical rep	No
2	48	Organic grower	Yes
3	25	Conventional grower	Yes
4	40	Sustainability	Yes
5	23	Conventional grower	Yes
6	23	Consultant	Yes
7	25	Chartered Accountant	Yes
8	10	Plant and Food Research	No
9	20	Organic grower	Yes
10	40	KVH	No
11	7	Regen Ag leader	Yes
12	25	Organic grower	Yes
13	15	Technical	No
14	14	Technical	No
15	18	Technical	No
16	5	Technical	No
17	21	Conventional grower	Yes
18	8	Technical	No
19	25	Conventional grower	Yes
20	14	Conventional grower	Yes
21	6	Zespri	No
22	5	Zespri	No
23	13	Zespri	No
24	25	Organic grower	Yes

Table 1. Stakeholder information for the questionnaire.

Literature Review

Kiwifruit

The seeds of Kiwifruit (*Actinidia chinensis*) were first brought into New Zealand from China in 1904 by a teacher Isabel Fraser who resided in the Whanganui region. Back then, kiwifruit was known as Chinese Gooseberry. In 1928, New Zealand grower Hayward Wright bred a cultivar of kiwifruit named after him which is still the most widely grown green-fleshed kiwifruit variety worldwide. Since then, yellow-fleshed varieties (such as Hort16A, Gold3) and red-fleshed varieties (such as Red19) have been successfully bred and marketed profitably throughout the world.

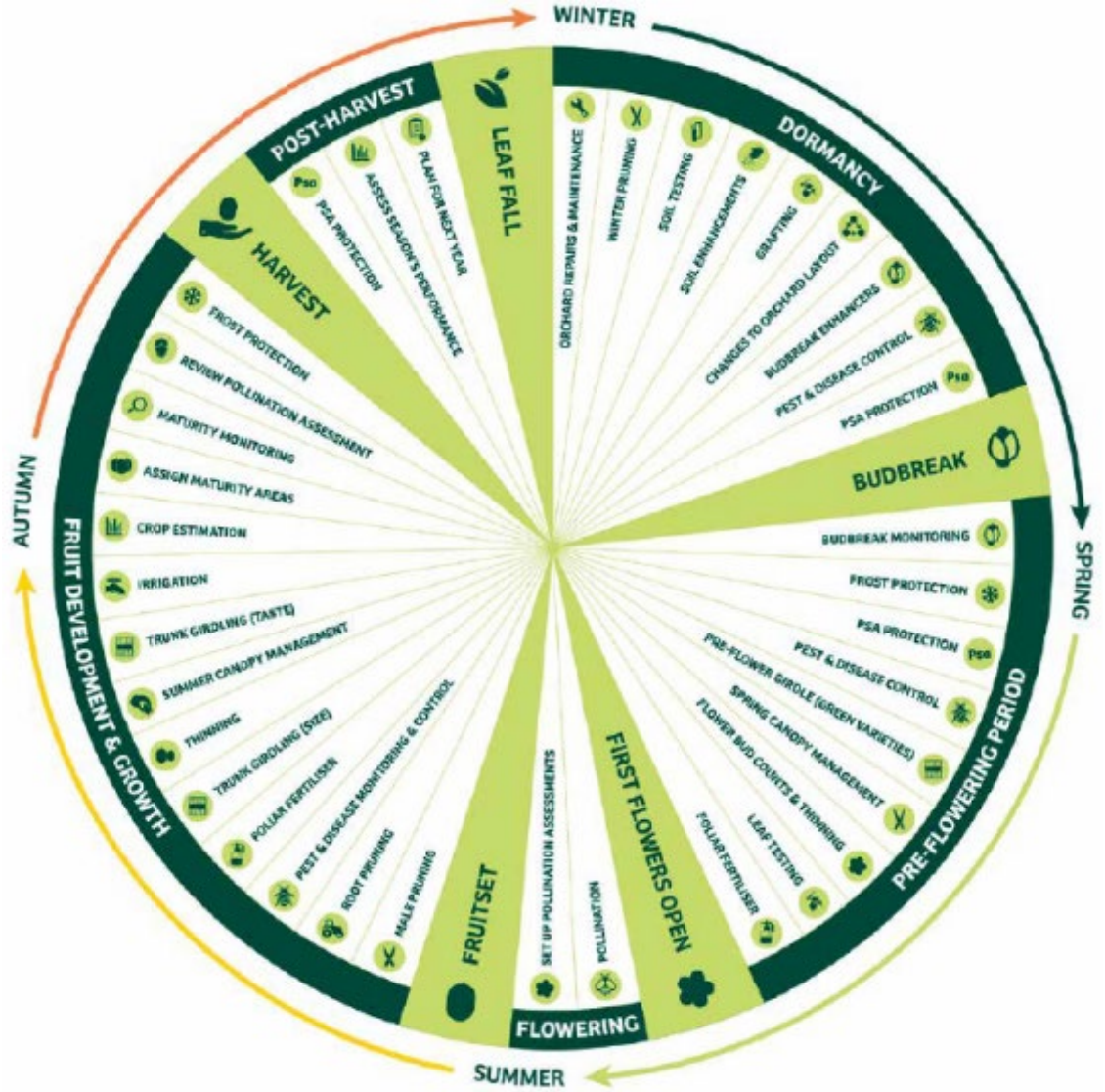

Figure 1. On-orchard kiwifruit production steps and key management actions [Adopted from: The Kiwifruit Book (NZKGI, 2024)].

Kiwifruit in New Zealand has a growth cycle (Figure 1) of ~240 days with vine pruning in winter (June), which immediately follows the previous year's harvest. During the winter months (June to August) the vines lay dormant accumulating chill units. During Spring (September to November) budbreak occurs with shoots starting to grow on the canes along with the first

flower buds. When the flowers blossom, bees are introduced for pollinating the female flowers (Figure 2) that transform to fruitlets. During summer, the fruitlets go through cell division and cell expansion stages, followed by dry matter accumulation that is significantly related to sun exposure (Figure 1). Kiwifruit canopies are notoriously dense which means there is little light penetration reaching the soil surface for five to six months of the year, thereby making cover cropping a challenging aspect.

New Zealand's kiwifruit industry is youthful in comparison to many other primary industries. The food and fibre sector in the New Zealand economy created $59.9b in export revenue as of 30 June 2025 - the horticulture sector contributed $8.5b and nearly half of this came from kiwifruit exports (Apparao et al., 2025). The success of the New Zealand kiwifruit is due to its outstanding leadership, its world class marketing through Zespri and its biggest focus on delivering best fruit quality.

Figure 2. Bees pollinating kiwifruit flowers (Photo: Pranoy Pal).

Climate change has started to significantly affect food production across the globe and New Zealand has not been spared. For instance, growers/farmers are still recovering from the devastating effects of cyclone Gabrielle that occurred in February 2023 (Hatton, 2023). Region specific climatic extremes have caused significant rain events causing flash flooding, storms, hail, frosts, wind gusts, and wildfires. These extreme climatic events have brought

everyone's attention to focus on the preparedness across these unanticipated events and how to become more environmentally resilient as a consequence.

Environmental resilience is defined as an ecosystem's capacity to withstand disturbances, recover from stress, and adapt to changing conditions while maintaining its core functions. Resilience is a term that has **not** shown to be a 'measurable', 'tangible' parameter and hence, lacks a scientific definition per se. However, the term is often used synonymously with sustainability and adaptation. Achieving environmental resilience has become the top priority for several organisations and countries to ensure that food production systems are less significantly affected during and after extreme weather events.

On these lines, an emerging concept is 'Regenerative Agriculture' (aka Regen Ag) often used synonymously with 'Sustainable Agriculture' or 'Restoration Ecology'. This has been discussed in the following sections.

Regenerative agriculture

Regen Ag has become a global phenomenon. Governments see it as a pathway to reducing greenhouse gas emissions. Major food production companies use it to secure their supply chains. Some farmers see it as an eco-friendly alternative to conventional farming, while others see it as just a trendy label.

The term 'regenerative agriculture' was first documented by Medard Gabel in 1979. Regen Ag does not yet have a globally accepted definition and hence, sometimes considered a leaky term. The complexity of defining the Regen Ag concept was highlighted by Gordon et al. (2023) in terms of adapting existing approaches versus more culturally focussed paradigms.

An MPI-facilitated Technical Advisory Group (MPI, 2022) for Regen Ag was created as part of the 'Regenerating Aotearoa' campaign in 2022, which is comprised of more than 25 representatives from Māori and the scientific, farming, farm advisory and business sectors. They created the below vision statement.

"Practices that, in isolation or collectively, can achieve improved outcomes for our productive landscapes, rivers, coastal and marine environments, biodiversity and natural ecosystems, improve animal welfare, have potential to increase profitability and add value, promote health and wellbeing for humans, whilst ensuring we can grow and consume our food and fibre products sustainably, and meet goals of taiao, whenua ora, mauri ora and tea o tūroa."

Regen Ag is a farming approach focused on restoring and improving the health of the land by building healthy soils, increasing biodiversity, and improving water quality. The aim of Regen Ag is to reduce and prevent the non-sustainable practices of intensive/conventional agriculture. Regen Ag involves promoting all aspects possible that are based on five main principles (Figure 3).

1. **Minimising soil disturbance** – decreasing tillage, ploughing – this can help in building soil biology, soil aggregates, and increase organic matter.
2. **Maximising crop diversity** – by increasing crop rotations. Trying to mimic nature. This may not be possible in the case of perennial crops such as kiwifruit and vineyards.

3. **Cover cropping** – to increase aboveground and belowground biodiversity and increase soil organic carbon levels. Also helps increase beneficial soil biology, increase soil organic matter, decrease runoff and erosion.
4. **Maintain living roots** year-round – cover cropping is the key to this practice.
5. **Integrate livestock** – this can significantly improve nutrient cycling, increase soil health, and help move towards a circular economy. However, this may not be feasible for kiwifruit systems, due to damage caused by livestock to the kiwifruit vines' trunks, and risk of food safety.

The outcomes of these principles are interdependent on each other, are synergistic and mutually beneficial. For instance, increasing crop biodiversity can help to mine soil nutrients from various soil depths while also increasing soil carbon, and the similar benefits can be achieved through non-cash crops such as cover crop species.

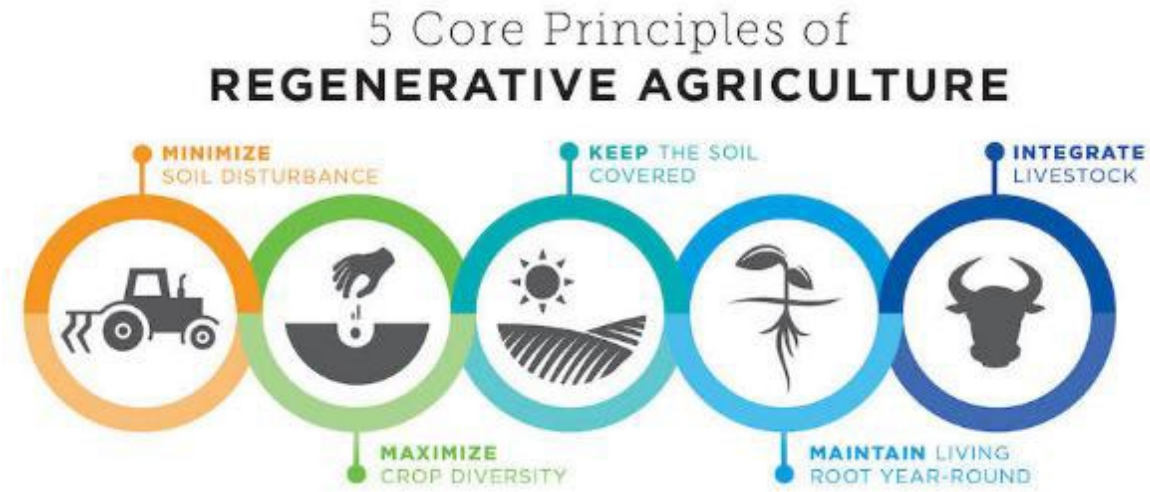

Figure 3. Core principles of regenerative agriculture (Adopted from: LandscapeDNA.org)

New Zealand produce often claims premiums due to its 'clean-and-green' image across the global market and to keep competing, we need to pick up the pace in global trends related to Regen Ag developments.

In 2021, the first attempt to collate all Regen Ag information across Aotearoa available at the time, was presented as a white paper (Grelet et al., 2021). The authors found that Regen Ag may open overseas premium and niche markets for marketing New Zealand grown produce. However, the paper also identified that in the absence of a clear definition/guideline on Regen Ag, scepticism exists about its claimed benefits and that New Zealand's agricultural practices are already regenerative in some shape or form. And, if the benefits ACTUALLY are real, then there is an acute knowledge gap that needs to be addressed to make Regen Ag a mainstream practice.

The latest KPMG report (KPMG, 2025) released in June this year, is a testament of how and why Regen Ag holds tremendous potential. The report mentions Regen Ag at least 19 times and indicates that 74% of global consumers are willing to pay more for sustainably produced goods. It states that '*nature-based solutions, particularly Regen Ag, are beginning to shift the dial, by restoring soil health, increasing on-farm biodiversity, and sequestering carbon – these regenerative practices can generate measurable environmental, financial and operational benefits.*' Key points from the report are mentioned below.

- The report indicates that Regen Ag can build resilience from the ground up and when practiced over a few years, can provide compounding benefits both to the farmer and the environment. When Regen Ag is complemented with AI-powered climate modelling, smart irrigation and bioengineered seed varieties, can ensure higher production even when grown in suboptimal growing regions.
- Their survey found that 64% of the participants (consisting of professionals from agriculture, technology, retail, healthcare, finance and energy sectors) and under the age of 35 are prioritising Regen Ag practices and climate resilience, indicating that the younger generation is prepared for a transformational change.
- Global companies and policymakers are advocating Regen Ag and incentivising the benefits gained due to Regen Ag and sustainable production.
- Global investments on Regen Ag, agri-tech innovation, carbon and biodiversity credits, and nature-based climate solutions are projected to reach US $53trillion in 2025.
- Banks across the world, including New Zealand, are promoting sustainability-linked loans and investment platforms to support Regen Ag practices, improve soil health and reduce emissions. This also includes incentives for meeting environmental and social targets, including biodiversity enhancements and improving water quality.

The **Kellogg Leadership program** also reflects this paradigm shift in the last decade towards Regen Ag where more than nine scholars have presented their reports on Regen Ag across their respective sectors [e.g. (Bailey, 2023; Morrison, 2023; Pedley, 2024; Pentreath, 2024; Wilson, 2022)] and a few more related reports focussed on soil health and its importance.

A report prepared by Lincoln University (Renwick, 2025) states that Regen Ag-led principles can improve social, environmental and economic conditions for future generations while also help New Zealand achieve greenhouse gas emission targets as shown in Figure 4.

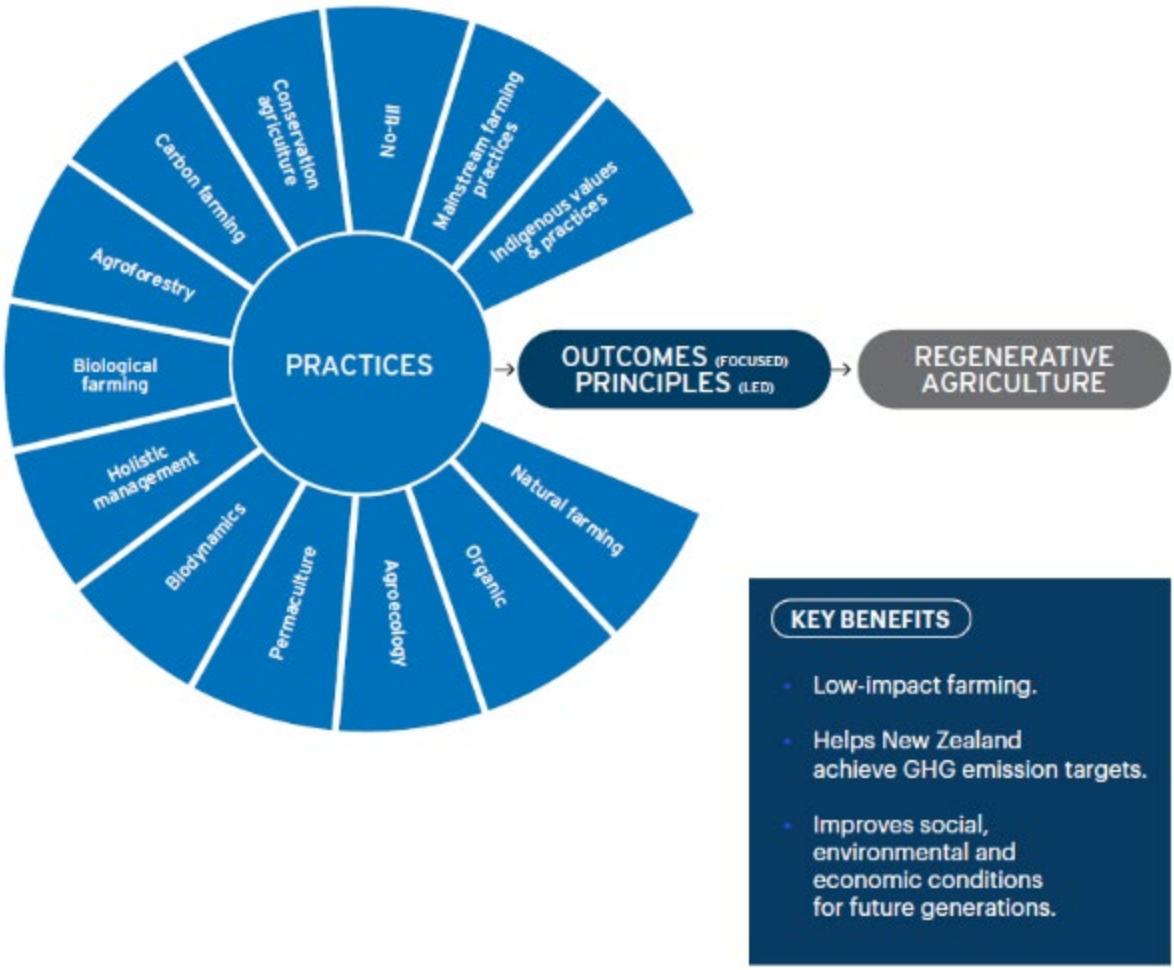

Figure 4. The concept of regenerative agriculture [Adopted from: Renwick (2025)].

Regen Ag is often used similarly to organic farming. Organic farming uses an input restriction approach, which is defined with standards set out as rules stating what is permissible or not in organic agriculture and regularly audited. In New Zealand, 'BioGro' (www.biogro.co.nz) is the national organic certification body governing the regulations and agricultural inputs under a set of rules. These rules are often set out in considerable detail such as those which relate to fertilisers and pest and disease control products. It is therefore considered, at the farm level, that organic agriculture is an 'input focused' approach even though it has wider, more holistic aims. The Organic Products & Production Bill was passed on 30 March 2023, to harmonise and enforce organic standards in New Zealand and take us a step closer to a robust and internationally recognised organic standard (GlobalGAP).

Regen Ag, in contrast, has a set of semi-informally defined objectives to achieve. These relate to soil health, especially microbial health, building soil organic matter for soil health and climate change mitigation and adaptation. To achieve this there is a set of on-farm practices to follow thus making Regen Ag an 'outcome focused' approach, in direct contrast to the 'input' focused approach of organic agriculture (Gosnell et al., 2019; Schreefel et al., 2020).

Carlisle (2016) investigated the barriers to adoption of Regen Ag practices in arable cropping systems in the United States. The author found that while majority of farmers

surveyed acknowledged the positive effects of cover cropping, the practice itself was its own barrier. This is because there was confusion around the lifecycle of certain species of cover crops used, that interrupted the growing of the main crop, which in turn, affected the termination and incorporation of the cover crop residues into the soil. Other concerns around cover cropping was its germination and the competition for soil moisture needed for the cash crop. Initial costs associated with equipment/infrastructure, and ongoing investment costs into seed, labour and management also served as a barrier to cover cropping. Lastly, scientific knowledge of the Regen Ag principles and social stigma (age, education and other demographics) deterred farmers from investing in Regen Ag practices.

Gonzales-Gemio & Sanz-Martín (2025) using farmer interviews, framed around the diffusion of innovation model, surveyed the socioeconomic barriers to the adoption of Regen Ag practices in Spain and Italy. The authors found that while the benefits of improved soil health and increased biodiversity are well recognised, the lack of immediate economic benefits discouraged investment. Further to this, the authors identified that effective knowledge transfer, clearer financial incentives, targeted educational programs and policy adjustments could improvise further adoption of Regen Ag practices.

Benefits of Regen Ag

- Cover cropping can reduce erosion, improve soil health, enhance water availability, smother weeds, decrease pests and diseases, increase biodiversity, provide late pollinator food sources (Figure 5).
- The above benefits can directly improve soil aeration and increase soil microbial abundance. Some studies have indicated that improving the rhizosphere conditions (Figure 6) and increasing soil microbial communities can increase crop yield and improve nutritional quality (Brevik et al., 2020; Martínez-Hidalgo et al., 2019).
- Improved nutrient cycling due to cover crop can help to reduce synthetic fertiliser inputs.
- Suppression of weeds and pests via biofumigation (Quintarelli et al., 2022).
- Reduced water usage.
- Increased soil organic matter content.
- Resilient vine and orchard system – to pest and disease.
- Catch crops – Italian ryegrass, brome, ryecorn.
    - Annual crops to use-up residual soil nitrogen and then mulched.
    - Can reduce nitrate leaching especially during winters.
- Trap crops – species with volatiles, marigold, silver beet, peas.
    - Additional plant species planted as decoys for pests and attract beneficial insects.
- Nitrogen fixers – clover, lupin, peas.

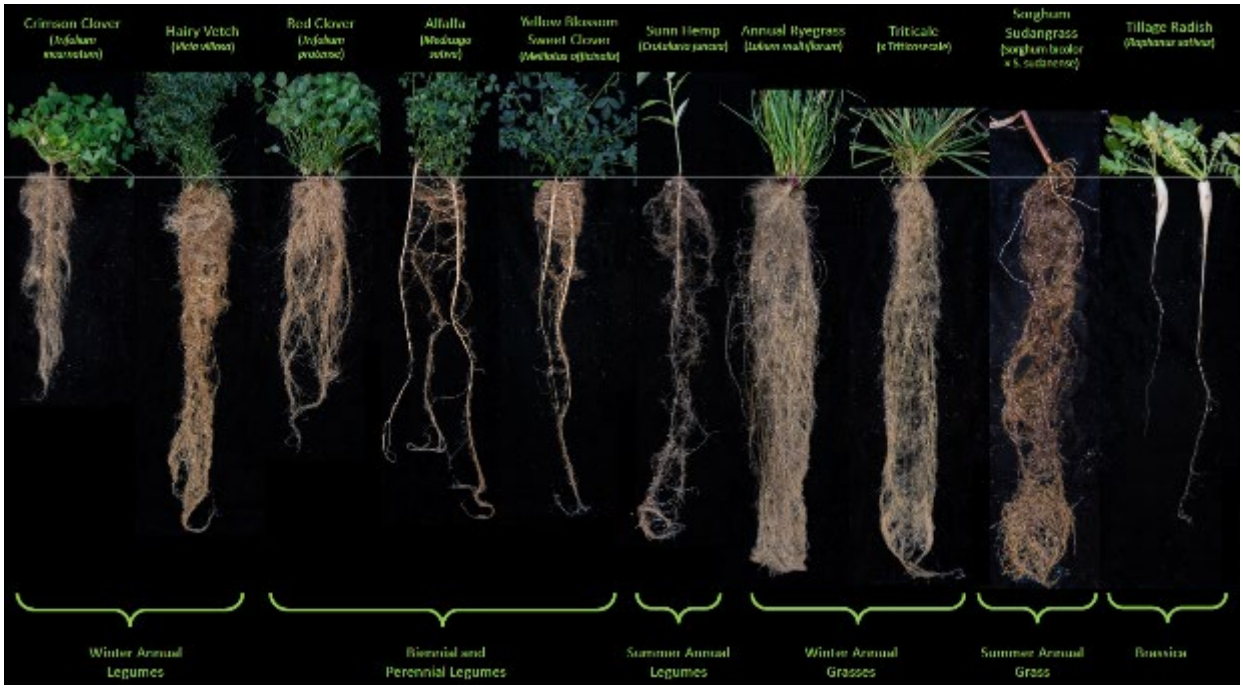

Figure 5. Root structure of different cover crops indicating the difference in benefits that can occur above-ground vs below-ground (Photo: College of Agriculture and Life Sciences, Cornell University).

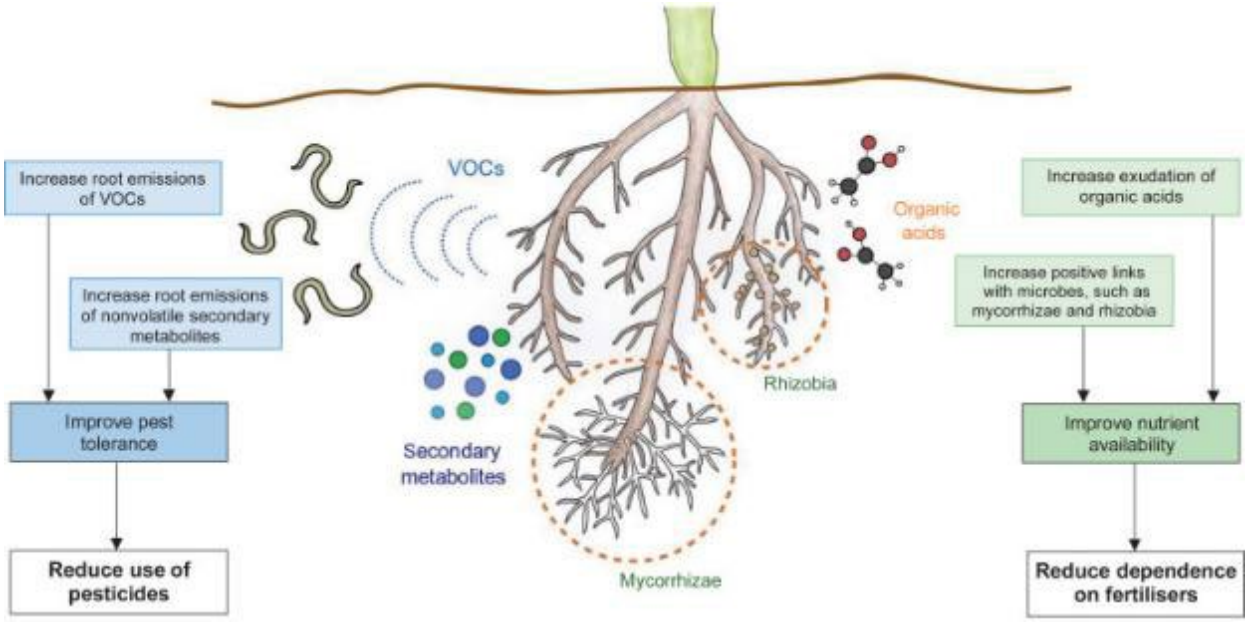

Figure 6. Symbiotic effects of root exudates and mycorrhizal fungi in soil [Adopted from: (Preece & Penuelas, 2020)].

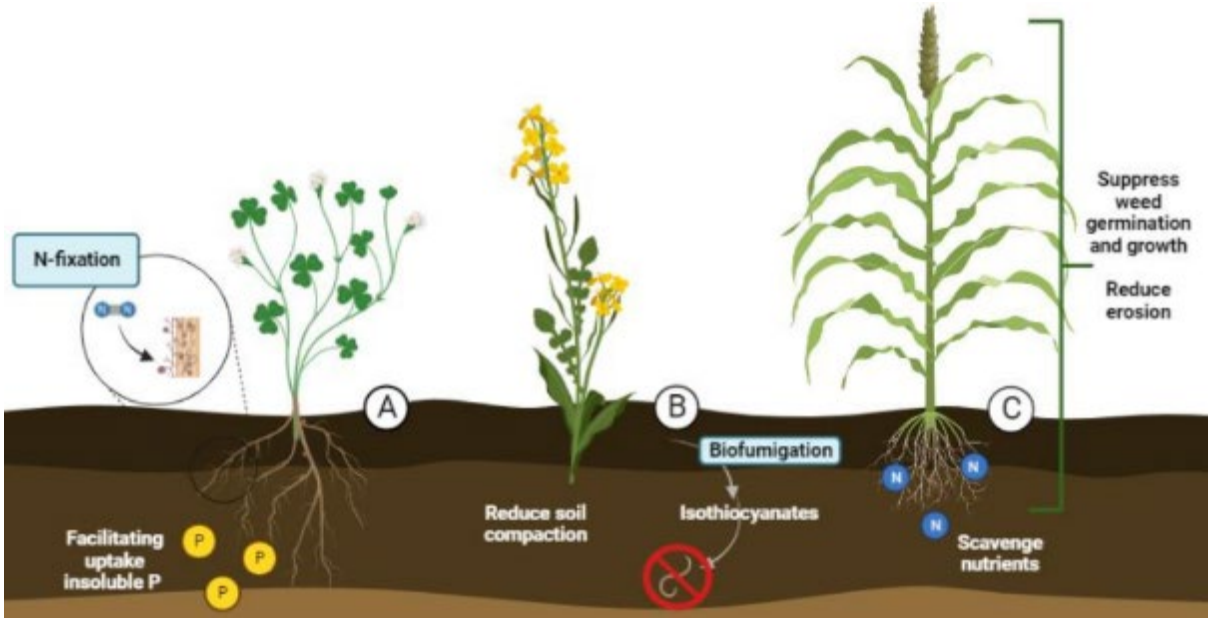

Figure 7. Benefits of cover cropping [Adopted from: Quintarelli et al. (2022)].

Regen Ag in New Zealand

Regen Ag has a special importance in New Zealand context because of its close alignment to the Māori concept of 'Kaitiakitanga' which means actively protecting and caring for the land, water, and resources, ensuring their health and sustainability for present and future generations. In other words, kaitiakitanga is the principle of guardianship and stewardship of the natural world, and this can be achieved, when the core principles of Regen Ag are followed (Grelet et al., 2021; MPI, 2022).

Balks et al. (2022) collated a total of 10 priority areas in soil research that New Zealand should focus on amongst which three are closely aligned with the Regen Ag pillars. The authors iterated that research needs to focus on soil biology and biogeochemistry, especially focussed on soil health, biodiversity pools and fluxes of nitrogen and phosphorus for better managing fertiliser efficiency and water quality, carbon sequestration, and greenhouse gas emission dynamics and effects of climate change on soils, primary productivity, and natural ecosystems.

The concept of Regen Ag has truly taken off in New Zealand as well, however, lacks robust scientific data to prove its net benefits. Following the white paper presented by Grelet et al. (2021), the New Zealand Ministry for Primary Industries (MPI, 2022), reached out to the scientific and farming community, industry leaders under the banner of 'Regenerative Aotearoa' with a total investment of $54.74 million under the portfolio of 11 research projects to specifically address the Regen Ag questions in the New Zealand context. The projects spanned around all agricultural sectors across the whole of New Zealand.

Most recently, in November 2025, Lincoln University has collaborated with McCain Foods over an eight-year regenerative project spread across 20 hectares in a 1:8 potato rotation (Lincoln University, 2025).

Beef+LambNZ released a consumer insights document (Beef+LambNZ, 2022) with respect to Regen Ag. It identified that there is a growing consumer interest and that they are willing to

pay more for regeneratively produced meat, especially if science can show that it tastes better, is healthier and good for the environment. The report also mentioned that they need to have verifiable and relevant standards of Regen Ag to link in with international supply chains and underpin the 'story'- backed by science.

One of the 11 projects committed by Regenerating Aotearoa campaign was a collaboration of MPI with Zespri International, Turners & Growers Global, and Plant & Food Research in the Bay of Plenty and Hawke's Bay regions in a 6-year partnership to address the Regen Ag questions in the kiwifruit, berry and apple sectors. In terms of kiwifruit, the collaborative project sowed cover crops under the kiwifruit vines. Early results from this trial found that the soil's macroporosity increased from 2.9% to 8.3% under the cover cropped areas, decreased soil gleying (an indication of soil anaerobicity), and the visual soil assessments showed improvements along with increased soil aggregation (Clothier et al., 2024). Some of these trials are still ongoing, however, more information around this could not be retrieved.

A vineyard in Hawke's Bay (Figure 8) has actively been planting cover crops since the last five years for a variety of purposes such as increasing water infiltration, increasing soil organic matter and flowering strips to increase beneficial insect biodiversity. Each of these benefits are sought by specific species of cover crops in different parts of the vineyard due to a gradient in soil characteristics. While exercising these Regen Ag practices for over five years, they have found an improvement in grape quality, wine quality and increased flavour profiles.

Figure 8. Cover cropping in vineyards in the Hawke's Bay region (Photo: Pranoy Pal).

Another study (Knill et al., 2025) investigated the effect of a 17-species cover crop seed mix in a kiwifruit block located on a light, pumice soil. The authors found reduced erosion and that soil compaction was significantly reduced where cover crops were present. Hot-water extractable carbon in soil samples, however, did not show any statistical differences.

The only comprehensive Regen Ag study to date in kiwifruit in New Zealand has been done by Pal & Skipage (2024) who investigated the effect of a 16-species shade-tolerant seed mix as a cover crop under kiwifruit vines located on light, pumice soils. They were also the first to investigate the effect of applying biochar (at 5ton/ha) to kiwifruit with the aim to improve soil biology and lift soil organic carbon levels. Their trial included four treatments – cover crops (seed drilled at 40kg/ha), biochar (Figure 9), biochar+cover crops and an untreated control. Soil biology was tested at 3-month intervals that showed a lift in the active fungi within three to four months. Further testing revealed that the benefit continued for six to eight months following the planting; the leading results in treatment #2 where the biochar and seed mix combination was applied. The trial was repeated again in 2023-24 season at a larger scale in the next season with compost added as a 'treatment'. The 'biochar+cover crops' treatment had the highest dominance of ground cover, followed by the 'biochar+compost+cover crops' treatment. Biochar applied in combination with compost and seed mix showed lower levels of mineral nitrogen (i.e. leachable nitrogen), and higher levels of available carbon. These changes in soil chemical attributes corresponded with increased soil fungal and bacterial activities in these respective treatments. The fruit from those experimental bays was also tested, however, it did not show significant differences in elemental analyses at that time point. In summary, this study addressed three Regen Ag pillars, i.e., cover cropping, soil cover and increasing below ground biodiversity (soil biology).

Figure 9. Biochar application and recently emerged cover crop seedlings from an interrow of a kiwifruit orchard (Photo: Pranoy Pal).

Figure 10. Interrow cover cropping in a kiwifruit orchard (Photo: Pranoy Pal).

In the same year, Pal & Skipage (2024) attempted to address one more of the Regen Ag pillars, i.e., increasing above ground biodiversity using 'movable insect pods' (aka mobile insectaries). Four intermediate bulk containers (IBCs) were cut in half, filled with compost, planted with five flowering species and placed between the rows of kiwifruit in the orchard. Mobile insectaries have gained more exposure in recent times as they claim to provide a concentrated 'SNAP' effect, i.e., shelter, nectar, alternative food and pollen for beneficial insects. Beneficial insects provide natural pest control and pollination services, contributing to ecosystem health and reducing reliance on agrichemicals. Throughout the trial, they observed an increase in beneficial predators, such as ladybird beetles, mites, and spiders, as well as native bees. The authors tested a small subsample of fruit from around these movable pods and found subtle increases in fruit quality attributes such as fruit size, sugar content, and dry matter levels. The results from these trials are ongoing, but are highly promising, demonstrating potential for:

- improving fruit production and quality,
- building orchard resilience,
- reducing the reliance on pesticides, and
- increasing orchard profitability.

The authors were recently recognised for their work by Horticulture New Zealand who awarded them with the **Sustainable Innovation Award 2025**.

Figure 11. Movable insect pods planted with flowering species to increase aboveground biodiversity (Photo: Pranoy Pal).

Soil carbon and biochar's relevance

With soil health as the core pillar of Regen Ag, it is crucial that all techniques to improve soil health are employed. Soil carbon is the backbone of soil formation and it is obvious that increasing soil carbon can improve soil chemical, biological and physical characteristics. The below sections highlight the importance of soil carbon and how biochar can be a key tool in improving soil health.

Healthy soil is the foundation of agriculture and an essential resource to ensure all human needs such as food, feed, fibre, clean water and clean air and constitutes the most vital part of the delivery of primary ecosystem services (Keesstra et al., 2016).

The importance of increasing soil organic carbon has been highlighted in all versions (Nabuurs et al., 2022) of the Intergovernmental Panel on Climate Change (IPCC) of the United Nations Framework Convention on Climate Change (UNFCCC). It is the basis of soil organic matter which in turn governs all the crucial soil parameters that makes plant growth possible, viz. aggregate stability, bulk density, water-holding capacity, soil erodibility, soil colour, soil strength, compaction characteristics, friability, nutrient cycling, cation exchange capacity, soil acidity and buffering capacity, capacity to form ligands and complexes, reduced salinity, and the interaction with soil biology.

Ways to increase soil carbon

Soil organic carbon can be increased by the following techniques/amendments, but not limited to,

- Biomass production (agriculture and forestry)
- Soil amendments – compost, humates
- Biochar
- Management of crop residues – leaf litter, kiwifruit summer/winter prunings
- Cover crops
- Crop rotation - cultivation of species and genotypes with larger and deeper root systems
- Agroforestry
- Reduced or nil tillage

Biochar

Thermal decomposition of biomass such as crop and forestry wastes and animal manure (i.e., the feedstock) under partially anaerobic conditions and at relatively low temperatures (<700°C) produces biochar - a relatively more stable form of carbon (C) due to the formation of condensed aromatic structures. Below are some key facts on biochar adopted from Pal (2015).

- Biochar can have a shelf life of >100 years.
- Importance of capturing carbon (in the form biochar, spreading crushed silicate rock) has been identified by the IPCC (Nabuurs et al., 2022).
- Biochar sequesters carbon and this aligns with Regen Ag principles.
- Biochar can govern soil nitrogen availability.
- Biochar increases pH in acidic soils due to higher number of cations (Ca, Mg, K). Can therefore cause a short-term liming effect.
- Forms aggregates with the soil particles and stabilises the soil.
- Increases soil's cation exchange capacity (CEC).
- Increase soil microbial biomass, water holding capacity, soil porosity and aeration.

Pal (2015) also reported a unique interrelationship (Figure 12), i.e., not all biochar types, applied to any soil, may produce the same benefits as in the case of a differently produced biochar. Hence, caution must be exercised with the rate and timing of biochar application to a specific soil type.

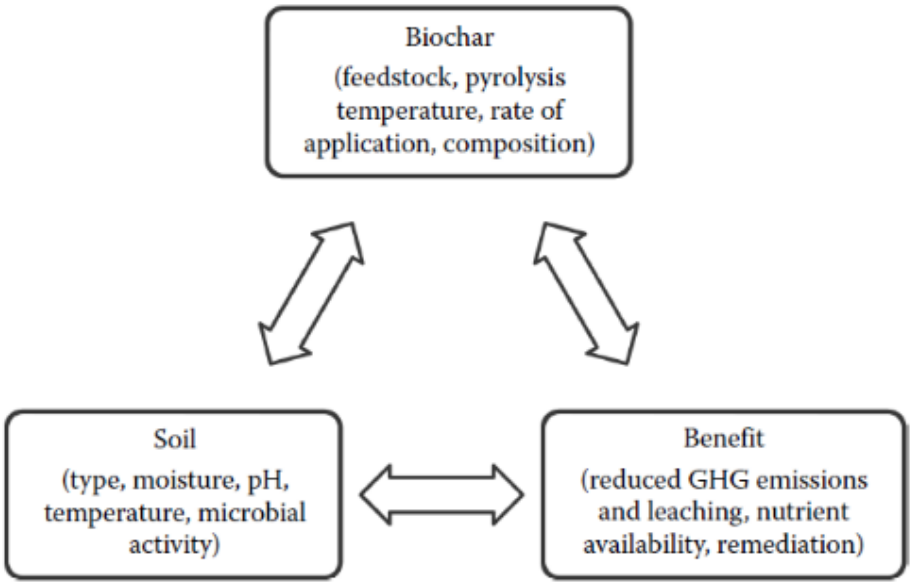

Figure 12. Interrelationships of biochar with soil type, type of biochar and its sought benefits [Adopted from: (Pal, 2015)].

Barriers to the adoption of Regen Ag practices

As discussed in the previous sections, Regen Ag, as a concept, is a paradigm shift for farmers/growers. There are potentially several factors that are serving as a barrier to the adoption of Regen Ag practices. There is a mismatch between academic and policy interest focusing on the scientific need for and value of Regen Ag, and the social and human factors motivating Regen Ag benefits. It is imperative that with a greater support and extension of Regen Ag, climate change and environmental degradation can be addressed much more quickly, more thoroughly and less contentiously.

In view of the questionnaire responses in the following sections, it is imperative that farmers/growers do realise that several benefits can be achieved through Regen Ag practices such as enhanced soil fertility, nutrient cycling, and water retention, improved yields (Techen & Helming, 2017), reduce erosion, increase organic matter, and improve soil structure and microbial diversity (Quintarelli et al., 2022). However, the actual adoption can fall into different categories of the rate at which the innovation comes to practice.

This rate can be explained by the 'diffusion of innovation model' (Rogers et al., 2008), developed by Everett Rogers in 1962, that describes how new ideas, products, or practices spread through a social system over time. It categorises individuals into five adopter categories (Figure 13), each with distinct characteristics and motivations for adopting an innovation. This model helps understand how innovations gain traction and become widely adopted, and it's usefulness for businesses and marketers and growers, in the case of this report.

- **Innovators**: The first to adopt an innovation. They are often risk-takers and enjoy exploring new ideas.

- **Early Adopters**: Opinion leaders who are respected and often adopt innovations early to gain a competitive advantage; embrace change opportunities.
- **Early Majority**: This group does not involve leaders but are open to new ideas and only persuaded by the visible success and benefits of earlier adopters.
- **Late Majority**: These individuals are sceptical of change and will only adopt an innovation once it has become mainstream and the benefits are clearly established.
- **Laggards**: These individuals are the last ones to adopt an innovation. They are traditional, conservative, and resistant to change.

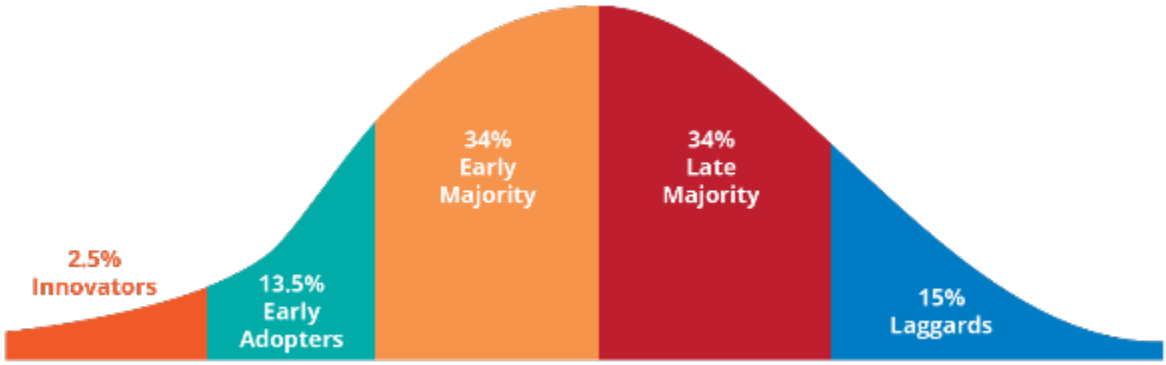

Figure 13. Innovation adopter categories according to Rogers model of diffusion of innovation [Adopted from Rogers et al. (2008)].

In terms of the hindrances to the adoption of Regen Ag practices, Aghabeygi et al. (2024) investigated the adoption of specific practices in Germany around the Regen Ag pillars and found that economic constraints decreased crop rotation diversification in conventional systems by 14%. Lower tillage increased the chances of adoption by 16% where farmers would manage their farms conventionally. The study touched on several aspects such as economic factors, inconsistent policies, lack of technical support, and insufficient financial incentives from government as the major aspects that hindered the adoption of Regen Ag practices.

Another survey study (Alexanderson et al., 2024) on Australian dairy farmers revealed that improving the health and resilience of their farm system was a major motivating factor of Regen Ag adoption, alongside reducing inputs. The authors found that 3/4th of Australian Regen Ag farmers see it as a means to enhance profitability, and about 2/3rd view it as a risk mitigation strategy. Moreover, 59% of the respondents indicated that Regen Ag is crucial for mental health and personal resilience.

Analysis of the questionnaire's responses

Among the 24 respondents, approximately half were a mixture of conventional and organic kiwifruit growers with an average of ~25 years of kiwifruit growing experience. The other half constituted a mixture of industry and technical people with an average of ~16 years of experience in the kiwifruit sector. Moreover, using the diffusion of innovation model proposed by Rogers et al. (2008), the 24 respondents fitted in the below categories (Figure 14). Their responses have been captured and discussed in the upcoming sections.

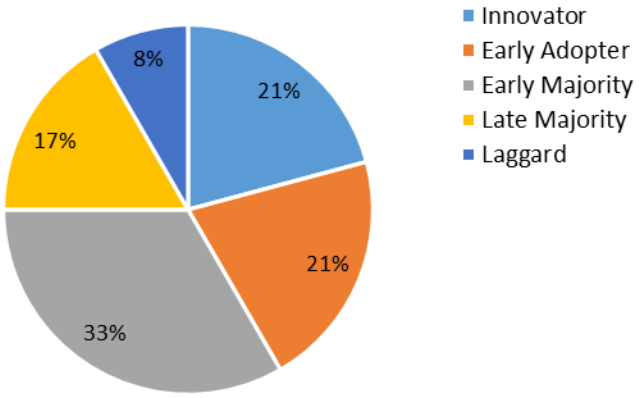

Figure 14. Categories of respondents of the questionnaire of this project report.

Using thematic analysis, Figure 15 shows the following key themes/benefits that were identified by the respondents that they anticipate now or in the near future, by using Regen Ag practices.

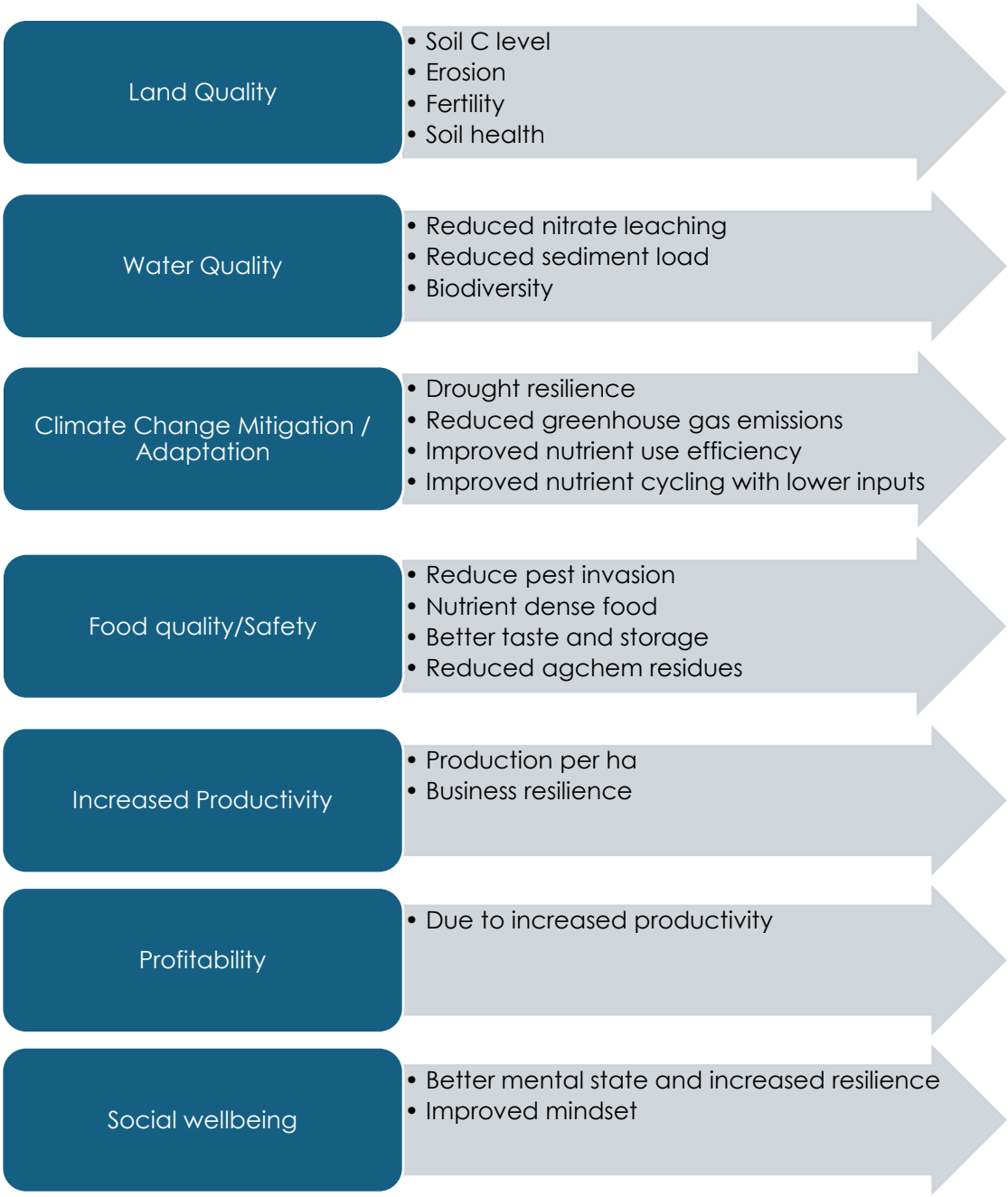

Figure 15. Key benefits identified by the questionnaire respondents if Regen Ag practices are actively adopted.

Questionnaire responses

Q1. What practices did the respondents think are practical under kiwifruit orchards?
The information on the five pillars of Regen Ag was provided in the introduction to the questionnaire and 100% of the respondents answered that except the pillar of 'livestock integration', all the remaining pillars would practically be possible for adoption in all kiwifruit orchards. The majority responded that the most easily achievable practices are

- Manual weeding and transition to soil covered ground area.
- Use effective biological inputs to minimise chemical inputs.
- Decreased mowing of the inter-rows to protect orchard floor and reduce fuel costs.
- No herbicides in the weed strips.
- Cover cropping and soil amendments such as biochar, compost, humates.

Q2. What according to you, are the economic and financial implications of Regen Ag.
The response to this question was pretty clear with a counter question – 'what is the best bang for the buck' – questioning if they can expect financial gains when they have invested in practices such as cover cropping and native planting.

However, few respondents, mainly the technical consultants, also acknowledged that the expected benefits (Figure 15) could be achieved only if Regen Ag is practiced over a prolonged period for the ecosystem to 'reset'. Tangible benefits in the short term of 1-2 years is less likely to be achieved.

Grower respondents (50% of total respondents) mentioned that better quality fruit achieved through Regen Ag practices may help in increasing their profits. A decrease in production costs (reduced agrichemical inputs and fertiliser costs) can increase grower returns.

One more response was that Regen Ag in the near future supports the ability to meet national and global production standards with respect to things such as carbon sequestration, water management and future consumer expectations. This as a consequence, is financially and/or economically important as it maintains brand distinction and market access to our international customers and consumers.

Q3. Do you think Regen Ag practices are really needed in kiwifruit orchards or we are sorted already?
Yes, Regen Ag is definitely needed. The majority of the respondents think that the Regen Ag concept has just about started in kiwifruit growing systems, hence, we are far from 'sorted' actually. More than half of the respondents were kiwifruit growers; however, they were not aware that the government, and Zespri, has contributed significantly towards a Regen Ag research project in 2021-22. The results of the government-funded trials have not been publicly promoted efficiently. Two of the respondents with technical background, were aware of the government funding but could not find any relevant information from any source, whether those trials revealed any new knowledge into the Regen Ag space relevant to the kiwifruit growing systems.
The concept of stewardship of the soil and water should be more credibly passed to the younger generation of kiwifruit growers, and this could possibly be achieved by promoting Regen Ag practices.

Q4. What is stopping kiwifruit growers from adopting these Regen Ag practices – do you think it's the knowledge gap, monetary input, social aspect or something else?

This question carried the highest weightage in terms of this report.

- Almost 100% of the respondents noted that scientific knowledge is the main barrier to Regen Ag's adoption. The literature review in this report also indicated that among the limited number of studies on Regen Ag in New Zealand, <10% studies were scientifically backed up. Amongst these studies, only three studies to date were performed in kiwifruit orchards, and a single study (Pal & Skipage, 2024) reported scientific and statistical measurements.

- Several respondents also indicated that the initial monetary inputs including seeds for the cover crops, machinery costs, gate fees, were indeed a consideration if it was actually going to provide 'significant' and/or 'tangible' benefits. This response was connected back to the lack of scientific knowledge in this space.

- When responses were collated, the theme that indirectly emerged was Roger's model of diffusion of innovation – adoption of Regen Ag is dependent on age of the growers, their financial status, educational background, individual personalities and social stigma (i.e. fear of humiliation and/or being different).

- Adoption of Regen Ag is also significantly dependent on the shoulders of technical consultants, agrichemical and fertiliser merchants, and scientists which is again, closely connected to the unavailability of scientific knowledge. Technical consultants rely on the science, innovation and extension activities of giants such as Zespri and crown research institutes (CRIs) (such as AgResearch, Plant and Food Research). To date, there has been minimal extension activities and the consequent knowledge that has percolated to the end user, i.e. the kiwifruit grower.

- Respondents also mentioned a counter question – 'what's in it for me?' indicating that there is no inspiration or drive to adopt Regen Ag practices. The current 'kiwifruit growing model' is highly profitable. For instance, there are identified niche overseas markets that accepts regeneratively grown beef and lamb meat at a premium, however, there is no mention of something similar in the kiwifruit sector. There are no financial incentives in place to reward sustainable growing practices.

- Kiwifruit growers and the technical representatives have all got a significant appetite for knowledge in this space, e.g.
  - Growers are keen to know what specific cover crops will grow better in shaded conditions under the kiwifruit canopies.
  - Does the industry have the knowledge on cover crops with respect to what seed mix or species can be targeted for specific requirements such as reducing soil compaction, or improving soil organic matter, increased soil borne diseases, lower aeration, or reducing soil erosion.
  - Is there a 'one size fits all' approach for cover cropping?
  - Is the 'Regen Ag recipe' different for a newly developed orchard versus an established block of >5 years – argued on the lines of competition for soil moisture and nutrients?

- Do they need to invest money into drilling the cover crop seeds every year?
- How long (in years or each kiwifruit season) will the cover crop seeds take to 'self-seed' and become a self-sustaining system?
- What is the best timing of sowing cover crop seeds, especially when budbreak enhancing chemicals such as hydrogen cyanamide can 'burn' the newly emerged cover crop seedlings?
- How do we work around the normal practices while the cover crops are in the ground. Practices such as winter/summer pruning, mulching, fertiliser applications and mowing can be difficult to achieve if they aim to protect the young cover crop seedlings in which they have invested the money on.
- The **overall question** they asked was – can we expect higher productivity, which is governed by greater cropload, better fruit quality (bigger fruit, higher dry matter) and greater storability?
- If this concept is successful, would Zespri be prepared to market it as a separate '*regeneratively produced*' category?
- There is a big knowledge gap on earning biodiversity credits and/or carbon farming credits using native planting around the kiwifruit orchards and the natural shelterbelts.

Q5. How many of the five pillars of Regen Ag can kiwifruit growing practices can actually achieve?

100% of the respondents said that all Regen Ag pillars could be achieved efficiently except one, i.e. livestock integration. One of the respondents who holds a senior position in the Food Safety portfolio at Zespri (>10 years' experience) mentioned that majority of organisms of human health and market access concerns such as *salmonella* and *listeria*, can originate from animal excreta. Zespri as the biggest marketer of New Zealand-grown kiwifruit that takes food safety very seriously and there can be significant brand degradation in the case a food safety concern of such type is raised.

However, unbeknown to Zespri, several kiwifruit growers introduce sheep on a regular basis (and sometimes cattle) in their orchards, to keep their interrow swards shorter in order to meet worker safety regulations. These growers have not had any food safety concerns (Note: this was not recorded in the questionnaire due to significant potential repercussions to those grower(s)).

Q6. How do you think Regen Ag is different from organic kiwifruit growing?

Two kiwifruit growers who have grown kiwifruit organically for the last 25 and 40 years, respectively, mentioned that they do not observe significant differences in Regen Ag vs organic system of growing. They did mention that climate change has significantly affected the way they grew kiwifruit 30-40 years ago and extreme weather events have forced them to make certain changes to address soil compaction, waterlogging issues and increase in soilborne diseases. Because of their significant experience in the industry, they also are onboard with Regen Ag concept with the aim of 'stewardship of the land and water' – exactly rhyming with the 'kaitiakitanga' concept as discussed in the literature review.

Other respondents mentioned that organic growing system replaces all synthetic agrichemical and fertiliser inputs by a set of standards but completely ignores the other pillars of Regen Ag.

Q7. How do you think is Regen Ag is different from Conventional kiwifruit growing?
Recorded responses (that aligned with the literature review) indicated that transitioning to Regen Ag from conventional systems can be easily achieved by reducing synthetic fertilisers significantly, increased focus on plant health and soil biology/soil carbon, ensuring ground cover and the use of biological products that are less detrimental to the environment.

Q8. What according to you is more sustainable – Regen Ag vs Organic vs Conventional?
Shortest responses were recorded for this question. Respondents who are organic growers declared their system of growing to be more sustainable, simply because their efforts are recognised using a separate marketing category and a set standard. However, the remaining respondents did mention Regen Ag to be more sustainable in the long run with the caveat that there is no separate marketing category or premiums attached to regeneratively grown kiwifruit, and this deters away people from adopting it.

Q9. How much do you think does practices such as cover cropping and biochar cost? If the costs are lowered due to wider adoption, do you think you will 'switch'?
The majority of respondents did not know the cost but indicated the willingness to adopt some Regen Ag practices if costs are known upfront. They requested a cost benefit analysis of each Regen Ag pillar if possible. One of the organic kiwifruit growers mentioned that figuratively speaking, one can never put a cost to increasing environmental resilience.

Some acknowledged that the costs should go down if the Regen Ag practices become mainstream. A separate chat with the cover crop seed provider mentioned that in 2022, they serviced approximately 80-90 hectares of kiwifruit orchards while this has increased to ~290 hectares in 2025. The cost of cover crop seeds however, has remained unaffected due to market monopoly.

Q10. If you are already a Regen Ag supporter, what are you trying already and/or, would like to achieve through your practices?
The majority of respondents are expecting a tangible improvement to their soils with the ultimate goal of increased productivity and fruit quality.

Q11. If you have already started your Regen Ag journey – what benefits are you expecting in the near or far future? Are you taking any measurements?
Respondents who are already in this journey are taking soil biological and soil chemical measurements, leaf brix, visual soil assessments. However, they would like more guidance on what the ideal ranges of some of these parameters are, again reiterating the expected goal of increased productivity and fruit quality.

Three kiwifruit growers mentioned that their 'measured' outcomes are healthy vines and happier workforce.

Conclusion

This project report aimed at understanding what Regen Ag practices are practical under kiwifruit orchards and what are the barriers to its adoption and stopping it from becoming a mainstream practice.

The results of the questionnaire responses closely aligned with the literature review, although there were limited number of studies reported on kiwifruit cropping systems.

Several Regen Ag practices were found to be plausible and practical in kiwifruit orchards - such as cover cropping, reducing agrichemical/synthetic fertiliser inputs, reducing machinery use (thereby reducing soil compaction), reduced herbicide use in the weed strips, increasing aboveground (native plantings, flowering species in the weed strips and/or headlands) and belowground biodiversity (natural soil amendments, cover cropping), and increasing soil organic matter (using biochar, compost, manures).

It is concluded that the industry needs to collectively perform science and extension activities to prove the perceived benefits of Regen Ag and incentivise these practices for a sustainable future of the kiwifruit industry. The next section discusses future recommendations to ensure the success of Regen Ag practices in kiwifruit.

Recommendations

Science-based approach

- This report has already identified knowledge gap to be the key factor hindering the adoption of Regen Ag practices in kiwifruit orchards. Therefore, a science-based, data-driven approach is critical to the success of Regen Ag.
- In order to do so, CRIs, Zespri and key industry experts need to form a committee who can be responsible for conducting experiments and scientifically demonstrate the benefits of Regen Ag to kiwifruit growers.
- The committee would also be responsible to conduct cost-benefit analyses thereby demonstrating the economic feasibility of Regen Ag in kiwifruit, and this should be done alongside risk assessments and risk mitigation strategies.
- The suggested committee will govern data-driven decision-making, collaborate and identify key strategies to upskill and share knowledge for the wider industry.
- These committee experts would also serve as key advocates and extension specialists to bring science to growers in the most simplified manner.

Collaboration and communication

- Followed by government and Zespri collaboration in 2021, currently, no facts and figures around Regen Ag are easily accessible to kiwifruit growers; nor they have been communicated to the wider industry. Therefore, cross-sector collaborations across various horticultural sectors are critically required.
- These collaborations do not always need to be limited to funding; rather, it's the learnings and testing the practicality of the successful outcomes in other sectors, such as kiwifruit in this case.
- A pooled-funding and a strategic collaboration is critically required with key deliverables and stop-go decisions strategised. One of the key deliverables should be

clear messaging with a multi-directional flow of dialogue between experts, industry and regulators.

Regulation, certification and potential for incentives

- As already discussed in this report, some primary sectors have already started to fetch a premium for supplying a 'certified, regeneratively-grown' produce. All attempts are required to establish a certification system for regeneratively-grown kiwifruit, and in order to do so, New Zealand, as a collective, is required to agree upon a 'New Zealand version' of Regen Ag and regulate the practices around it.
- Once a certification and Regen Ag definition has been established, kiwifruit growers can be incentivised for becoming regenerative, and this can drive the kiwifruit industry to become sustainable to remain competitive and profitable in the future.

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Appendix

Below is the questionnaire that was sent to various industry stakeholders.

QUESTIONNAIRE

Regenerative agriculture (Regen Ag) is generally defined as an adaptive, ecological approach to managing the agricultural landscape. It has a particular focus on the health and function of our soil, plants, animals and people with an expectation of similar or improved profitability. It emphasises the connection between the health of our farms, and the health and resilience of our communities, waterways, biodiversity and climate.
It has five pillars – minimise soil disturbance, maximise crop diversity, maintain soil cover, increase above-ground and belowground biodiversity, and integrating livestock.

Q1. Now that you know about Regen Ag, what practices do you think are practical under kiwifruit orchards? (TYPE RESPONSES BELOW)

Q2. What according to you, are the economic and financial implications of Regen Ag.

Q3. Do you think Regen Ag practices are really needed in kiwifruit orchards or we are sorted already?

Q4. What is stopping kiwifruit growers from adopting these Regen Ag practices – do you think it's the knowledge gap, monetary input, social aspect or something else?

Q5. How many of the five pillars of Regen Ag can kiwifruit growing practices can actually achieve?

Q6. How do you think is Regen Ag different from Organic kiwifruit growing?

Q7. How do you think is Regen Ag different from Conventional kiwifruit growing?

Q8. What according to you is more sustainable – Regen Ag vs Organic vs Conventional?

Q9. How much do you think does practices such as cover cropping and biochar cost? If the costs are lowered due to wider adoption, do you think you will 'switch'?

Q10. If you are already a Regen Ag supporter, what are you trying already and/or, would like to achieve through your practices?

Q11. If you have already started, you Regen Ag journey – what benefits are you expecting in the near or far future? Are you taking any measurements?

Name:
Occupation:
Variety of kiwifruit and hectares:
Number of years in the industry: