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CASE STUDY | JULY 2026

# Oakdale demonstration site

## Soil health and nutrient management

## Background

Phil Bartolo (Figures 1 and 2) grows cabbages (specifically green coronet variety) on a slightly elevated site (around 408–420 metres above sea level) in Oakdale, part of the Sydney basin. This elevation allows him to successfully produce cabbage through the summer months, tapping into a valuable niche window in the market.

The farm sits on rich clay loam soils in excellent condition. Organic matter levels are also exceptionally high at around 8–9%, helping create a well-structured soil with stable aggregates and plenty of air space. The result is a highly active biological system, reflected in the abundance of earthworms and other soil life throughout the profile (Figure 3).

Phil's healthy soils are not a coincidence. As he largely runs the farm on his own, managing everything from field work through to transport, and with more land available than capacity to work it, he has taken a more measured approach to management. Rather than pushing the system hard, Phil uses cover crops between cash crops to protect, maintain, and steadily build soil health over time.

## KEY MESSAGES

- Study aimed to improve nitrogen supply to cabbage using mixed faba bean–oat cover crops and post-cover crop tillage methods.
- Faba bean + oat and straight oat cover crops produced ~7 t/ha dry matter.
- Faba bean + oat supplied ~248 kg N/ha; straight oats supplied ~156 kg N/ha.
- Nitrogen was released gradually over ~6 months after roller crimp termination.
- Cabbage yields were similar across treatments, with the highest in the faba bean + oat + speed disc treatment.
- Timing is important, as unused nitrogen may be lost or tied up in the soil.
- Oats suited longer-term soil protection and weed suppression; faba beans better for maximising nitrogen supply before cash crops.
- Reduced tillage maintained yield while reducing labour, fuel use, and environmental impact.

Hort Innovation

This project has been funded by Hort Innovation using the vegetable and melon research and development levies and contributions from the Australian Government. Hort Innovation is the grower-owned, not-for-profit research and development corporation for Australian horticulture.

RMCG

ahr applied horticultural research

**Figure 1, 2:** Grower Phil Bartolo in faba bean and oat cover crop

## Cover cropping goals

Despite his already healthy soils, Phil has become increasingly interested in refining his system further to improve efficiency and sustainability.

Traditionally, Phil has used winter cover crops such as oats and faba beans, and occasionally summer species like millet and sunflower, to manage weeds, break disease cycles, reduce erosion, and retain soil moisture. More recently, he has placed greater emphasis on legume-based cover crops to naturally fix nitrogen and reduce reliance on synthetic nitrogen fertilisers.

Ever open to new ideas and committed to continuous improvement, Phil is also exploring reduced tillage practices to preserve soil structure, support beneficial biology, and cut down on time and fuel costs.

## Knowledge gaps

Despite the key signs of a heathy soil, and the effort invested into growing legumes for nitrogen supply, cabbage crop performance was not quite meeting expectations.

A key part of Phil's system involved roller crimping the mixed cereal and legume cover crop and leaving residues on the soil surface for up to six months to protect the soil, reduce erosion, and suppress weeds. What remained unclear was how much plant-available nitrogen was still left for the cabbage crop after this period, and whether different tillage methods used for bed preparation influenced both soil health and nitrogen availability.

To better understand these dynamics, this trial set out to measure and better understand what was happening within the system.

**Figure 3:** Well structured soil on Phil's farm with earthworms

## Approach

Phil's main goal was to better harness legumes as a nitrogen source for his cabbage crop by both maximising nitrogen fixation and improving how and when that nitrogen becomes available. This meant focusing on getting the fundamentals right, namely

- Inoculating seed with the correct rhizobia
- Maintaining a near-neutral soil pH
- Maximising legume biomass
- Terminating crops at flowering to preserve residue quality
- Growing legumes alongside cereals to encourage legume nitrogen fixation
- Exploring ways to better align nitrogen release with crop demand by experimenting with the timing and methods of cover crop termination, as well as different approaches to ground preparation

While this demonstration specifically focused on ground preparation methods (speed disc, strip rotary hoe, and full rotary hoe), Phil has been actively refining other aspects of this system across the farm.

## The trial/demonstration

### Aims

The trial set out to investigate both cover crop performance and the impact of different tillage approaches on nitrogen availability and cabbage production.

It compared three cover crop treatments to assess their contribution to nitrogen supply, weed suppression, and overall soil health:

- A mixed planting of faba beans and oats
- Straight oats
- Fallow (control)

Further investigations examined how much nitrogen was released from these cover crop residues following three different bed preparation methods and how these methods influenced cabbage performance.

- Speed disc (reduced tillage, Figure 4)
- Strip rotary hoe (reduced tillage, Figure 5)
- Rotary hoe (conventional)

These three approaches were selected to explore opportunities to reduce the intensity of tillage and better protect soil structure. Reduced tillage options offer a less aggressive alternative, while also allowing for faster tractor


**Figure 4:** Speed disc

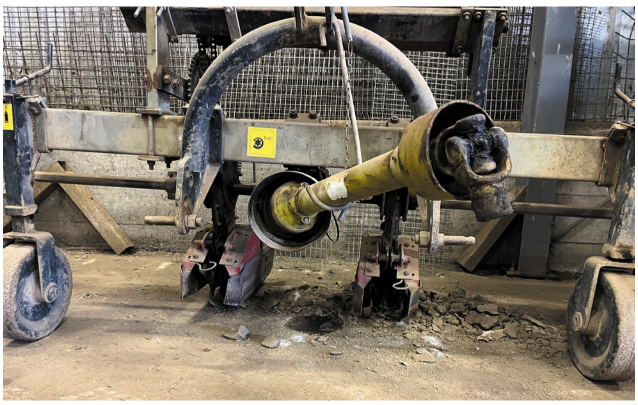
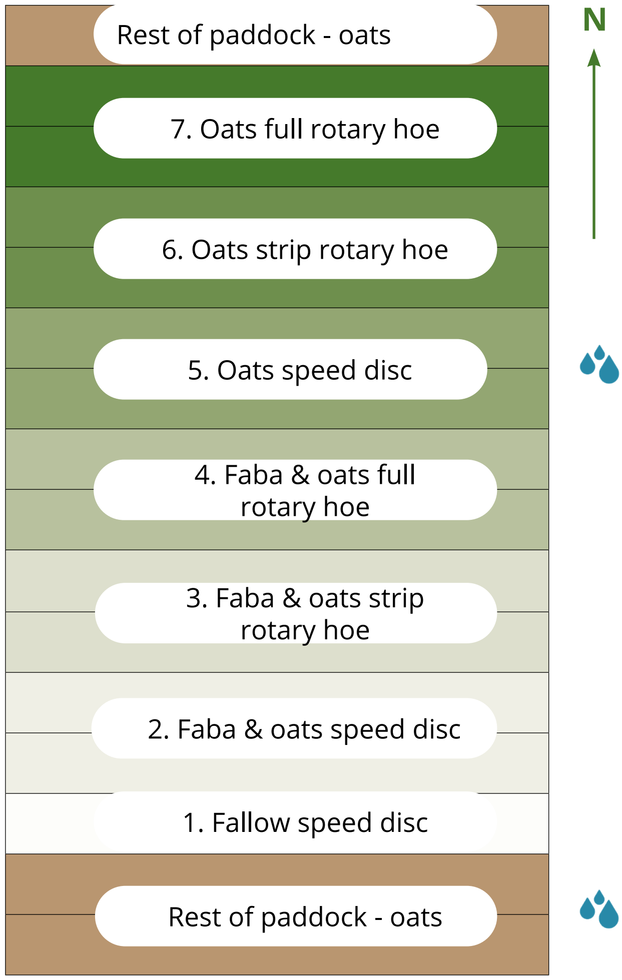


**Figure 5:** Strip rotary hoe

operation. This creates potential benefits not only for soil health, but also for farm efficiency through savings in time, fuel, and machinery wear and tear.

### The treatments

1. Fallow Speed Disc (SD) (control)
2. Faba & Oats Speed Disc
3. Faba & Oats Strip Rotary Hoe (SRH)
4. Faba & Oats Full Rotary Hoe (FRH)
5. Oats Speed Disc (SD)
6. Oats Strip Rotary Hoe (SRH)
7. Oats Full Rotary Hoe (FRH)




**Figures 6:** Trial layout - note this is not a replicated trial

**Figure 7:** Cover crop of faba and oats

**Figure 8:** Faba bean roots with nodules

**Figure 9:** Trial area November 2024, faba & oats (left), fallow (middle), oats (right)

## What was measured and why

This trial was conducted over a period of 18 months:

1. Established a baseline soil condition (May 2024) before planting the cover crop (August 2024)
2. Planted different cover crop treatments to build biomass and fix nitrogen (Figures 7 and 8). Key measurements at flowering (November 2024, Figure 19) and after termination (by roller crimping, Figure 11) help quantify how much nitrogen and carbon were added to the system.
3. Tracked (December 2024, March 2025, May 2025) how soil nitrogen levels and residue breakdown change over time, providing insight into nitrogen release dynamics.
4. Applied different bed preparation (June 2025) methods for transplanted cabbages to understand their impact on soil condition, nitrogen availability, and crop performance. Ongoing soil and plant measurements throughout this stage (June-September 2025, Figure 15) helped link management practices to outcomes, culminating in yield and post-harvest soil assessments.

**Figure 10:** Trial area mid Nov 2024, cover crop being roller crimped.

**Figure 11:** Trial area Dec 2024, L faba & oats, M fallow, R oats, 5 weeks after termination by spraying and roller crimping.

**Figure 12:** Trial area May 2025, L faba & oats, M fallow, R oats

**Figure 13:** Trial area Sept 2025, cabbages at cupping growth stage

**Figure 14:** Trial area Nov 2025, cabbages at harvest

**Figure 15:** Trial area Nov 2025, cabbages harvested and assessed for yield and quality

## Results from the trial

### Cover crop results - biomass quantity (t/ha) and quality (carbon, nitrogen, C:N)

The mixed cover crop of faba beans and oats produced a total of 7.2 t/ha of dry biomass (Figure 16), containing around 296 kg N/ha overall (Figure 17). The faba beans contributed the majority of this nitrogen, with 5.6 t/ha of biomass and approximately 248 kg N/ha in total (including an estimated 140–150 kg N/ha fixed biologically), while the oats contributed 1.6 t/ha and 52 kg N/ha.

The combined system had a relatively low C:N ratio (around 13–15, Figure 18), indicating good potential for nitrogen release. In comparison, the **straight oat cover crop** produced a similar level of biomass at 7 t/ha but contained less nitrogen overall at 156 kg N/ha and had a higher C:N ratio of 20, suggesting slower decomposition and nitrogen release.

Phil noted that the faba bean component likely underperformed due to it being planted too late in the season and would have been more productive if established earlier in winter.

Following termination, both cover crops broke down substantially over the six months they remained on the soil surface, resulting in much lower residue levels by May 2025 (2.9 t/ha in the oat system and 1.1 t/ha in the mixed faba & oat system), along with a corresponding decline in remaining nitrogen compared to pre-termination levels.

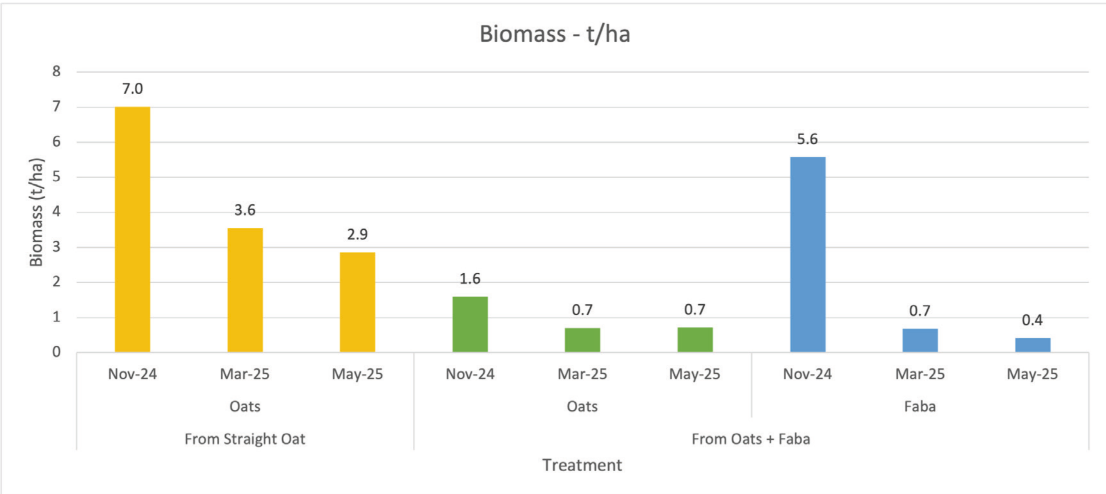



**Figure 16:** Biomass dry weight (t/ha)

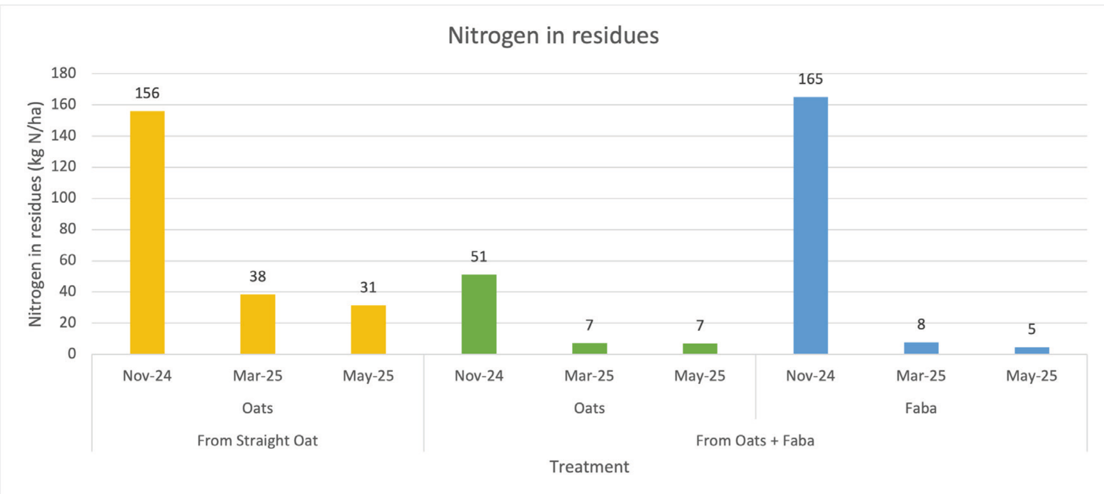



**Figure 17:** Biomass dry weight (t/ha)

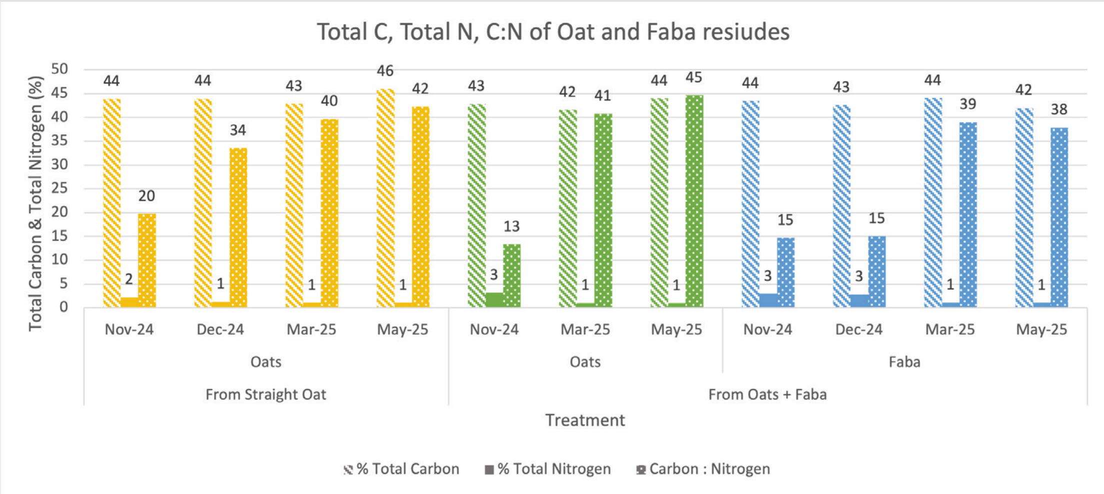



**Figure 18:** Cover crop residues Total C, Total N, C:N

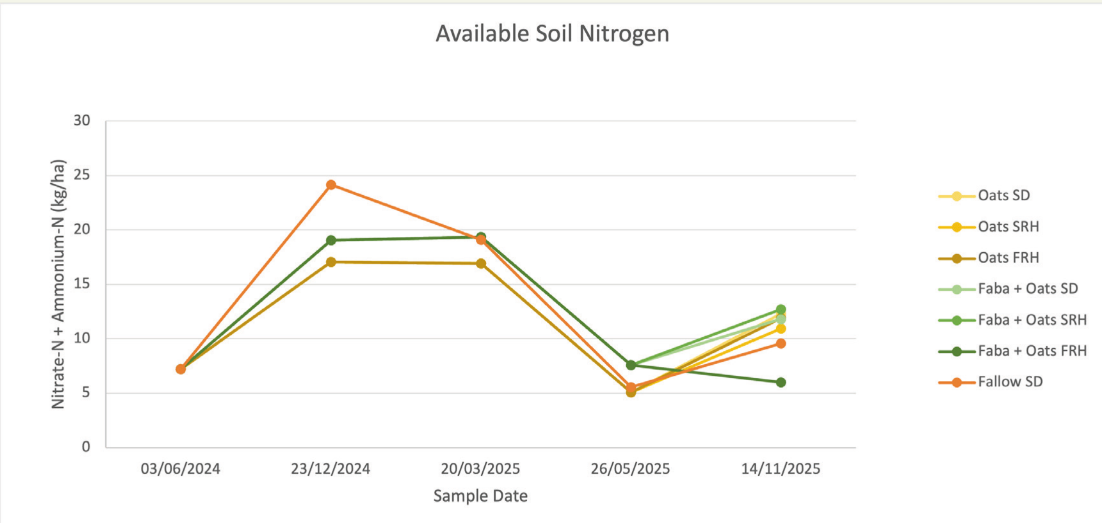



**Figure 19:** Soil available nitrogen (ammonium and nitrate kg/ha)

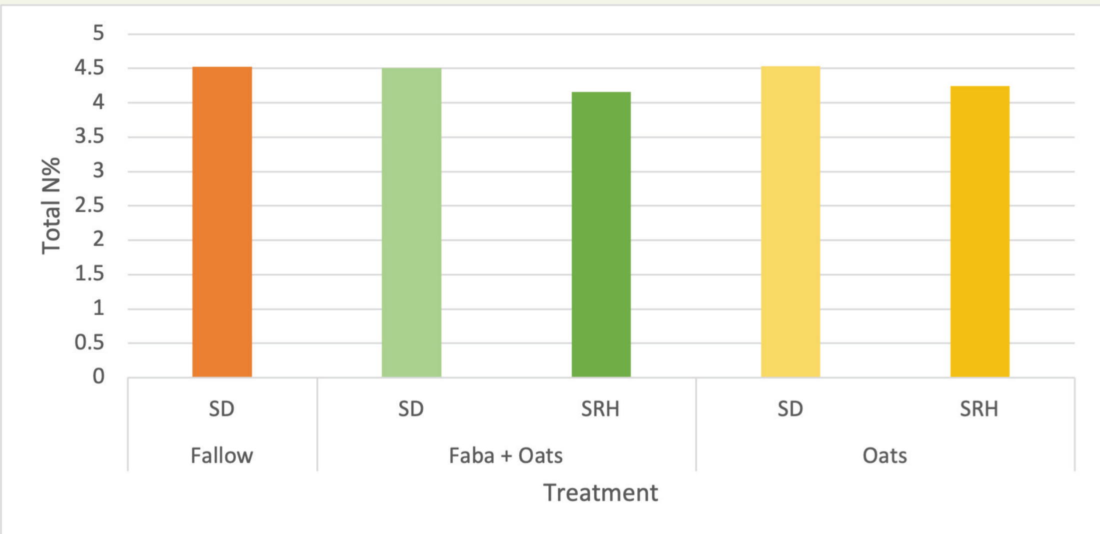



**Figure 20:** Cabbage total nitrogen % collected at cupping growth stage in Sept 2025

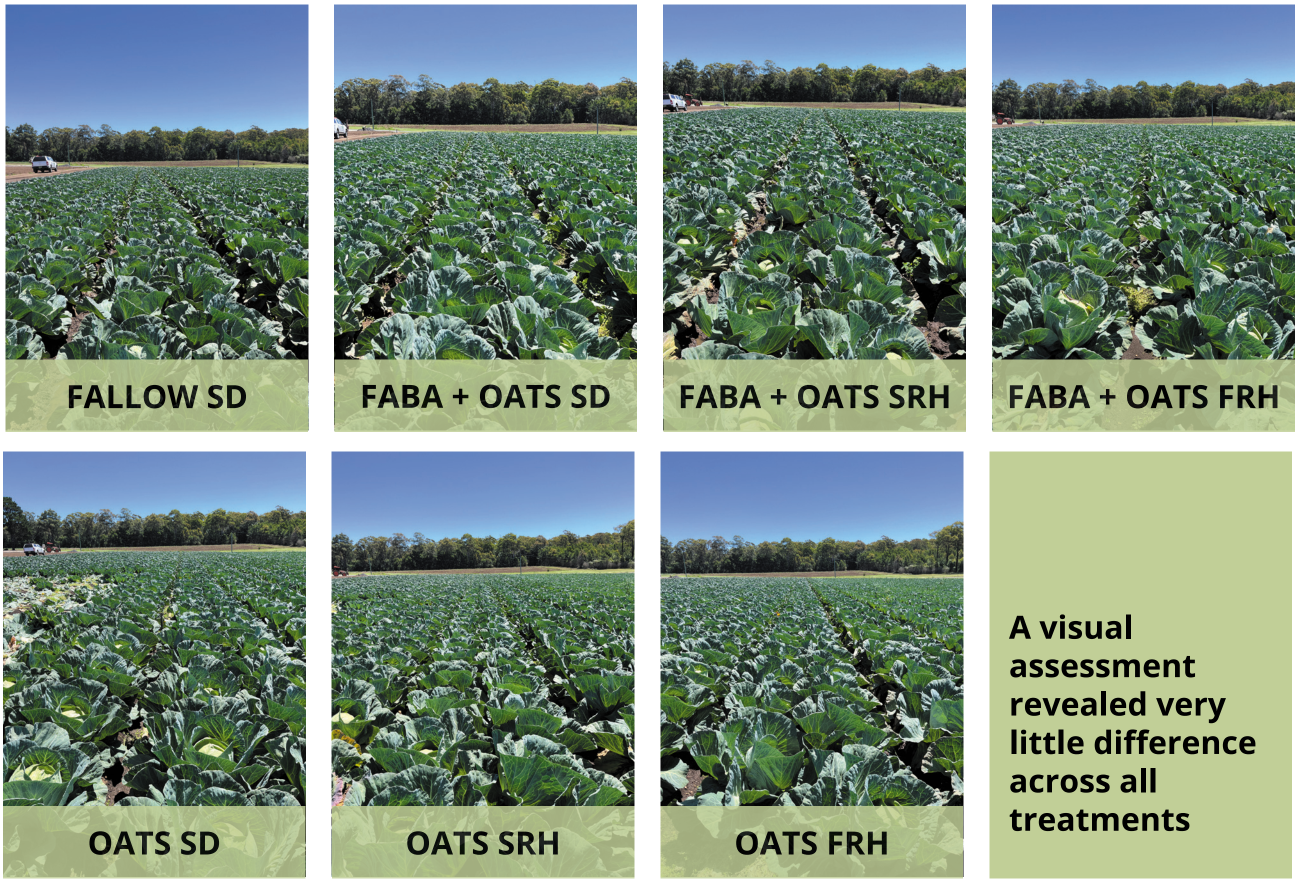



**Figure 21:** Cabbage crop treatments at harvest - Nov 2025

Soil available nitrogen was initially very low prior to cover crop establishment, measuring just 7 kg N/ha (Figure 19). These low nitrogen conditions are ideal for encouraging legumes to actively fix atmospheric nitrogen rather than relying on soil reserves. Although soil nitrogen was not measured during cover crop growth (Aug–Nov 2024), it is likely that the growing cover crops took up much of the available soil nitrogen and stored it within plant biomass and residues.

Following cover crop termination, soil available nitrogen increased across all treatments, peaking in December 2024 at around 17–24 kg N/ha. This suggests that some nitrogen was being released from decomposing cover crop residues shortly after termination. A similar increase in the fallow treatment indicates that nitrogen was also likely released from soil organic matter through mineralisation of soil organic matter and decomposition of weed residues following herbicide application.

However, this increase in available nitrogen was relatively short-lived. Over the following six months, as residues remained on the soil surface, much of the released nitrogen was likely tied up in microbial biomass, incorporated into soil organic matter, or lost through leaching and volatilisation. By May 2025, prior to cabbage planting, soil available nitrogen had declined back to very low levels of just 5–7.5 kg N/ha across all treatments.

This indicates that little immediately plant-available nitrogen remained for the cabbage crop despite the substantial nitrogen initially stored in the cover crop biomass.

Following cabbage harvest, residual soil nitrogen levels remained low at 6–13 kg N/ha across treatments.

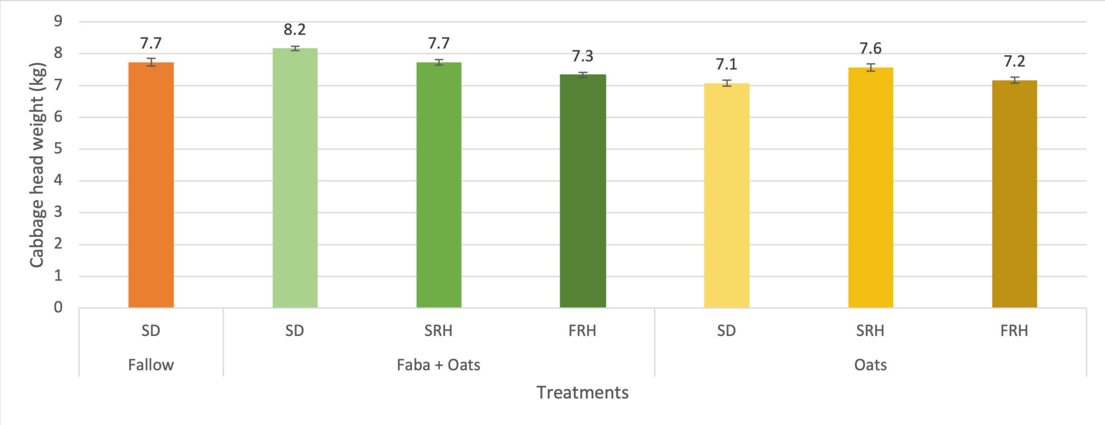



**Figure 22:** Cabbage head weights, harvested Nov 2025

## Cabbage crop insights

### Tissue tests

The crop performed exceptionally well across the treatment areas, with minor to very subtle differences observed visually.

The tissue tests collected at cabbage cupping growth stage indicated crop nitrogen levels within the adequate range across all treatments, with a slightly lower total nitrogen percentage in the cabbages planted into 'strip rotary hoe'd' bed preparation treatments, compared to those prepared with a speed disc (Figure 21).

### Cabbage yield

Cabbage yield was relatively consistent across all treatments, with only modest differences observed between systems. The highest average head weights were recorded in the faba and oat cover crop combined with speed disc bed preparation, producing heads averaging around 8.2 kg (Figure 22).

The mixed faba and oat system overall also produced slightly heavier heads (7.7 kg on average) than the straight oat cover crop treatment, which averaged approximately 7.3 kg per head.

While the faba-based systems produced larger cabbages, in this situation these yield differences did not necessarily translate into improved profitability. Head cabbage into the central markets is typically sold within set weight categories, where heads greater than 7 kg does not attract a higher market price. However, as the improvements in cabbage head weights in some treatment areas resulted in quicker growth to the desired size, this could have allowed for earlier harvest and potentially reduced growing costs (e.g. irrigation, monitoring).

**Overall, the results suggest that while cover crops captured and cycled significant amounts of nitrogen, much of this nitrogen was either released gradually over time, stabilised within the soil system, or lost before the subsequent cash crop could fully utilise it.**

# Economics

## Cover crops

The use of cover crops, particularly when combined with roller crimping as a termination method, reduced herbicide use on Phil's farm by approximately 50%. This was largely due to improved weed suppression from dense cover crop growth, along with reduced tillage limiting soil disturbance and weed seed germination compared with conventional rotary hoeing.

Comparing system costs side by side, from cheapest:

- The straight oat cover crop was the lowest-cost option at approximately $514/ha.
- The fallow system, which relied on herbicides for weed control, cost around $588/ha
- The mixed faba bean and oat cover crop had the highest upfront cost at $772/ha due to additional seed and inoculant inputs. When including added fixed nitrogen contribution from the legume component (~$70/ha value), the effective cost reduced to approximately $702/ha.

**BO BOX PHIL'S VIDEO**

**The results highlight that maximising individual cabbage size is not always the most profitable outcome, but when timed appropriately can result in improved return and reduced costs. Instead, the greatest value comes from improving overall production efficiency, such as increasing the number of marketable heads per hectare or reducing operational costs.**

**In this trial, reduced tillage approaches such as the speed disc offered clear advantages by lowering labour, fuel use, machinery wear, and physical strain, while still maintaining comparable crop performance.**

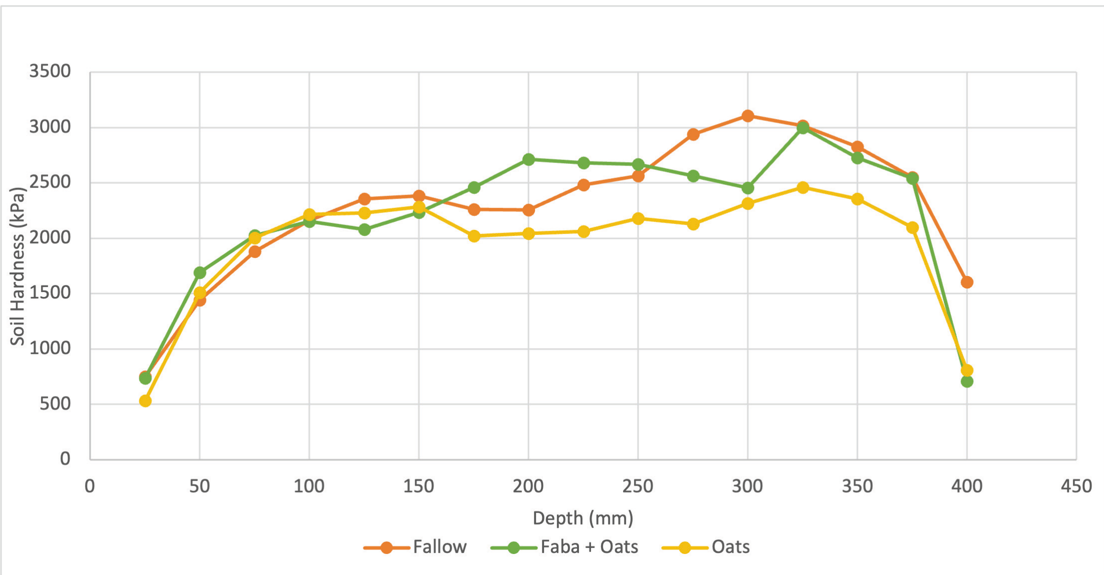



**Figure 23**: Soil hardness across different cover crop treatments in Dec 2024, 1 month after termination

A potential option to reduce cover crop costs, is to consider reducing the seeding rate, to find balance between sufficient cover crop density to reduce weed growth and seed costs.

The inclusion of legumes raises the question of value further, as they provide 'free' nitrogen through biological fixation and contribute diversity and other rotational benefits to the system.

## Tillage methods

While cabbage crop health and yields were broadly consistent across all treatments, the most notable gains came from reduced operating costs associated with less intensive tillage. In particular, using a speed disc instead of a conventional rotary hoe delivered clear efficiency benefits, including faster field operations, reduced diesel consumption, and less mechanical wear on the tractor due to the avoidance of powered implements.

From a cost perspective, the different bed preparation methods showed a clear gradient.

- The speed disc was the most economical option at approximately $191/ha
- Followed by the strip rotary hoe at $222/ha
- The full rotary hoe (conventional system) was the most expensive at around $290/ha.

**These results show that cover cropping can actually be more economical than leaving paddocks bare, while also delivering additional benefits such as reduced erosion, increased organic matter, improved soil biology, better water infiltration, and greater overall soil resilience.**

These figures account for the number of passes required, as well as associated labour (time) and fuel inputs for each implement. Overall, the results highlight that less intensive tillage can maintain crop performance while delivering meaningful savings in both time and operational costs.

**Soil hardness** was measured using a penetrometer in December 2024, one month after termination of the cover crop. The results suggested that cover crops, particularly grasses like oats with their fibrous root systems, may help improve soil structure at depth by reducing compaction (Figure 24).

However, a distinct hardpan layer was still present at around 250–350 mm depth, indicating that while cover crops can contribute to improved soil condition, deeper constraints may persist.

Changes in **soil carbon and organic matter** were also observed over the course of the trial. Prior to cover cropping, soil organic matter was 8.3%, with total carbon at 5.4%. Following the cover crop and cabbage phase, both measures increased across treatments. The straight oat area reached 9.1% soil organic matter and 5.8% total carbon, while the faba bean and oat mix performed slightly better, with 9.7% soil organic matter and 6.2% total carbon. These results highlight the positive contribution of cover crops to building soil carbon and improving overall soil health.

**Weed pressure** varied between treatments shortly after cover crop termination. Higher weed presence was observed in the fallow (Figure 24) and mixed faba and oat (Figure 25) areas compared to the straight oat treatment (Figure 26). This is likely due to the dense tillering of oats, which provided greater soil cover and shading, helping to suppress weeds. In contrast, slightly higher levels of available nitrogen in the fallow and mixed treatments may have encouraged weed growth. The dominant weed species observed during this period was pigweed (*Portulaca* spp.).

## Results from other farm activities

### Termination methods and nitrogen dynamics – other learnings and overall next steps for tweaking practices

- As nitrogen levels in both the cover crop residues and soil declined substantially between cover crop termination in December 2024 and cabbage planting in June 2025, Phis is re-thinking his termination strategy to better align nitrogen release with cabbage crop demand.
- Rather than roller crimping and leaving residues on the soil surface for 6–12 months, Phil has since begun experimenting with mulching and incorporating cover crop residues (particularly those including legumes) 4–8 weeks before planting cabbage. The aim is to shorten the gap between residue breakdown and crop establishment, improving nitrogen uptake and reducing potential losses.
- Early attempts highlighted some practical challenges, particularly incorporating large amounts of biomass and root material using a speed disc. In response, Phil refined the process by mulching residues first, allowing partial breakdown before incorporation.
- The next step is to fine-tune the timing between mulching, incorporation, and planting to further improve nitrogen use efficiency. As this becomes better understood within Phil's system, there may also be opportunities to gradually reduce synthetic nitrogen fertiliser inputs to account for nitrogen supplied by the legume cover crops.

**Figure 24:** Trial area Dec 2024, Fallow

**Figure 25:** Trial area Dec 2024, Faba & oats

**Figure 26:** Trial area Dec 2024, Oats

## Further reading

Exploring nitrogen management with cover crops at Oakdale

Optimising nitrogen with cover crops: Oakdale (NSW) demonstration site update

Cover Crops for Australian Vegetable Growers


## ACKNOWLEDGEMENTS

The Soil Wealth ICP team would like to acknowledge Phil Bartolo for his efforts and ongoing support with the demonstration trial, and commitment to continuous improvement.