OPTIMAL SOIL AND WATER MANAGEMENT INCREASES DROUGHT RESILIENCE — FROM THE PLOT TO THE PADDOCK

Drought is an inevitable part of farming in Australia, but outcomes from the *Improved drought resilience through optimal management of soils and available water* project are equipping farmers with a host of additional strategies with which they can prepare for the inevitable.

Numerous small-scale field trials across southern NSW have shown that early sowing of slower-maturing crops, diverse legume rotations and nitrogen banking can all increase profitability and productivity by increasing soil moisture availability and preventing carbon and nutrient loss under drought conditions. But proving these practices are profitable on a paddock scale is key to ensuring grower adoption.

Using on-farm demonstrations, this project has demonstrated how growers can apply the theoretical strategies profitably on a paddock scale, across different soil types, environments and land uses.

Charles Sturt University, under the Southern NSW Drought Resilience Adoption and Innovation Hub, led the project in partnership with Farming Systems Groups Riverine Plains, FarmLink Research, Central West Farming Systems and Southern Growers, in collaboration with CSIRO and the NSW Department of Primary Industries. The collaboration saw management strategies that had been tried and tested by researchers, over six years on four sites, validated on farm with growers and advisors.

The project was supported through funding from the Australian Government's Future Drought Fund Drought Resilient Soils and Landscapes Grants Program and is co-funded by the Grains Research and Development Corporation.

DIVERSE LEGUME (PULSE) ROTATIONS

Incorporating pulse crops into a typical wheat–canola rainfed or irrigated rotation offers long-term benefits for subsequent crops. The primary goals are to manage disease and weeds more effectively and to enhance soil health. Pulse crops fix atmospheric nitrogen, providing an immediate benefit for the current season and potentially storing nitrogen for future crops.

LEGUME ROTATION RELIEVES PRESSURE AS FERTILISER PRICES SOAR

Farmer:	Trevethan family
Location:	Howlong, NSW
Soil type:	Clay loam
Rainfall (annual):	588 mm
Growing season rainfall:	292 mm
Enterprises:	Cropping (wheat, canola, maize), Merino sheep

Management strategy:	Diverse rotations
Treatments	Comparing canola (2023) on failed faba beans and wheat (2022)
Sowing date:	16 May 2023
Sowing rate:	2.5 kg/ha (canola)
Crop species:	Canola
Variety:	NeSeed Eagle Truflex RR
Row spacing:	6.5 inch (16.51 cm)
Equipment:	Disc seeder

AT A GLANCE

- **Deep nitrogen analysis and farmer observations showed incorporating a legume into the cropping rotation provided more nitrogen than a cereal crop for the following season.**
- **Nitrogen application based on deep nitrogen soil testing, nitrogen budgeting and farmer observations, balanced the in-crop nitrogen status of the paddock.**
- **Soil testing for sulphur at the same time as testing for nitrogen is recommended to ensure it does not limit yield.**
- **Soil water analysis prior to sowing canola revealed the wheat stubble stored more water than the faba bean stubble — likely a result from increased ground cover over the summer.**

Despite challenging seasonal conditions and inconclusive yield results, a two-year paddock-scale investigation has given the Trevethan family, Howlong NSW, the confidence to continue incorporating a legume into their cropping rotation.

On the back of escalating fertiliser prices and a desire to reduce nitrogen inputs to the system, it was a 'no brainer' for the Trevethan family to partake in the *Improved drought resilience through optimal management of soils and available water* project.

The Trevethans typically employ a wheat–canola rotation, followed by a maize crop over summer, on their irrigated property between Howlong and Corowa, NSW. They also run a sheep enterprise on their dryland block, about 10 km north of Howlong.

"We're not set on any particular rotation, we're just trying to find what makes us money and to be honest, we are still trying to work out the best rotations to do this," said Tim.

The family saw the project as an opportunity to test a different cropping system and explore the impact of incorporating a legume crop on nitrogen levels and soil water.

"At the end of the day, we want to reduce our nitrogen spend in-crop and lower our cost base," Tim said.

"We also want to understand how much the nitrogen fertiliser input for the following crop might be reduced and whether we can grow high-yielding crops using organic nitrogen instead of applying large amounts of fertiliser."

As outlined in the following case study, deep nitrogen analysis and farmer observations show a legume history can provide more nitrogen than a cereal history for the following crop.

For the Trevethans, replacing wheat with faba beans in their traditional wheat–canola rotation reduced their in-crop nitrogen requirements for the canola phase by 58 kg N/ha. At $700/t and an application cost of $7.50/ha this equates to a saving of $95.70/ha.

WET CONDITIONS HAMPER 2022 RESULTS

During April 2022 the Trevethans sowed half a 104 ha paddock to faba beans and half to wheat, following a previous wheat crop across the entire paddock. Table 1 shows the soil test results for 2022 and 2023.

The extremely wet season saw both crops fail. The paddock was extensively waterlogged and the predicted 6–8 t/ha yield for wheat dropped to 2.5 t/ha, while the faba beans went from a potential 5–7 t/ha crop to yield only 0.98 t/ha.

Although the yield results were disappointing, soil nitrogen levels following the 2022 harvest revealed a total of 233 kg N/ha following the faba beans and 165 kg N/ha following the wheat, with most of the additional nitrogen from the beans being held in the 30–60cm layer of the soil profile (Figure 1). Based on the rule of thumb of 80 kg N to grow 1 t/ha of canola there was the potential to support a 2.1 t/ha canola crop following wheat and a 2.9 t/ha crop following the faba beans.

Table 1 Soil test results from a split paddock of faba beans and wheat (2022) followed by canola (2023), Howlong, NSW.

ROTATION 1: FABA BEANS, CANOLA			
	2022 AMBERLEY FABA BEANS		**2023 CANOLA**
Soil properties	**Pre-sowing**	**Post-harvest**	**Pre-sowing**
Nitrogen (kg N/ha)	122.2	232.7	249.3
Soil moisture (PAW mm)	78.5	17.6	106.6
ROTATION 2: WHEAT, CANOLA			
	2022 COOTA WHEAT		**2023 CANOLA**
Soil properties	**Pre-sowing**	**Post-harvest**	**Pre-sowing**
Nitrogen (kg N/ha)	112.6	164.8	171.1
Soil moisture (PAW mm)	103.4	90.3	157.9

NB. 2023 canola followed wheat in 2022. Paddock was sown to maize after canola harvest in 2023 and no soil sampling was done.

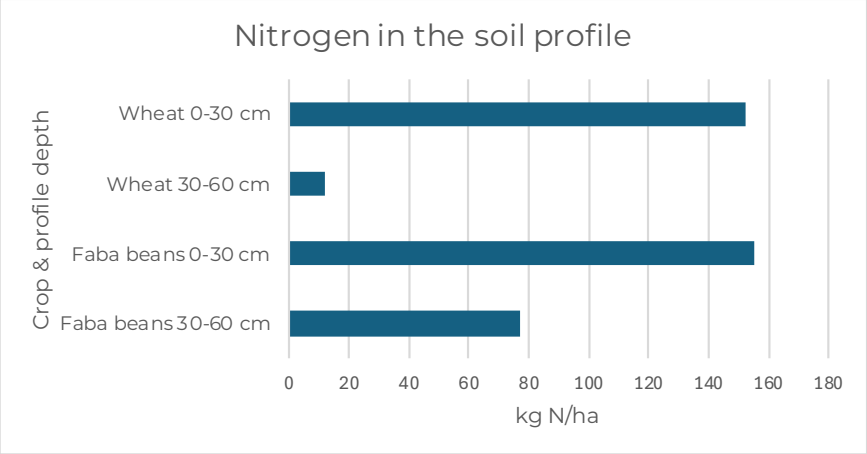

Figure 1 Post-harvest nitrogen (kg N/ha) in the soil profile for a split paddock of wheat and faba beans sown in 2022 at Howlong, NSW (sampled 27 January, 2023).

CASE STUDIES

According to Riverine Plains Project Manager, Kate Coffey, the higher levels of soil nitrogen after the failed faba bean crop were likely a result of unused mineral nitrogen and the breakdown and mineralisation of crop residue.

Soil moisture levels under the faba bean crop fell by 60.9mm from sowing (May 2022) to post-harvest (January 2023). In comparison, the reduction in soil moisture under the wheat crop was only 13.1mm, possibly as a result of more ground cover from the wheat stubble compared with the faba bean stubble, over summer.

Kate indicated the limited plant available soil moisture (PAW) following the faba beans could impact the yield of the 2023 canola crop.

IMPACT OF LEGUMES VERSUS CEREALS ON SUBSEQUENT CANOLA

During May 2023 the Trevethans sowed the entire paddock to Eagle Truflex canola. Deep soil nitrogen and soil water tests were taken before sowing to determine the quantity of nitrogen and moisture available for the canola crop, based on the previous year's crop (Table 1).

Sulphur, soil pH and sodicity were also measured before sowing and plant counts, NDVI imagery and RGB were used to assess nitrogen treatments applied during the growing season.

Including faba beans in the rotation during 2022 reduced the fertiliser inputs for the following canola crop, with the deep soil nitrogen tests showing the faba bean stubble had 78 kg N/ha more nitrogen compared with the wheat residue before sowing the canola.

Based on the soil tests and in-crop observation, the Trevethans applied 58 kg N/ha and 14 kg S/ha across the whole paddock on 25 May 2023 a week after sowing. In July, they applied a further 58 kg N/ha and 14 kg/ha of sulphate of ammonia to the canola sown into the wheat stubble.

"The soil test results showed marginal results, particularly in the 0–60 cm layer, where the sulphur is needed, hence the application of sulphate of ammonia to boost sulphur levels and allow the canola to better utilise the nitrogen," Kate explained.

"To validate the soil test results, a nitrogen-rich strip (72 m wide) was applied on the faba bean half of the paddock, which didn't receive the second nitrogen application."

"Unfortunately, due to a technical issue, the yield data was not able to be analysed and we were unable to determine the impact of the nitrogen-rich strip."

Soil moisture tests showed the wheat stubble stored 51.3 mm more water than the faba bean, which was consistent with previous soil moisture test results.

With a full soil moisture profile, the Trevethans decided to sow the canola shallow — around 10 mm with some slightly shallower — to avoid bogging the sowing equipment and tearing up the paddock.

"The residual trash from the wheat and faba bean crops meant seed placement was probably too shallow and as a result plant numbers and field establishment suffered," Tim said.

"We were aiming for 35–40 plants/m^2, but we ended up with only 19–22 plants/m^2," Tim explained.

"NVDI imagery taken mid-late July showed large variability across the paddock post-sowing. Visual observation of uneven plant establishment and growth, particularly in the centre of the paddock where the centre pivot is located, reinforced the variability," said Kate.

"Throughout the season we also had issues with slugs, especially on the faba bean stubble. We baited post-sowing, pre-emergent with 3 kg/ha of Metarex® and didn't see any slugs for the remainder of the season. A fungicide was also applied mid-July to treat blackleg in the canola."

The paddock received around 430 mm of rainfall (annual) to the end of September. Following a hot, dry September, 50 mm of irrigation was applied during October.

LEGUME ROTATION PROVES ITS WORTH

Although a technical fault meant the yield data for the treatments could not be analysed, a visual assessment showed the best-performing parts were where the canola was grown on faba bean stubble.

Figure 2 shows the NVDI image of the paddock, with canola sown into the wheat stubble on the left (western side of the paddock) and sown into the faba bean stubble on the right (eastern side).

The darker colours on the image show the best-performing parts of the paddock. The NDVI is calculated by comparing the reflectance of near-infrared light (NIR) to red light. Values range from -1 – 1; values closest to 1 indicate healthy, dense vegetation and values closer to -1 indicate minimal or no vegetation.

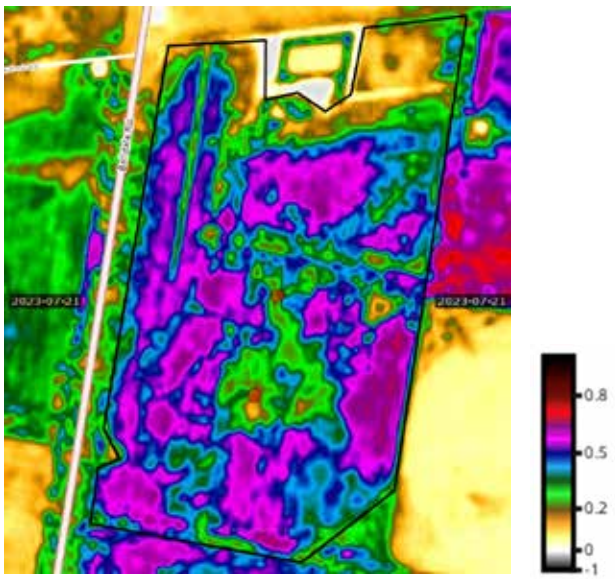

Figure 2 NVDI imagery taken 21 July, 2023 showing canola sown into wheat stubble on the left and canola sown into faba bean stubble on the right

Although the Trevethan's normally direct head their canola, with the paddock being sown to maize over the summer and the urgency to get the crop off, the crop was windrowed and harvested on 19 November. The paddock was split into a dryland section and an irrigated section — the whole paddock yielded an average of 2.4 t/ha. Although the Trevethan's were targeting 4 t/ha with their nitrogen applications, the dryland section yielded about 3.5 t/ha, and it was estimated the irrigated part yielded less than 2.5 t/ha.

"While soil tests and budgets suggest nitrogen was not limiting yield, in the absence of yield map analysis, we are unable to confirm this."

"One possible reason for the yield variability may be windrowing rather than direct heading the canola — generally speaking, the direct headed canola yielded higher than the windrowed canola under the irrigation circle," Tim said.

LEGUMES IN FUTURE ROTATIONS

While the Trevethan's plan to continue including a legume in their cropping rotation, it probably won't be faba beans.

The family has sown faba beans for the past two years, but they have also been growing vetch/clover/ryegrass pastures on their dryland block, where they run their sheep enterprise.

"The biggest disadvantage I see with faba beans is if they fail due to wet conditions or disease, you can't graze them. This is where vetch-based pasture has the upper hand."

"This allows us to graze our pasture base over the winter–spring period before brown manuring in preparation for sowing wheat or canola the following season — a value-add to the grazing operation," he explained.

"The project has 'backed up' what we already knew — we expected the canola on wheat to need more nitrogen than the canola sown into the faba bean stubble and that was the case.

The biggest takeaway from the trial for the Trevethans has been knowing the nitrogen spend is less when there is a legume in the rotation — and this is backed up by the soil data. With high fertiliser prices and availability issues, they have enjoyed not putting out as much urea this year.

"There is a pile of research about incorporating legumes into cropping rotations and the benefits of doing this, but it's good to do the research on your own farm to really understand the results and what they mean to your farming system," Tim emphasised.

This case study was authored by Toni Nugent as part of the *Improved drought resilience through optimal management of soils and available water project.*

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