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 Riverina 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.

MEASURING RESIDUAL NITROGEN AND 'BANKING' IT IN THE SOIL

Nitrogen banking (N-Banking) is a strategy that involves maintaining consistently high soil nitrogen levels regardless of seasonal yield forecasts, thereby reducing the yield gap caused by nitrogen undersupply.

NITROGEN BANKING HELPS BUILD ON-FARM RESILIENCE

Farmer:	Duncan Stewart
Location:	Harden, NSW
Soil type:	Red chromosol
Rainfall (annual):	615mm
Growing season rainfall:	217.4mm (April – October 2023)
Enterprises:	Livestock (cattle and sheep) and cropping (oats, wheat, canola, faba beans)

Management strategy:	Nitrogen banking
Treatments:	Variable rate urea
Sowing date:	Late April
Crop species and variety:	Cootamundra wheat and Blazer TT canola
Row spacing:	8 inch (20cm)
Equipment:	Disc seeder

AT A GLANCE

- Incorporating strategies such as nitrogen banking into farming systems, is helping southern NSW grower, Duncan Stewart, manage seasonal fluctuations and achieve profitability across his business year on year.
- Nitrogen banking not only provides benefits to subsequent crops, but the unused nitrogen also plays a vital role in maintaining soil fertility.
- Nitrogen banked in the soil together with the nitrogen that mineralises during the growing season are the most important sources of nitrogen for the crop.

Recent CSIRO research has busted the myth that nitrogen applied and not used by crops during the season of application is a lost cost. Rather, this unused nitrogen has a vital role in maintaining soil fertility and results show it is taken up by future crops — for at least two years after the initial application.

The research also shows that little (30 – 40%) of a wheat crop's nitrogen requirement is extracted from fertiliser. The nitrogen banked in the soil together with the nitrogen that mineralises from organic nitrogen during crop growth are the most important sources of nitrogen for the crop.

Duncan Stewart and his family run a mixed farming operation on their property at Harden, NSW, with a split of 50 per cent cropping and 50 per cent livestock — Angus cows and Merino sheep. The pasture phase is around seven years followed by a 5 – 6-year cropping phase.

Duncan is capitalising on the results of the CSIRO research by participating in the Improved drought resilience through optimal management of soils and available water project and using nitrogen banking to build resilience in his farming system and it's paying dividends.

"In the past we haven't applied enough nitrogen to some paddocks, and this coupled with the nitrogen removed by the crop, has resulted in us mining the soil rather than farming it," Duncan said. "Now we are farming nitrogen."

With Australia's highly variable seasonal rainfall, trying to match nitrogen fertiliser to yield potential is challenging. The high cost of nitrogen fertiliser is a key determinant in the decision-making process, along with factors such as crops haying-off under high nitrogen applications and terminal drought stress, and nitrogen loss through environmental processes including leaching, denitrification and volatilisation.

"We took a strong interest in nitrogen banking after seeing the results from other research trials, and so working with the FarmLink research team, in 2022, we started to implement the strategy on our own farm, through a combination of nitrogen banking and variable rate nitrogen application."

With high crop yields removing nitrogen from the soil profile, Duncan shifted to variable rate fertiliser applications, zoning his paddocks based on aspect and soil type.

“We’ve been using variable-rate lime applications for a few years and have also started to incorporate variable-rate nitrogen into our management strategies,” Duncan said.

“The tricky part for us, and I suppose for all farmers, is estimating how much rainfall we will get during the season.”

“At sowing we soil test each zone and look at crop removals from the previous year. This information feeds into our nitrogen-banking strategy, allowing us to calculate application rates for the following season.”

“Nitrogen is our biggest input cost, but using the information from climate models and top-dressing most of our urea, gives us the confidence to apply high rates of nitrogen knowing it will be banked in the soil and available for the crop regardless of the amount of rainfall we receive,” Duncan explained.

FarmLink Research Officer, James Holding, agrees that trying to match nitrogen inputs to the season determined yield potential is a major issue for farmers.

“Nitrogen banking removes the stress in making these decisions — it’s simpler and easier,” he explained.

“In this case, we have identified a pre-determined nitrogen amount for each management zone. Each year we will apply urea to reach these pre-determined nitrogen targets, regardless of the weather,” James said.

“In a drier year the unused nitrogen will be ‘banked’ and carry over into the following season. If sufficient rainfall occurs, then we can be confident the crop has sufficient nitrogen to reach its potential,” said Duncan.

“It’s a win-win situation.”

VARIABLE RATE APPLICATION TAILORS NITROGEN BANKING APPROACH TO PRODUCTIVITY ZONES

Using management zones and variable rate nitrogen, Duncan can tailor his urea application to the high-performing and low-performing areas of the paddock. For example, poor productivity areas prone to frost, soil constraints or bad aspect receive less nitrogen than the higher-productivity areas. This strategy has worked well for Duncan, but to further build resilience in his mixed-farming system, he wanted to push nitrogen rates higher across all management zones and implement nitrogen banking.

In 2023, Duncan applied urea at variable rates (251 – 290kg/ha) across the management zones (Figure 1).

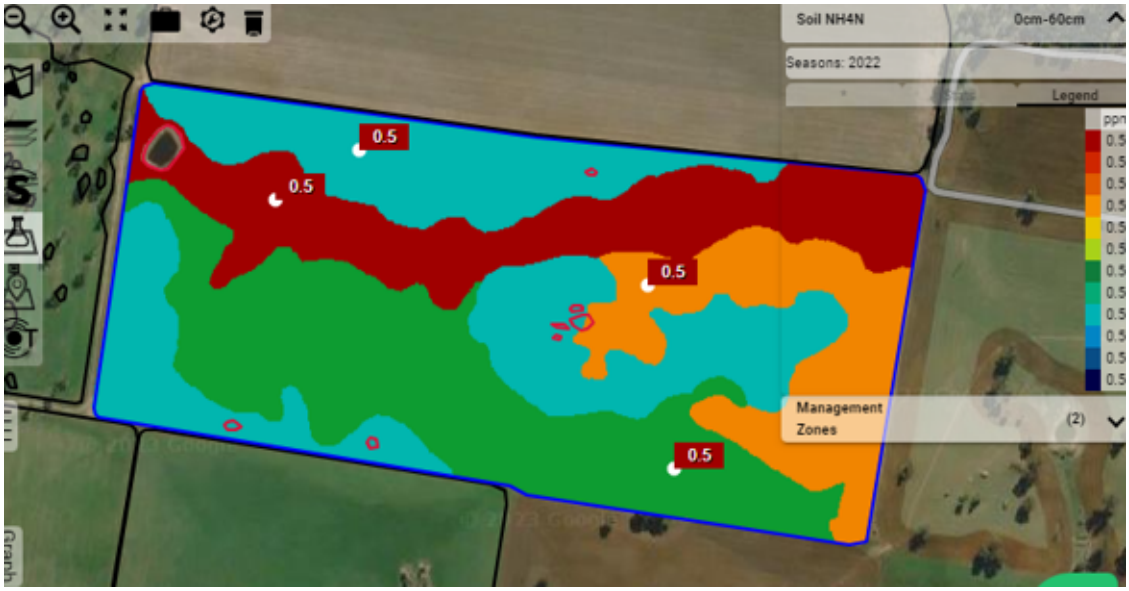

FIGURE 1. MANAGEMENT ZONES BASED ON CROP PRODUCTIVITY POTENTIAL, 2023, HARDEN, NSW.

[#]Note the GPS located data collection points in each zone.

"We're not always sure what the response will be when we apply higher rates of nitrogen, so we are interested to see if our rates are high enough or if we should increase them further across each of our management zones," Duncan said.

The FarmLink team took soil samples before and after the 2023 season to see what the carryover nitrogen was and determine if any nitrogen was being banked at the current application rates (Table 1).

TABLE 1. SOIL TEST RESULTS – 2022 AND 2023, HARDEN, NSW.

Management zones	March 2023 soil N (kgN/ha) 0 – 100cm	Total N application 2023 season	March 2024 total N (kgN/ha) 0 – 100cm
Green	55.3	133.4	180.6
Yellow	82.4	122.4	41.8
Red	62.7	115.5	15.4
Blue	38	115.4	95.3

The results show there was significant variability in nitrogen demand across the paddock. The green zone is low in the landscape and likely frost affected. This may have contributed to lower yields and less demand for nitrogen, hence 180kg/ha N remaining at sowing in the following year.

"It's difficult to match nitrogen supply to crop nitrogen demand across variable paddocks," James said.

"Utilising paddock management zones and robust nitrogen rates is an appropriate strategy as nitrogen rates are more targeted, and unused nitrogen has been shown to largely remain in the soil and be available for the following crop."

Duncan agrees, “It was promising to see that in lower-yielding management zones, high nitrogen rates were banked in the soil and carried through for subsequent crop use.”

Some visual differences were seen throughout the growing season, but the 2023 yield map showed the real story (Figure 2). There was significant yield variability across the paddock, which was largely attributed to frost and moisture stress late in the season. The average yield was 2.34t/ha, but this ranged significantly from less than 1.5t/ha to almost 3t/ha.

“We had issues with frost and a dry finish in our canola during the 2023 season, which severely impacted yield,” Duncan said.

“The oil content of the canola ranged from 45 – 47% which was above average.”

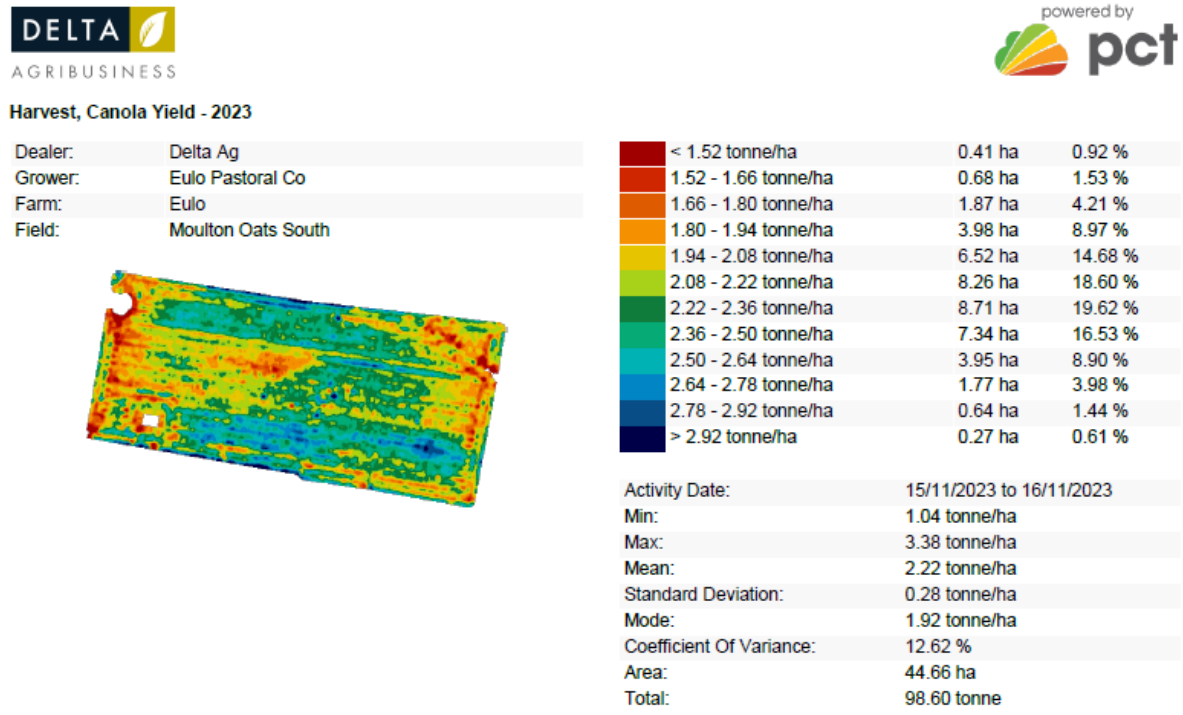

FIGURE 2. YIELD MAP, BLAZER TT CANOLA – 2023, HARDEN, NSW.

MULTI-PRONGED APPROACH YIELDS BENEFITS

Taking the key findings from the CSIRO small-plot research trials and applying them to larger on-farm paddock scale trials is proving profitable for Duncan.

“We’re trying to transition the research from small-plot trials through to a large-scale commercial cropping,” James said.

“And our farming systems research is showing that using robust and higher rates of nitrogen year on year, regardless of the seasonal outlook, is proving profitable across years.”

Moving forward Duncan says he will continue to use robust nitrogen rates.

“Knowing the nitrogen is banked in the soil profile and is available for subsequent crops gives us piece of mind,” Duncan said.

“It removes the uncertainty around the seasonal outlook, and we can go into each season knowing our crops have the best chance of accessing the required nitrogen during the growing season and ultimately translating this into yield productivity.”

Resilience in their farming system is key for the Stewarts. They have made significant changes to their farming operations over the past few years, in order to build resilience.

“In this higher-rainfall area, using a disc system isn’t common, but we believe it will improve the water use efficiency of our soils,” Duncan said.

“For us it’s all about incorporating different strategies into our farming systems that assist us to manage the seasonal fluctuations and achieve profitability across our business year on year.”

“Moving to a multi-pronged approach where we are trying to conserve as much moisture as possible, we can keep our nitrogen at optimal levels where the crop and soil health doesn’t suffer,” Duncan said.

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