

GRDC RiskWi\$e: Nitrogen use efficiency and profitability through optimising rotation and N application strategies

Hosts: Kendenup – Beech Family

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KEY MESSAGES:

- In the first year of the 4-year small plot trial, three nitrogen strategies were applied (decile 5, decile 8, Nil) across three crop rotations (listed below).
- The decile 5 management system was significantly more efficient at converting the applied N to yield across all crop types.
- There was no significant increase in yield of any crop type resulting from the additional N that was applied under the decile 8 strategy compared to the decile 5 strategy.
- Interestingly, the legume crop (lupin) had a higher revenue than any other crop type trialled in year one.

Background

Nitrogen use efficiency is an increasing topic of discussion amongst growers in the high rainfall zone (HRZ) of Western Australia. As there is a significant yield gap in WA HRZ from that achieved in the eastern states HRZ, the question is raised as to why WA growers in our HRZ aren't receiving the same gain in yields for similar applications of nitrogen. It is suspected that the low conversion rate of applied nitrogen to grain yields and grain protein is a direct result of WA's HRZ soil types, which are characterised with high rates of leaching and denitrification. This has likely prompted farmers to be more conservative with nitrogen use.

In 2023, Stirlings to Coast Farmers established a long-term small plot trial (4 years) in Kendenup, to examine the impact of N strategy (appetite for risk) and rotation choice on nitrogen use efficiency. The goal of the small-plot trial is to assess how crop rotation and nitrogen strategies influence profitability, carbon emission efficiency, and nitrogen use efficiency. It is hoped this will boost growers' confidence in their ability to make nitrogen decisions and ultimately enhance grain productivity and sustainability in the HRZ of South-west WA.

Methodology/Treatments

The small plot trial is located north-east of Kendenup and was sown late, on the 16th June (due to late contracting of the project). The experimental treatments consist of three crop rotations; double break (wheat, canola, legume, barley), no legume (wheat, canola, barley, canola), and single break (wheat, canola, barley, legume). The experimental design also includes three nitrogen strategies, (decile 5, decile 8, Nil). As the trial is fully phased, each treatment will be trialled in each year of the project so that a 'bad' or 'good' year impacts the results less.

Results

Given it was year one of the trial, there was no effect of rotation on the trial's first years outcomes. The focus of the 2023 results is on the effects of nitrogen treatment on the different crop types grown. Rotational effects and long-term patterns will be measurable as the experiment progresses in the upcoming seasons.

The date of sowing had a negative impact on the yield performance of canola, barley and wheat within the plot trial. June sowing of canola impacted early growth and

emergence due to waterlogged soils. For the wheat and barley, the effect wasn't as severe, but the late seeding date still affected flowering and grain fill due to an early season cut off in rainfall and warm conditions in the months of October and November. The lupins yielded well.

Harvest Yield

When comparing the yields of each crop type (except for lupins) to the nil N package, each crop type demonstrates that there is a significant N treatment effect for both the decile 5 and decile 8 nitrogen packages (Figure 1). In contrast to the decile 5 method, the extra N applied under the decile 8 strategy did not, however, significantly boost the yield of any crop species. This was to be expected, considering the trial site received rainfall at decile 5. Notably, the Nil treatments produced excellent results. This was likely caused by the crop using existing in-season N from mineralisation and depleting the available soil N. The nil treatment average wheat yield of 2.19t/ha would have required approximately 110kg of N.

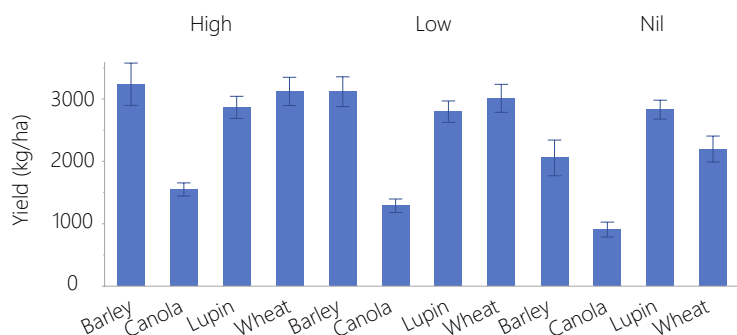


Figure 1. Average yield (t/ha) for each crop type by nitrogen treatment, 2023.

Nitrogen Use Efficiency

Across the trial site, a variety of nitrogen use efficiency (NUE) measurements were recorded, examining important metrics for each crop type under the various N management approaches.

It is typical to think of NUE as a measurement of grain produced by nitrogen applied (Figure 2), which ignores all the nitrogen in the soil that exists prior to application and mineralisation that takes place over the season. The NUE for the low input (decile 5) barley is about 78%, which is quite good (Figure 2). However, this figure is not a true measurement of the NUE for the crop. NUE was significantly less for the higher high N input treatments (decile 8).

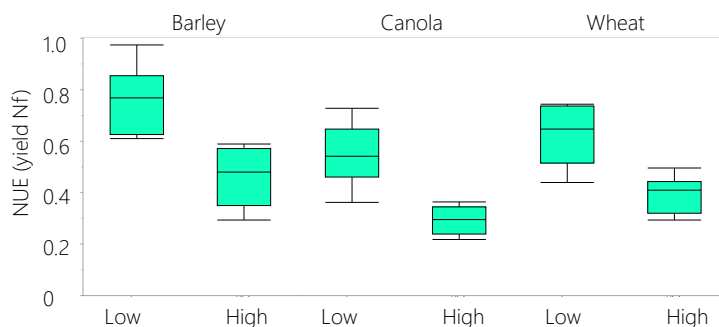


Figure 2. Nutrient use efficiency (grain yield by nitrogen applied) for each crop type under each nitrogen treatment, 2023.

Agronomic efficiency is a more precise measure of nitrogen use efficiency. This measurement shows the grain produced (kg) per unit of nitrogen applied, after the measured soil N prior to sowing has been considered. Crops grown with the decile 5 N management system (low) converted applied N to yield far more efficiently than those in the high input (Decile 8) N strategy (Figure 3).

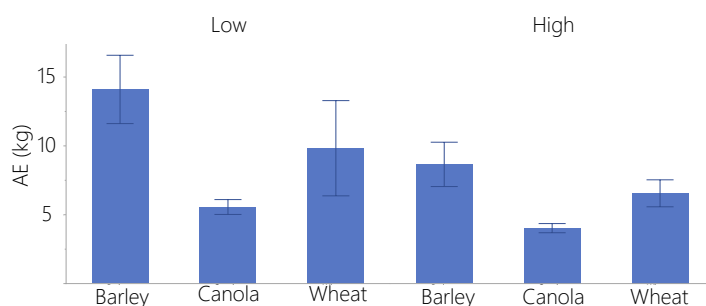


Figure 3. Agronomic efficiency for each crop type under each nitrogen treatment, 2023.

Economic Response

The Economic Response shows profit earned from grain production, per dollar spent on fertiliser. There was reduced profitability across all crop types in the decile 8 N treatments compared to the decile 5 N treatments. (Figure 4). It shows the impact of fertilising a crop with the expectation of a good year, but then only receiving average rainfall.

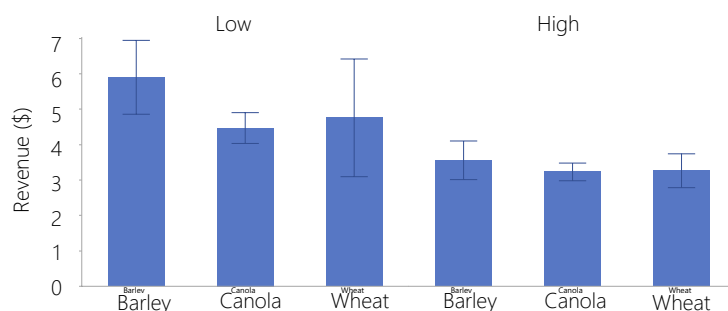


Figure 4. Grain revenue per \$ spent on urea for each crop type across the high and low nitrogen strategies, 2023.

Financial efficiency is calculated as grain revenue minus the cost of urea only. Lupins produced the highest revenue across all three N treatments based on financial efficiency



(Figure 5). The yield of lupins was higher than the 5th decile fertiliser treatment of the other crops, which closely matches the rainfall-limited yield of 2023 (a decile 5 year). This is important because a profitable lupin phase in a rotation is likely to be a key driver of the overall profitability of the rotations that feature a legume crop.

Canola was the only crop type where the high input package generated more revenue than the low input package. This difference is driven by the high commodity price of the canola. Although the canola revenue per dollar spent on urea was higher under the decile 5 N strategy (Figure 4), the marginal increase in yield under decile 8 N strategy coupled with high commodity price for canola, resulted in a higher financial efficiency (Figure 5) even after subtracting the urea spend.

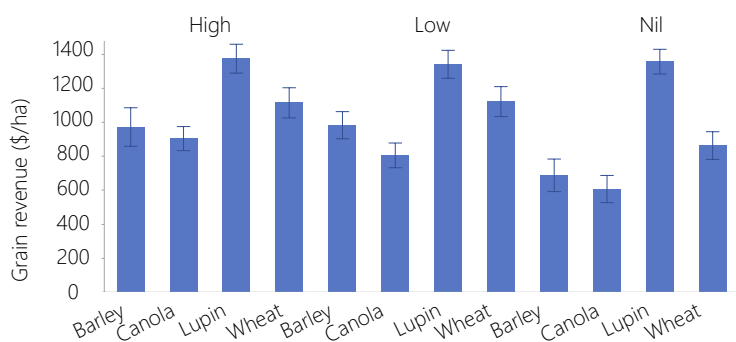


Figure 5. Financial efficiency (grain revenue minus the fertiliser cost only) for each crop type across each nitrogen strategy.

This is important, as canola is often seen as a risky crop in the high rainfall zone of WA due to the volatility in yield, risk of environmental stress and the high cost associated producing the crop. However, this graph shows that the high commodity price of canola can lower the downside risk of over applying fertiliser, as small nutrition driven increases in yield can result in a larger revenue relative to the increased cost in fertiliser spend.

Discussion

The results show that there was no significant increase in yield of any crop type resulting from the additional N that was applied under the decile 8 strategy (high N package) compared to the decile 5 strategy. The decile 5 N strategy

was significantly more efficient at converting the applied N to yield. It should be noted that the site received a decile 5 rainfall year and applying a decile 8 N strategy to specific treatments did not achieve decile 8 yields due to the rainfall restricting yield potential. Nil N treatments yielded quite well as a result of being able to use some of the available N in the soil.

The 2023 trial results clearly show the legume (lupin) treatments having a higher revenue than any other crop type trialled in this first year. This was partly due to a nil fertiliser spend on the lupins but also due to the high yields the lupins achieved in 2023. The revenue generated for the lupins was higher than the decile 5 fertiliser treatment for the other crop types, which closely matched the 2023 rainfall limited yield (2023 was a decile 5 year). This is important, as a profitable lupin phase in the crop rotation will likely be a key driver of the overall profitability of the rotations that feature a legume crop.

In terms of a sustainability standpoint, the emission intensity of decile 8 canola was significantly higher than any other commodity. This is a direct result of the higher inputs needed to produce a relatively low grain yield. Canola will always generate a higher emission rate compared to cereals due to the high inputs needed to achieve maximum yield. Moving forward, it is likely that performance of canola yield relative to the inputs will have a strong influence over the sustainability of each rotation.

The project results give growers confidence that regardless of how the rainfall is received in a decile 5-year (i.e., all at once in June in 2023!), matching fertiliser to this decile would still be a good decision for yield and revenue.

Acknowledgements

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