Carryover of nitrogen after crop failures.

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Key words

Carryover nitrogen, frost, crop failures.

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Key messages

- On average, relying on carryover Nitrogen (N) led to a grain yield penalty of 500 kg/ha and an economic loss of $125/ha. Growers and agronomists should not rely on N applied to crops that get frosted to carryover and deliver a grain yield or economic benefit to the following crop.
- When making fertiliser decisions for 2023 consider soil testing to 60cm. Soil testing in this project found N levels in the 10-30cm and 30-60cm depths are very low (Nitrate <5 mg/kg, Ammonium <1 mg/kg).

Aims

- To determine if N applied to crops that were frosted in 2021 carries over and has a positive grain yield and economic benefit to the 2022 crop.

Introduction

In 2021, favourable growing conditions early in the season led to above average grain yield potential across much of the Geraldton and Kwinana East port zones.

This led to growers applying additional N, in some cases well above budget, to capture the higher grain yield potential. In September 2021, several widespread frosts were recorded across both port zones. At harvest it become clear that the frost had significantly impacted grain yield, many paddocks yielded <500 kg/ha.

This posed a question, will the N applied to crops in 2021 that got frosted carryover and benefit the crop in 2022? This was particularly relevant given the high price of N fertiliser going into the 2022 season.

Research on the carryover effects of N has been studied in eastern Australia. In a droughted wheat crop near Wagga Wagga, Sandral et al (2019) studied the effects of carryover N and concluded that N recovery is low, recovery rates ranged from 1% to 18%. In southern NSW, Hunt et al (2021) explored the concept of an 'N' bank and concluded that unused N carries over and is available to subsequent crops on most soils. Little research on the carryover effects of N after frosted crops has been done under Western Australian farming conditions.

Method

In 2022, 20 growers (10 each from Geraldton and Kwinana East port zones) established 40 farm scale trials (2 trials/farm, 1 paddock=1 trial) to measure the impact of carryover N.

The Laconik Combine™ trial design, which randomly locates a 'swarm' of replicates across the paddock, was used (Image 1). Individual plots were 50m long x 36m wide. The number of replicates per trial was governed by the size of the paddock and ranged from 10 at the Yelbeni trial site, to 28 at the Bonnie Rock trial site. Each grower was provided with a custom trial design that was uploaded to the variable rate controller in the machine, as the machine went across the paddock different rates of N fertiliser were applied.

Each replicate contained four treatments arranged in a square, Treatment 1 – Nil N (green plots in Image 1), Treatment 2 - half grower rate N fertiliser (red plots in Image 1), Treatment 3 – grower rate of N fertiliser (yellow plots in Image 1) and Treatment 4 – twice the grower rate of N fertiliser (pink plots in Image 1). Treatment 1 – Nil N is the treatment against which other treatments have been compared to measure the impact of carryover N from 2021. It was not possible to have a true Nil N treatment because N can be found mixed with other fertilisers. All efforts were made to minimise the amount of N applied in Treatment 1. Trial site details and the amount of N (kg/ha) applied in 2021 and 2022 are shown in Table 1.

Table 1: Rotation and amount of N (kg/ha) applied in 2021 and 2022 for each trial site.

Trial Site	Nungarin		Yelbeni		Bonnie Rock		Wialki	
Year	2021	2022	2021	2022	2021	2022	2021	2022
Rotation	wheat	barley	wheat	wheat	wheat	canola	wheat	wheat
Treatment 1	34	16	51	3	30	23	51	16
Treatment 2	34	22	51	25	30	31	51	23
Treatment 3	34	26	51	47	30	40	51	29
Treatment 4	34	44	51	91	30	57	51	42

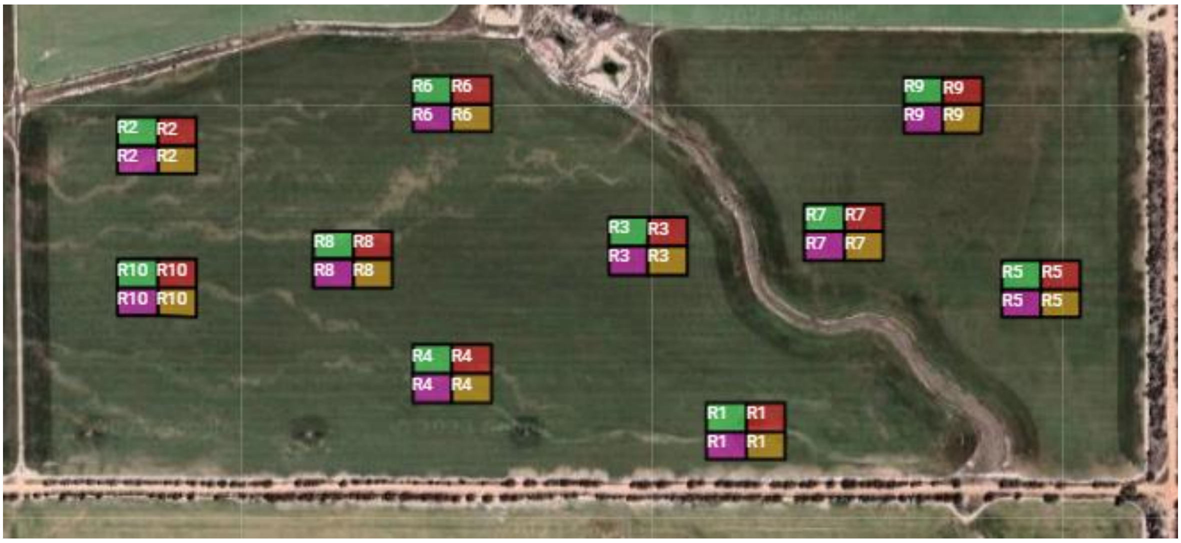

Image 1: Laconik Combine™ trial design at the Yelbeni site in 2022.

This paper summarises the results and draws conclusions based on data from four trial sites where the frost in 2021 reduced grain yield by more than >1t/ha. Readers interested in the results from other trial sites are encouraged to contact the author.

Results

Nitrogen levels in the soil

In March and July 2022 and January 2023, soil samples were collected from each site at intervals of 0-10cm, 10-30cm, and 30-60cm. Samples were tested for Nitrate and Ammonium, results are presented in Table 2.

Only Nungarin at 0-10cm, in March 2022, was the nitrate level within the desired range (10-50 mg/kg). At every other site, at every other depth, and at every timing, nitrate levels were <10 mg/kg. Similarly, only Nungarin (0-10 cm, March 2022 and January 2023) and Bonnie Rock (0-10 and 10-30cm, March and July 2022) had ammonium levels within the desired range (2-10 mg/kg). All other sites, depths, and timings had ammonium levels below the desired range.

These results show that the soils at these trial sites were N deficient prior to the growing season, early in the growing season, and after the growing season.

Table 2: Soil test results for N (mg/kg) at the four trial sites.

	Nungarin			Yelbeni			Bonnie Rock			Wialki[a]	
	Mar 22	July 22	Jan 23	Mar 22	July 22	Jan 23	Mar 22	July 22	Jan 23	July 22	Jan 23
0-10 cm											
Nitrate	10	1.8	6.7	4.2	5.7	2.7	8.9	7.2	3	3.9	3
Ammonium N	5.6	1.3	2.3	<1	<1	<1	1.4	2.9	1.9	1	1.9
10-30 cm											
Nitrate	2.9	1.2	2	2.1	5.3	1.8	3.9	4	1.4	1.3	1.4
Ammonium N	<1	<1	<1	<1	<1	<1	<1	2.6	1	1.2	1
30-60 cm											
Nitrate	1.7	1	1.1	1	3.1	1.5	3.1	3.7	1.6	1.7	1.6
Ammonium N	<1	<1	<1	<1	<1	<1	<1	1.5	<1	1	<1

[a]Soil samples were not taken from the Wialki trial location in March 22. The trial was originally planned to go out at another location, however, due to seasonal conditions this trial was relocated.

Grain Yield and Economics

At all sites, Treatment 1 recorded grain yield significantly (P=<0.1) lower than all other treatments (Table 3). In wheat at Yelbeni grain yields ranged from 2.88 t/ha in Treatment 1 to 4.37 t/ha in Treatment 4. In canola at Bonnie Rock yields ranged from 0.91 t/ha in Treatment 1 to 1.10 t/ha in Treatment 4. At Yelbeni there was a $261/ha difference between Treatment 1 and Treatment 3. Similarly, at Bonnie Rock, there was a $52/ha difference between Treatment 1 and Treatment 3.

The results show that to maximise grain yield and economic returns in 2022 crops needed N. Relying on N to carryover from 2021 was not sufficient to meet crop demands.

Table 3: Grain yield (t/ha) and economic ($/ha) responses to N at the four trial sites.

	Nungarin		Yelbeni		Bonnie Rock		Wialki	
	t/ha	$/ha	t/ha	$/ha	t/ha	$/ha	t/ha	$/ha
Treatment 1	1.07 d	$283	2.88 d	$1,014	0.91 d	$ 575	3.05 c	$1,040
Treatment 2	1.34 c	$349	3.38 c	$1,127	0.97 c	$ 595	3.09 b	$1,035
Treatment 3	1.81 b	$482	3.95 b	$1,275	1.05 b	$ 627	3.12 a	$1,029
Treatment 4	2.23 a	$561	4.37 a	$1,306	1.10 a	$ 616	3.13 a	$998
LSD	0.02		0.03		0.01		0.02	

Grain yields followed by the same letter do not significantly differ, P=<0.1. Economics = Grain yield * Grain Price (wheat $355/t, canola $700/t, barley $305/t) – (N rate * $2.7/unit N).

Conclusion

This project was established to determine the grain yield and economic benefits of carryover N after frosted crops. The results show that on average for cereals there was a 620 kg/ha yield penalty and $150/ha economic loss between Treatment 1 (Nil N) and Treatment 3 (Grower Practice N). Similarly, the yield loss for canola was 140 kg/ha and $52/ha economic loss.

To maximise grain yield and economic returns in 2022 crops needed N, relying on N to carryover from 2021 was insufficient to meet crop demands. Growers and agronomists should not rely on N after frosted crops to carryover and deliver a grain yield or economic benefit to the following crop.

There is a theory within the industry that N applied to crops that get frosted is stored in the soil, the soil test results from this project do not support this theory. Soil N is well below desired levels across all depths sampled. Growers and agronomists should be aware of this when making fertiliser decisions for 2023.

The conclusions of this project need to be considered in the context that they have been determined based on one year of field trials conducted in 2022. Many growers who hosted the trials experienced very favourable seasonal conditions and recorded grain yields well above their five-year average. The magnitude of the responses recorded in the project may not be as big in a more normal year.

References

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