NORTHERN NSW RESEARCH RESULTS 2024

Effect of fungicide combination and timing on management of net form net blotch barley – Grafton 2024

Sam Blanch[1], Natalie Moore[1], Ashley Moss[1], Nathan Collins[1] and Kefei Chen[2]

[1] NSW Department of Primary Industries and Regional Development (DPIRD), Grafton, NSW

[2] Curtin University, Analytics for the Australian Grains Industry (AAGI), WA

Key findings

- 2024 was a high disease pressure season with the greatest individual return on investment from using varieties with improved genetic resistance against net form net blotch (NFNB), i.e. varieties Rosalind⦶ (rated moderately resistant (MR)) and Combat⦶ (rated moderately resistant-moderately susceptible (MRMS)).
- Of the 6 fungicide treatments incorporating 2 mode of action (MOA) groups (3 and 7), 2 application timings (Zadok's growth stage 33 and 39) and 4 varieties, the highest yielding treatment was the variety Rosalind⦶ (4.05 t/ha) with the fungicide Aviator® Xpro® (prothioconazole 150 g/L and bixafen 75 g/L) applied at GS33 plus Prosaro® (prothioconazole 210 g/L and tebuconazole 210 g/L) applied at GS39.
- Fungicide use can reduce tissue damage in the top 3 leaves by more than 50% in an MRMS or MR variety.
- No fungicide or application timing combination effectively reduced NFNB severity in the susceptible-very susceptible (SVS) rated variety Zena CL⦶.
- In a high disease risk situation, such as planting into NFNB-infested stubble in a season with conditions conducive to disease development, fungicides alone cannot control NFNB.

Keywords Barley, net form net blotch, NFNB, integrated disease management, IDM, *Pyrenophora teres*, fungicide

Introduction

Net form net blotch (NFNB) disease, caused by the fungus *Pyrenophora teres* f. *teres*, is estimated to be responsible for 18–31% yield loss annually in Australian barley crops. The pathogen survives on infected stubble and is also spread in planting seed retained from infected crops.

Disease management decisions are complicated by several factors including fungicide mode of action (MOA), application timing, cost/ha, seasonal conditions, predicted yield and profit, and predicted disease pressure. Furthermore, resistance to some fungicide MOA groups (3 and 7) has been confirmed in Australian NFNB populations. A key strategy to minimise the development of fungicide resistance is to rotate MOA groups and active ingredients within groups, hence the inclusion of common fungicide options in this study.

The research investment ‘Integrated management strategies for NFNB in low, medium, and high rainfall zones’ (GRDC code DAQ2304-008RTX) started in winter 2023 and aims to identify cost-effective, integrated disease management (IDM) strategies for NFNB at field sites across eastern and southern Australia. The project is led by Department of Primary Industries Queensland (DPI QLD) with multiple state partners. The NSW DPIRD field sites are in high (Grafton) and low (Wagga Wagga) rainfall zones.

The combined data from all sites will be analysed by Analysis for the Australian Grains Industry (AAGI) and reported separately by DPI QLD.

This report presents data from the second field experiment at the high rainfall site in northern NSW conducted at NSW DPIRD Grafton in winter 2024.

Site details

Location	NSW DPIRD, Grafton Primary Industries Institute, Trenayr, Grafton, NSW. Latitude 29° 37’ 17.61” S, Longitude 152° 56’ 56.09” E.
Paddock history	• 2023 barley variety (Fathom⁽ᵈ⁾), inoculated with NFNB-infected stubble. • 2022–23 soybean (*Glycine max*).
Soil type/nutrition	• Brown loam over brownish clay. • Table 1 shows the soil chemical analysis at the experiment site.
Temperature and rainfall	A total of 350 mm rain fell during the growing season, 59 mm more than the long-term average (LTA) of 291 mm for the same period (Figure 1). In early June, 20 mm of supplementary overhead irrigation was applied to ensure establishment, making the total in-crop water received 370 mm.
Sowing date	14 May 2024.
Fertiliser	• Sulfate of potash (41.5% K, 17% S) @ 120 kg/ha broadcast 2 weeks pre-sowing. • Diammonium phosphate (DAP; 17.7% N, 20% P) @ 80 kg/ha broadcast at sowing. • Triple super phosphate (45% P, 15% Ca) @ 50 kg/ha banded with seed at sowing. • Urea (46% N) @ 100 kg/ha broadcast at Zadok’s GS20.
Sowing rate and established plant population	• Target population: 150 plants/m^2. • Established population: 125 plants/m^2.
Weed management	• Fallow: glyphosate 600 g/L (Crucial®) @ 2 L/ha. • Post-emergence: fluroxypyr 333 g/L (Starane® Advanced) @ 900 mL/ha.
Insect management	• To control corn aphid (*Rhopalosiphum maidis*): pirimicarb 500 g/kg (Pirimor®) @ 150 g/ha.

Harvest date	Physiological maturity (Zadok's GS93) was reached between 1 and 8 October 2024. Harvest: 8 October 2024, 147 days after sowing (DAS).

Table 1 Soil chemical analysis Paddock 19A, NSW DPIRD Grafton 2024 (Environmental Analysis Laboratory).

Characteristic/analyte	Unit	Soil depth (cm)			
		0–10	10–30	30–60	60–90
pH (1:5 water)	pH units	6.8	6.4	6.1	6.3
pH ($CaCl_2$)	pH units	6.3	5.9	5.7	5.9
Electrical conductivity (1:5 water)	dS/m	0.08	0.07	0.08	0.7
Aluminium (Al) base saturation	%	0.4	0.3	0.4	0.4
Boron (B) 12C2 hot $CaCl_2$	mg/kg	0.3	0.4	0.5	0.6
Carbon (C) total	%	1.7	1.5	0.8	0.5
Carbon:nitrogen	ratio	11	11	9.6	7.3
Organic matter estimated	%	2.9	2.6	1.4	0.8
Chloride estimate	mg/kg	51	45	49	44
Copper (Cu) DTPA	mg/kg	0.96	0.98	0.32	0.10
Iron (Fe) DTPA	mg/kg	38	36	15	6
Magnesium (Mg) Morgan 1	%	14	17	18	19
Manganese (Mn) DTPA	mg/kg	77	93	34	12
Nitrogen (N) ammonium-N KCl extractable	mg/kg	0.8	1	0.5	0.45
Nitrogen (N) nitrate-N KCl extractable	mg/kg	10	9.3	8.7	8.8
Nitrogen (N) total LECO Trumac	%	0.16	0.13	0.09	0.06
Phosphorous (P) Bray 1	mg/kg	21	5.8	2.4	<1
Phosphorus (P) Colwell	mg/kg	62	24	9.8	2.6
Phosphorous buffering index – Collwell adjusted	Index unit	117	100	148	203
Silicon (Si) S11 hot $CaCl_2$	mg/kg	31	35	31	18
Sulfur (S) KCl_40	mg/kg	10	22	46	60
Zinc (Zn) DTPA	mg/kg	1.3	1.0	<0.5	<0.5
Effective cation exchange capacity (ECEC)	cmol(+)/kg	8.7	7.0	6.2	6.5
Exchangeable aluminium (Al)	cmol(+)/kg	0.03	0.02	0.02	0.03
Exchangeable calcium (Ca)	cmol(+)/kg	6.5	5.1	4.6	4.8
Exchangeable magnesium (Mg)	cmol(+)/kg	1.2	1.2	1.1	1.2
Exchangeable potassium (K)	cmol(+)/kg	0.95	0.66	0.40	0.43
Exchangeable sodium (Na)	cmol(+)/kg	<0.0065	<0.0065	<0.0065	<0.0065
Calcium:magnesium	ratio	5.4	4.3	4.1	3.9
Soil basic texture	–	Loam	Loam	Clay	Clay
Soil basic colour	–	Brownish	Brownish	Brownish	Brownish

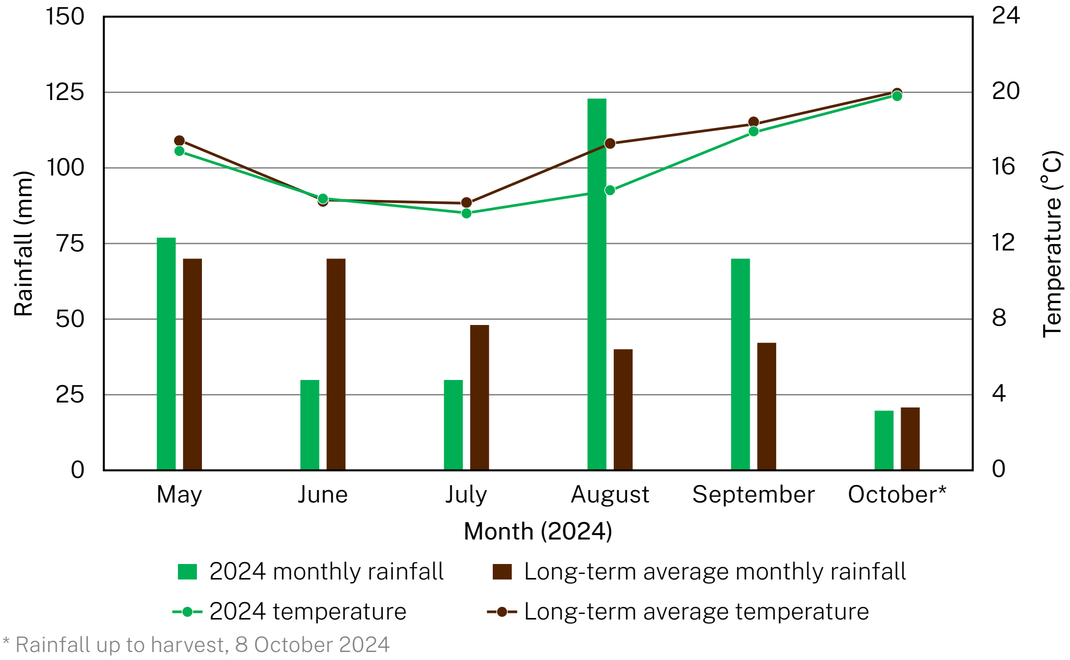

Figure 1 Temperature and rainfall for the 2024 growing season compared with long-term averages at Grafton Primary Industries Institute, NSW.

Treatments and trial details

Net form net blotch management treatments

The fungicides used are listed in Table 2 with the fungicide group and MOA.

Management for other barley diseases was not required this season.

Varieties

Four varieties were selected based on NFNB resistance ratings published in the GRDC NVT online for Queensland (GRDC 2024) and similar maturity in this region:

1. Zena CL⌽ (susceptible-very susceptible, SVS)
2. Fathom⌽ (moderately susceptible, MS)
3. Combat⌽ (moderately resistant-moderately susceptible, MRMS)
4. Rosalind⌽ (moderately resistant, MR).

The treatment combinations and the product cost per hectare are shown in Table 3. As application costs vary widely across farming systems, they have not been included.

The Zadok's GS scale was used to determine fungicide application timing as each variety reached GS33 and/or GS39.

Table 2 Fungicide groups and their modes of action (MOA).

Fungicide active ingredient	Example trade name combining active ingredients	Fungicide group	Fungicide MOA
Fluxapyroxad	Systiva® seed treatment	7 (pyrazole carboxamide)	Succinate dehydrogenase inhibitors (SDHI), respiration
Prothioconazole	Aviator® Xpro®	3 (triazole)	De-methylation inhibitors (DMI), sterol biosynthesis (SBI)
Bixafen	Aviator® Xpro®	7 (pyrazole carboxamide)	Succinate dehydrogenase inhibitors (SDHI), respiration
Prothioconazole and tebuconazole	Prosaro® 420 SC	3 (triazole)	De-methylation inhibitors (DMI), sterol biosynthesis (SBI)

Table 3 Fungicide treatments and cost per hectare for net form net blotch experiment, NSW DPIRD, Grafton 2024.

Fungicide treatment			
Number	**Code**	**Description***	**Product cost ($/ha)****
1	Control (nil)	Nil	0
2	SYS	Fluxapyroxad 333 g/L (Systiva®) seed treatment only	41
3	SYS+PSR@GS33	Fluxapyroxad 333 g/L (Systiva®) seed treatment + prothioconazole 210 g/L and tebuconazole 210 g/L (Prosaro® 420 SC) applied at GS33	68
4	SYS+AVX@GS33	Fluxapyroxad 333 g/L (Systiva®) seed treatment + prothioconazole 150 g/L and bixafen 75 g/L (Aviator® Xpro®) applied at GS33	101
5	AVX@GS33+PSR@GS39	Prothioconazole 150 g/L and bixafen 75 g/L (Aviator® Xpro®) applied at GS33 + prothioconazole 210 g/L and tebuconazole 210 g/L (Prosaro® 420 SC) applied at GS39	87
6	PSR@GS33+AVX@GS39	Prothioconazole 210 g/L and tebuconazole 210 g/L (Prosaro® 420 SC) applied at GS33 + prothioconazole 150 g/L and bixafen 75 g/L (Aviator® Xpro®) applied at GS39	87

* Product, active ingredient and crop growth stage at application. Products applied at label recommended rate.

** Cost of treatment ($/ha) based on the 2024 market price of fungicides applied at the recommended rate.

Experimental design

Randomised, split-plot design with fungicide treatment as the main plot (6 levels) and variety as the sub-plot (4 levels) with 4 field replicates.

Statistical analysis methods

Linear mixed models were fitted with ASReml-R version 4.2.0 (Butler et al. 2023) in the analyses of grain yield, where the variance parameters in the mixed models were estimated using the residual maximum likelihood (Reml) procedure of Patterson and Thompson (1971).

For each trait, spatial variations were examined, including local auto-correlations, global trends and extraneous variations. The blocking structures of the experiments were fitted as random effects. Spatial trends and residual variances with auto-regressive correlation at first order for rows and columns were examined and fitted when the global trends and auto-correlations were significant. Likelihood ratio tests were used for random effects, and conditional Wald tests (Kenward and Roger 1997) were used for fixed effects including variety, fungicide application and their interactions.

Residual diagnostics were performed to examine the validity of the model assumption of normality and homogeneity of variance. The empirical best linear unbiased estimations (eBLUEs) of fixed effects were produced from respective fitted models. The R package ASRemlPlus (Brien 2020) was used to compute the least significant difference (LSD with $\alpha = 0.05$) values for multiple comparisons.

Results

Crop establishment

All varieties and plots established evenly across the site with a plant population of 125 plants/m^2 (Figure 2). Weed competition was low during the season with management very effective.

Figure 2 The net form net blotch barley experiment on 28 June, 45 days after sowing.

Disease development and severity assessment

The experiment was sown into NFNB-infected stubble from a barley crop in 2023. Two additional inoculations were applied by sprinkling 150 g of dry NFNB infected stubble per 20 m into the middle 2 rows of the buffers on 10 June and 10 July.

Weather conditions were conducive to disease development throughout the season and overall disease pressure at this site was high. The disease developed earlier and more severely than in the similarly designed 2023 experiment (Blanch et al. 2024).

Symptoms of NFNB were initially observed in the Zena CL⁽ᴾ⁾ buffers and untreated control plots on 20 June, 37 DAS when the crop was at GS29 (Figure 3).

Figure 3 Net form net blotch leaf symptoms developing on susceptible-very susceptible variety Zena CL⁽ᴾ⁾, NSW DPIRD Grafton. Symptoms were observed 37 days after sowing.

Isolations of *Pyrenophora teres* f. *teres* were made from leaf lesions, and the pathotypes were confirmed by Dr Lisle Snyman and Dr Xuechen Zhang (DPI QLD) as NB73 and NB350. These pathotypes are frequently recorded in barley crops in the northern grains region, with NB73 becoming dominant since the widespread use of the NFNB-susceptible variety RGT Planet⁽ᴾ⁾ (Dr X Zhang, pers. comm.). This pathogen readily develops new pathotypes to overcome host variety resistance.

Leaf, grain and stubble samples from this experiment were provided to Dr Anke Martin and Dr Buddhika Amarasinghe Dahanayaka, University of Southern Queensland, for molecular marker analysis to assess population structure over time (results reported separately).

Disease severity was rated using 2 methods.

Disease rating method 1

The first method was used on all sites in the project this season. It expresses the combined percentage of damaged leaf tissue of each of the top 3 leaf layers (i.e. flag leaf, flag-1, and flag-2) at Zadok's GS69 (Table 4).

Table 4 The combined percentage of net form net blotch damaged leaf tissue of the top 3 leaf layers (flag, flag-1, flag-2) at GS69 for 4 barley varieties with different resistance ratings to net form net blotch, treated with different fungicide combinations and application timing.

Fungicide treatment		Disease severity of top 3 leaf layers combined at GS69 (% damaged leaf area)			
Number	Code	Zena CL (SVS)*	Fathom (MS)	Combat (MRMS)	Rosalind (MR)
1	Control (nil)	74.2	65.0	55.0	74.2
2	SYS	73.3	41.7	24.6	44.2
3	SYS+PSR@GS33	70.8	52.1	29.3	38.8
4	SYS+AVX@GS33	70.0	40.0	26.0	29.6
5	AVX@GS33+PSR@GS39	74.2	37.5	27.4	29.6
6	PSR@GS33+AVX@GS39	67.5	31.3	18.8	24.2
	LSD with α = 0.05	8.65	11.17	9.09	14.62

* Barley variety resistance rating to NFNB, National Variety Trial online ratings for Queensland, GRDC, 2024.

Fungicide treatments applied to variety Zena CL⁽ᵈ⁾ did not reduce the severity of disease symptoms in the top 3 leaf layers at GS69 compared with the untreated control (Table 4).

The greatest reduction in NFNB-damaged leaf tissue at GS69 was in variety Rosalind⁽ᵈ⁾ with treatment 6. This reduced the combined percentage of leaf tissue in the top 3 leaf layers by more than 50% (from 74.2% in the untreated control to 24.2% in treatment 6; Table 4). Treatment 6 also reduced leaf tissue damage of varieties Fathom⁽ᵈ⁾ by 33.7% and Combat⁽ᵈ⁾ by 36.2% compared with the untreated controls.

Disease rating method 2

Disease severity at GS69 was also assessed using a second method. This method is based on the National Variety Trial (NVT) winter crop pathology scoring system that combines the severity of disease symptom expression on the leaf and the advancement of diseased leaves up the plant. The system is scored from 1–9, with 1 being no visible symptoms and 9 being severe symptoms combined with the height of symptom progression in the crop. This score is included with yield data and return of investment (ROI) in Table 5.

Yield and economic return on investment for fungicide treatments

Analysed yield data are presented graphically in Figures 4a, b and c.

In the yield comparison of the fungicide treatments within each variety and between the varieties (Figure 4a; LSD 0.472 t/ha with α = 0.05), the yield of the SVS rated variety Zena CL⁽ᵈ⁾ was not significantly increased by any of the fungicide treatments. Conversely, the more resistant MR rated variety Rosalind⁽ᵈ⁾ produced significantly higher yield with all the fungicide treatments compared to the untreated control.

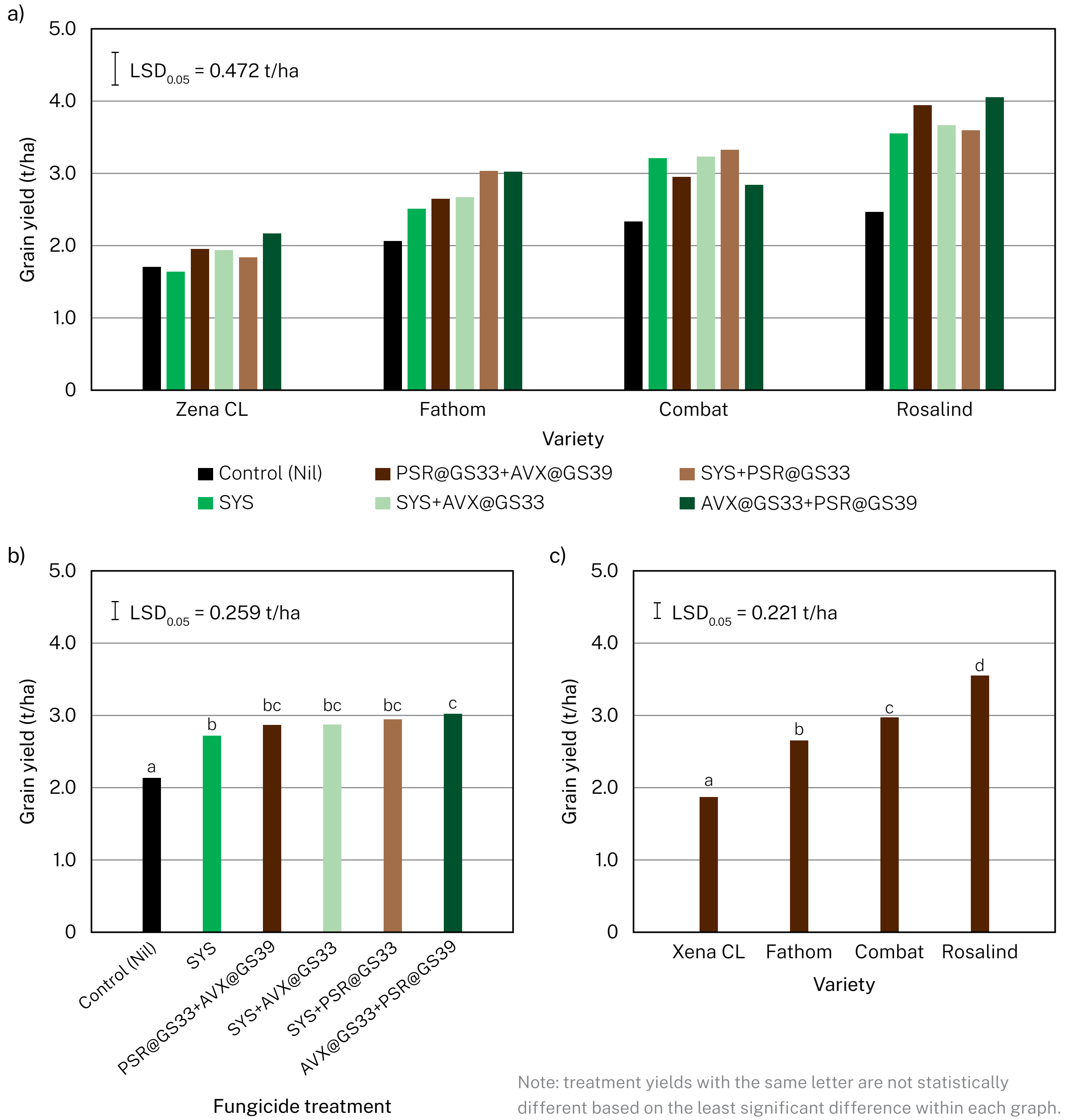

Figure 4 a) Grain yield for 4 barley varieties with different resistance ratings to net form net blotch: Zena CL⏀ (SVS), Fathom⏀ (MS), Combat⏀ (MRMS) and Rosalind⏀ (MR), with fungicide and application timing combinations. Treatment details in Table 3. b) Comparison of fungicide treatments with aggregated yield of all varieties in the experiment compared to the untreated control. c) Comparison of varieties with the aggregated yield of all fungicide treatments.

Another way to look at the yield data is provided in Figures 4b and 4c. The yield data for all varieties are aggregated for each fungicide treatment (Figure 4b) and the yield data for all treatments are aggregated for each variety (Figure 4c) with the respective LSD values for each analysis as shown.

Aggregating yields for each fungicide treatment (Figure 4b) shows that all treatments produced significantly higher yields than the untreated control. Of the in-crop foliar fungicide treatments, treatment 6 (PSR@GS33+AVX@GS39) produced the significantly highest aggregated yield.

The aggregated yield of all treatments for the 2 varieties with the lowest NFNB resistance rating (SVS, Zena CL$^{\phi}$ and MS, Fathom$^{\phi}$), was significantly lower than the aggregated yields for the 2 varieties with the higher NFNB resistance rating (MRMS, Combat$^{\phi}$ and MR, Rosalind$^{\phi}$; Figure 4c). The aggregated yield of each variety was almost doubled between the lowest rated fungicide treated variety (Zena CL$^{\phi}$, 1.86 t/ha) and the highest rated fungicide treated variety (Rosalind$^{\phi}$, 3.54 t/ha; Figure 4c).

The analysed yield data along with a disease severity score at GS69 and the ROI for each fungicide treatment are presented in Table 5. Note that the data in Table 5 are sorted from the highest to lowest yield.

For the purposes of ROI comparison, actual yield data and assumed barley grade 1 grain quality was used (BAR1, screenings <15%, test weight >62.5 kg/hL or 312.5 g/0.5L), although this quality was not achieved this season (Table 7).

To calculate the ROI, a grain price of $350/t was used as follows:

ROI = (grain price [$350/t] × yield [t/ha]) − (fungicide treatment product cost [$/ha])

The ROI for the MR-rated variety Rosalind$^{\phi}$ ($1,094.95/ha) and MRMS-rated variety Combat$^{\phi}$ ($989.99/ha) was highest with treatment 1 (Systiva® seed dressing), increasing yield by 27% and 22%, respectively, compared to the untreated controls of each of these varieties.

All treatments for SVS-rated variety Zena CL$^{\phi}$ resulted in a negative ROI compared to the nil control. None of the fungicide treatment combinations statistically affected yield compared with the untreated control of this variety (Table 5 and Table 6).

For ease of comparison, the ROI calculations for each fungicide treatment and variety combination are presented in Table 6.

Table 5 Yield ranked from highest to lowest with the disease severity score at GS69 and return on investment (grain value less cost of fungicide; ROI) for each fungicide treatment to manage net form net blotch of barley, NSW DPIRD, Grafton 2024.

Variety	Fungicide treatment code	Disease severity score at GS69 (1–9)[1]	Yield (t/ha at 11% moisture)	Return in investment ($/ha)[2,3]
Rosalind	AVX@GS33+PSR@GS39	6	4.05	1064.13
Rosalind	PSR@GS33+AVX@GS39	5	3.94	1036.00
Rosalind	SYS+AVX@GS33	6	3.66	911.28
Rosalind	SYS+PSR@GS33	7	3.59	1012.69
Rosalind	SYS	7	3.54	1094.95
Combat	SYS+PSR@GS33	6	3.32	934.92
Combat	SYS+AVX@GS33	5	3.22	800.58
Combat	SYS	6	3.20	989.99
Fathom	SYS+PSR@GS33	7	3.03	854.03
Fathom	AVX@GS33+PSR@GS39	6	3.02	793.13
Combat	PSR@GS33+AVX@GS39	4	2.94	773.79
Combat	AVX@GS33+PSR@GS39	5	2.83	743.82
Fathom	SYS+AVX@GS33	7	2.66	662.15
Fathom	PSR@GS33+AVX@GS39	5	2.64	693.06
Fathom	SYS	6	2.50	773.60
Rosalind	Control (nil)	8	2.45	858.15
Combat	Control (nil)	7	2.32	812.01
Zena CL	AVX@GS33+PSR@GS39	8	2.16	567.81
Fathom	Control (nil)	8	2.05	716.08
Zena CL	PSR@GS33+AVX@GS39	7	1.94	509.75
Zena CL	SYS+AVX@GS33	8	1.93	480.24
Zena CL	SYS+PSR@GS33	8	1.83	514.67
Zena CL	Control (nil)	8	1.69	591.91
Zena CL	SYS	8	1.63	502.25
	LSD with $\alpha = 0.05$	1	0.47	105.98

[1] Disease severity is based on the NVT scoring system of 1 (no disease symptoms) to 9 (severe disease symptoms)

[2] Assumes grain price $350/t

[3] Cost of treatment ($/ha) is calculated on 2024 fungicide costs applied at the recommended rate

Table 6 Return on investment (ROI) of different fungicide treatments and application timings for barley varieties with a range of resistance ratings to net form net blotch, NSW DPIRD, Grafton 2024.

Fungicide treatment			Return on investment for barley varieties ($/ha)			
Number	Code	Cost ($/ha)	Zena CL (SVS)	Fathom (MS)	Combat (MRMS)	Rosalind (MR)
1	Control (NIL)	0.00	591.91	716.08	812.01	858.15
2	SYS	41.00	502.25	773.60	989.99	1,094.95
3	SYS+PSR@GS33	68.00	514.67	854.03	934.92	1,012.69
4	SYS+AVX@GS33	101.00	480.24	662.15	800.58	911.28
5	AVX@GS33+PSR@GS39	87.00	567.81	793.13	743.82	1,064.13
6	PSR@GS33+AVX@GS39	87.00	509.75	693.06	773.79	1,036.00

Grain quality

Grain quality results are presented in Table 7. For every variety, treatment 1 (nil control) resulted in the highest screenings. Some variation in grain quality is expected between varieties due to disease severity, genetically conferred traits and environmental factors.

Table 7 Grain quality of 4 barley varieties with 6 different fungicide treatments to manage net form net blotch, NSW DPIRD, Grafton 2024. Varieties are listed from highest to lowest resistance rating to net form net blotch.

Variety	Fungicide treatment number	Grain screenings[1] (mean %)	1000 grain weight (g)	Test weight (kg/hL)	Grain protein concentration (mean % DMB)[2]
Rosalind (MR)	1	26.2	27.6	53.1	13.2
	2	19.4	32.3	55.7	12.8
	3	20.8	33.5	57.9	13.1
	4	16.2	33.1	58.0	13.7
	5	14.5	36.9	29.5	13.5
	6	15.0	30.5	58.5	13.9
Combat (MRMS)	1	21.3	35.6	54.0	13.4
	2	11.9	44.0	58.6	14.0
	3	11.5	41.7	57.8	13.6
	4	11.4	39.6	58.9	13.9
	5	14.4	39.9	58.3	13.9
	6	12.9	41.3	58.0	13.6
Fathom (MS)	1	19.6	34.0	52.2	14.5
	2	17.5	39.3	54.4	14.8
	3	17.5	35.1	56.0	15.1
	4	13.6	37.9	55.3	14.9
	5	10.9	39.9	57.2	14.9
	6	9.9	40.8	58.8	15.3
Zena CL (SVS)	1	12.8	40.3	61.4	13.8
	2	11.3	41.9	60.3	14.2
	3	9.3	40.3	60.4	14.2
	4	9.8	38.9	60.4	14.2
	5	9.0	44.6	61.8	14.2
	6	8.2	42.0	62.5	13.9
LSD with $\alpha = 0.05$		7.9	6.7	3.3	0.7

[1] Grain Trade Australia (GTA) standard grain screenings

[2] DMB = dry matter basis.

Conclusions

The combined effect of planting into NFNB-infected stubble from the previous season and high rainfall during the season resulted in highly conducive conditions for NFNB disease development, with symptoms visible 37 DAS.

The highest yield in this experiment (4.05 t/ha) was produced by the variety Rosalind⫯, which also has the highest resistance level to NFNB of the 4 varieties examined. In the GRDC NVT ratings published online (GRDC 2024), Rosalind⫯ is rated MR to NFNB in Queensland.

The results demonstrated that in a high disease risk situation, fungicides alone cannot control NFNB and do not provide acceptable ROI, particularly if susceptible varieties are grown. For example, variety Zena CL⫯, which is rated SVS in the GRDC NVT ratings for

Queensland (GRDC 2024), produced a disease severity rating of 8 out of 9 for 5 out of the 6 fungicide treatments (Table 5).

The most cost-effective disease control treatment in this high disease pressure was the combination of the variety Rosalind⟠ (MR rating) with Systiva® seed treatment, resulting in an ROI of $1,094.95/ha.

Variety choice is a crucial component of an IDM program. Choosing a variety with a high resistance level plus an effective fungicide program is critical to optimise ROI in conditions conducive to NFNB.

Continually planting varieties with low resistance to NFNB leads to increased inoculum levels in the stubble, which increases disease pressure at the beginning of the following season, as observed in this experiment. Using susceptible varieties reduces the ROI from fungicide treatments, even in a season with moderate disease pressure, such as 2023 (Blanch et al. 2024).

In this experiment, disease severity was reduced in the top 3 leaf layers at GS69 in varieties Fathom⟠, Combat⟠ and Rosalind⟠ with fungicide treatments. Where fungicides were applied to Zena CL⟠, no significant reduction in disease severity rating resulted. This might suggest that local strains of the pathogen that Zena CL⟠ is susceptible to (e.g. pathotype NB350) have developed resistance to these fungicide groups in this region. To test this, specimens were submitted to Brad Baxter at NSW DPIRD, Wagga Wagga (results pending).

Resistance of the *Pyrenophora teres* f. *teres* pathogen to fungicide Group 3 (DMI, triazoles) and Group 7 (SDHI) has been reported in Australia, particularly in southern barley growing regions. This is an important consideration when evaluating the efficacy of fungicide treatments. Selecting disease management options to minimise the development of resistance in the pathogen is critical to extend the usefulness of registered fungicides. For more information, read the GRDC fact sheet *Fungicide resistance in barley crops: causes, management and mitigation strategies* (GRDC 2021) and the GRDC update paper by Baxter et al (2025) *NSW fungicide resistance update - status of cereal pathogens - GRDC*.

Planting barley into barley stubble from the previous season is not the best practice. However, when this is unavoidable, growers are encouraged to use a variety with moderate resistance to NFNB (NVT online ratings do not yet list any varieties with a high level of resistance) with Systiva® (333 g/L fluxapyroxad) seed treatment as a minimum protection measure. The ROI of additional fungicide applications will depend on seasonal conditions and the yield potential of the crop.

Fungicide application when NFNB symptoms are not present in the crop ('just in case') is not best practice. Rotating fungicide MOA groups is strongly recommended to delay fungicide resistance developing in this pathogen.

References

Baxter B, Lopez-Ruiz F, Chang S, Turo C, Mair W, Dodhia K, Zulak, K, Poole, N, Park, R, Chhetri M, Williams M, Ovenden B, Milgate A and Simpfedorfer S (2025) NSW fungicide resistance update – status of cereal pathogens. GRDC NSW fungicide resistance update - status of cereal pathogens - GRDC [accessed 2 April 2025]

Blanch SG, Moore NY, Moss AJ and Chen K (2024) Effect of fungicide combination and timing on net form net blotch in barley – Grafton 2023. NSW DPIRD Northern Region Research Results, published online by NSW DPIRD [accessed 10 February 2025]

Brien C (2020) AsremlPlus: Augments 'ASReml-R' in fitting mixed models and packages generally in exploring prediction differences. R package version 4.3.55. http://chris.brien.name/rpackages

Butler DG, Cullis BR, Gilmour AR, Gogel BJ and Thompson R (2023) ASReml-R reference manual version 4.2, VSN International Ltd, Hemel Hempstead, HPI 1ES, UK.

GRDC (2021) *Fungicide resistance in barley crops: causes, management and mitigation strategies AFREN-GRDC.* Fact sheet [accessed 10 February 2025]

GRDC (2024) National Variety Testing ratings for disease resistance for barley in Queensland. Website [accessed 2 April 2025]

Kenward MG and Roger JH (1997) Small sample inference for fixed effects from restricted maximum likelihood. *Biometrics*, 983–997.

Patterson HD and Thompson R (1971) Recovery of inter-block information when block sizes are unequal. *Biometrika*, 58: 545–554.

Acknowledgements

Dr Lisle Snyman and Dr Xuechen Zhang, DPI QLD, are gratefully acknowledged for isolate pathotyping. Brad Baxter, NSW DPIRD Wagga Wagga, is gratefully acknowledged for fungicide resistance testing. Dr Steven Simpfendorfer, NSW DPIRD Tamworth, is gratefully acknowledged for technical advice. Penny Heuston and Amanda Warren-Smith, NSW DPIRD are gratefully acknowledged for editing and publishing the Northern Region Research Results.

This research is a component of 'Program 5: Integrated management strategies for Net Form Net Blotch of barley in low, medium, and high rainfall zones' a co-investment by GRDC, DPI QLD, NSW DPIRD, SARDI, and FAR Australia (GRDC Project code DAQ2304-008RTX).

Published by NSW Department of Primary Industries and Regional Development (NSW DPIRD).

NSW GOVERNMENT

www.dpird.nsw.gov.au

Always read the label

Users of agricultural chemical products must always read the label and any permit before using the product and strictly comply with the directions on the label and the conditions of any permit. Users are not absolved from any compliance with the directions on the label or the conditions of the permit by any reason of any statement made or omitted to be made in this publication.