Effect of fungicide combination and timing on management of net form net blotch of barley – Grafton 2025

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Key findings

- Seasonal conditions in 2025 were conducive to moderate net form net blotch (NFNB) disease pressure.
- The 3 treatments in this experiment that ranked highest for yield and return on investment (ROI) for fungicides (value of grain at BAR2 grade less cost of fungicide/ha) were produced by variety Rosalind⦶ with the following fungicide applications:
  1. fluxapyroxad 333 g/L (Systiva®) seed treatment + epoxiconzole 250 g/L and azoxystrobin 320 g/L (Radial® Opti) applied at GS33 (6.68 t/ha, ROI $1,713/ha)
  2. propiconazole 500 g/L (Tilt® 500 EC) applied at GS33 (6.47 t/ha, ROI $1,960/ha)
  3. azoxystrobin 322 g/L and metalaxyl-M 124 g/L (Uniform®) applied in furrow at planting (6.22 t/ha, ROI $1,773/ha).
- The lowest disease severity scores on the flag –2 and flag –1 leaves at GS69 of fungicide-treated varieties (5.6% to 13.7% infected leaf tissue) were recorded in Rosalind⦶ (MR) and Combat⦶ (MRMS).
- The highest disease severity scores on the flag –2 and flag –1 leaves at GS69 of fungicide-treated varieties (69.5% to 78.9% infected leaf tissue) were recorded in Zena CL⦶ (SVS). None of the fungicide treatments significantly reduced disease development in this variety.
- In all varieties and treatments, yield decreased as the percentage of NFNB diseased area of the flag –2 and flag –1 leaves at GS69 increased.
- Timely fungicide use can reduce NFNB disease in the flag –2 and flag –1 leaf layers by more than 75% in an MRMS or MR variety than a SVS variety, emphasising the importance of resistant varieties as a component of integrated disease management.

Keywords barley, net form net blotch, NFNB, integrated disease management, IDM, *Pyrenophora teres*, fungicide, fungicide resistance, return on investment, ROI

Introduction

Net form net blotch (NFNB) disease, caused by the fungus *Pyrenophora teres* f. *teres*, is estimated to be responsible for between 18% and 31% yield loss annually in Australian barley crops. Infected barley stubble is the primary source of inoculum. The pathogen can also spread via air-borne spores and planting seed retained from infected crops (Snyman and Moore 2025).

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 groups (3 and 7) has been confirmed in Australian NFNB populations. A key strategy to minimise the development of fungicide resistance is to rotate fungicide 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 in eastern and southern Australia. The project is led by the Department of Primary Industries Queensland (DPI QLD) with multiple state partners. In NSW, DPIRD manages field sites in a high (Grafton) and low (Wagga Wagga) rainfall zone.

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

This report presents data from the third field experiment at the high rainfall site in northern NSW conducted at NSW DPIRD Grafton Primary Industries Institute in winter 2025.

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 2024–25 fallow summer
2024 faba bean
2023–24 fallow summer
2023 barley
2022–23 soybean

Soil type and nutrition Brown loam over brownish clay.
Details of the soil chemical analysis at the experiment site are in Table 1.

Table 1. Soil chemical analysis for Paddock 19A, NSW DPIRD Grafton, 2025 (CSBP Soil and Plant Analysis Laboratory, WA).

		Soil depth (cm)			
Characteristic/anolyte	**Unit**	**0–10**	**10–30**	**30–60**	**60–90**
pH (1:5 water)	pH units	6.3	5.8	5.8	5.9
pH ($CaCl_2$)	pH units	5.8	5.3	5.1	5.5
Electrical conductivity (1:5 water)	dS/m	0.06	0.06	0.06	0.06
Aluminium (Al) base saturation[1]	%	0.4	0.3	0.4	0.4
Boron (Bo) 12C2 hot $CaCl_2$	mg/kg	0.4	0.5	0.7	0.9
Carbon (C) total	%	1.1	1	0.6	0.5
Carbon:nitrogen[1]	ratio	11	11	9.6	7.3
Organic matter estimated[1]	%	2.9	2.6	1.4	0.8
Chloride estimate[1]	mg/kg	51	45	49	44
Copper (Cu) DTPA	mg/kg	1.03	0.87	0.68	0.47
Iron (Fe) DTPA	mg/kg	44.8	32.3	14.8	9.8
Magnesium (Mg) Morgan 11	%	14	17	18	19
Manganese (Mn) DTPA	mg/kg	53.3	71.9	26.6	10.4
Nitrogen (N) ammonium	mg/kg	5	4	10	9
Nitrogen (N) nitrate	mg/kg	7	6	4	8
Nitrogen (N) total LECO Trumac[1]	%	0.16	0.13	0.09	0.06
Phosphorous (P) Bray 11	mg/kg	21	5.8	2.4	<1
Phosphorus (P) Colwell	mg/kg	89	44	10	11
Phosphorous buffering Index – Collwell adjusted[1]	Index unit	117	100	148	203
Silicon (Si) S11 hot $CaCl_2$[1]	mg/kg	31	35	31	18
Sulfur (S) KCl40	mg/kg	8.6	21.8	33.3	44.9
Zinc (Zn) DTPA	mg/kg	0.98	0.68	0.22	0.18
Effective cation exchange capacity (ECEC)	cmol(+)/kg	7.59	6.29	5.51	6.65
Exchangeable aluminium (Al)	cmol(+)/kg	0.02	0.03	0.08	0.10
Exchangeable calcium (Ca)	cmol(+)/kg	6.73	5.6	4.38	4.98
Exchangeable magnesium (Mg)	cmol(+)/kg	0.32	0.3	0.82	1.28
Exchangeable potassium (K)	cmol(+)/kg	0.49	0.33	0.19	0.21
Exchangeable sodium (Na)	cmol(+)/kg	0.03	0.03	0.04	0.08
Calcium:magnesium	ratio	21	18.7	5.3	3.9
Soil basic texture	–	Loam	Loam	Clay	Clay
Soil basic colour	–	Brownish	Brownish	Brownish	Brownish

[1] Analysis by Environmental Analysis Laboratory, NSW, 2024.

Temperature and rainfall

A total of 304 mm of rain fell during the growing season, 39 mm more than the long-term average (LTA) of 265 mm for the same period (Figure 1). In mid-September, 40 mm of supplementary overhead irrigation was applied to maintain disease development during a dry period, making the total in-crop water received 344 mm.

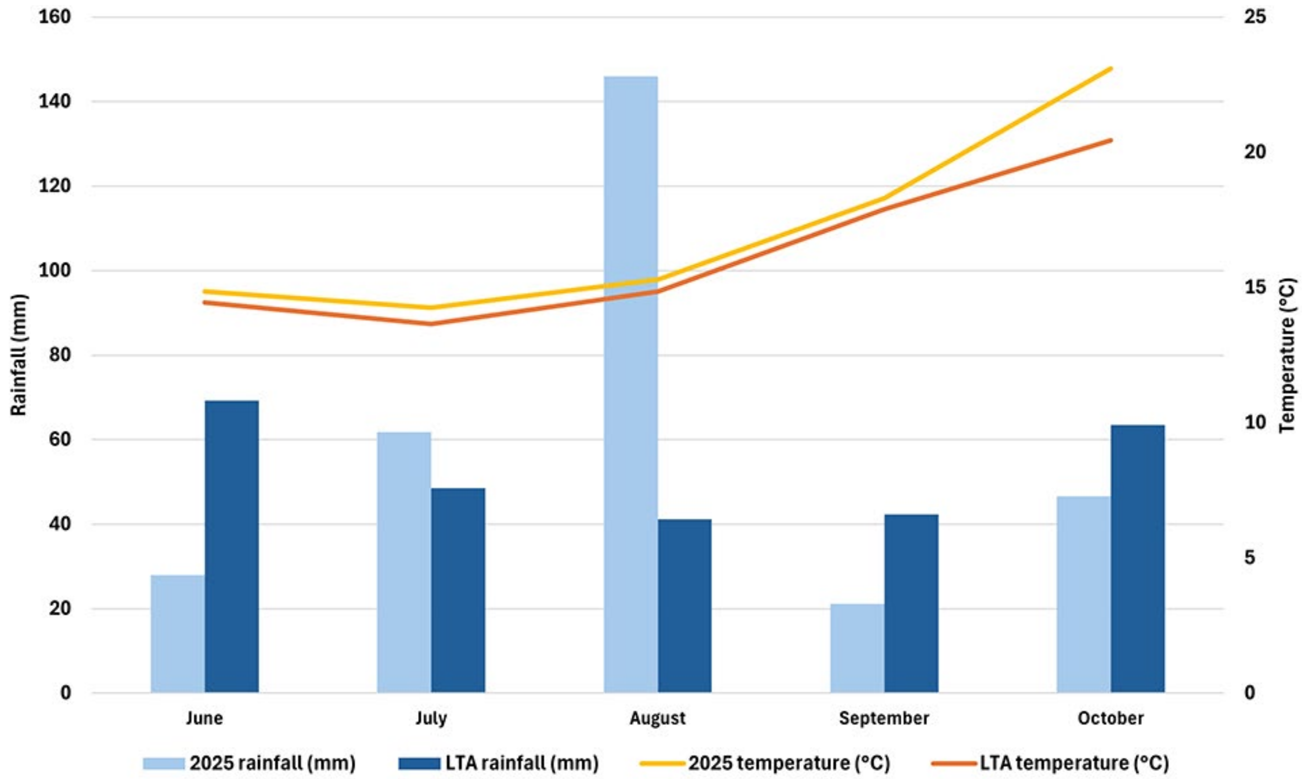

Figure 1. Temperature and rainfall for the 2025 growing season compared with long-term averages (LTA) at Grafton Primary Industries Institute, Grafton, NSW.

Sowing date

29 May 2025, which was 2 weeks later than planned due to wet conditions.

Fertiliser

- Sulfate of potash (41.5% K, 17% S) at 120 kg/ha broadcast in January 2025.
- Granulock® Z (11% N, 21.8% P, 4% S, 1% Zn) 30 kg/ha banded with seed.
- Urea (46% N) 150 kg/ha broadcast at sowing.

Plant population

Established plant population: 61 plants/m².

Varieties

Five 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. Maximus CL⊕ (moderately susceptible, MS)
3. Fathom⊕ (moderately susceptible, MS)
4. Combat⊕ (moderately resistant–moderately susceptible, MRMS)
5. Rosalind⊕ (moderately resistant, MR)

Weed management

- Fallow application of 600 g/L glyphosate at 2 L/ha (Crucial®).
- Fallow application of 333 g/L fluroxypyr at 900 mL/ha (Starane® Advanced).
- Post-emergence application of 333 g/L fluroxypyr at 900 mL/ha (Starane® Advanced) at the 3-leaf stage.

Insect management

- To control corn aphid (*Rhopalosiphum maidis*), 500 g/kg pirimicarb at 150 g/ha (Pirimor®).
- To control slugs, 50 g/kg metaldehyde and 1.5 g/kg fipronil molluscicide pellets at 4 kg/ha (Transcend®).
- To control *Helicoverpa*, 350 g/kg chlorantraniliprole at 70 g/ha (Altacor®).

Harvest date

- Physiological maturity of all varieties was reached between 1 and 8 October 2025.
- Harvest date was 10 October 2025, 133 days after sowing (DAS).

Treatments and experiment details

Net form net blotch management treatments

The fungicides used with the fungicide group and their mode of action (MOA) are listed in Table 2. Management for other barley diseases was not required this season. Powdery mildew developed in some plots of variety Rosalind⁽ᶦ⁾ but did not require treatment.

Table 2. Fungicide active ingredients, groups and their modes of action.

Fungicide active ingredient	Example trade name combining active ingredients	Fungicide group	Fungicide mode of action
Azoxystrobin and metalaxyl-M	Uniform®	11 (methoxy-acrylate) and 4 (acylalanine)	Quinone outside inhibitors (QoI) Phenylamide (PA)
Epoxiconazole and azoxystrobin	Radial® Opti	3 (triazole) and 11 (methoxy-acrylate)	Demethylation inhibitors (DMI) and sterol biosynthesis inhibitors (SBI) Quinone outside inhibitors (QoI)
Fluxapyroxad	Systiva®	7 (pyrazole-4-carboxamide)	Succinate dehydrogenase inhibitors (SDHI)
Propiconazole	Tilt®500 EC	3 (triazole)	Demethylation inhibitors (DMI) and sterol biosynthesis inhibitors (SBI)
Prothioconazole and bixafen	Aviator Xpro®	3 (triazole) and 7 (pyrazole-4-carboxamide)	Demethylation inhibitors (DMI) and sterol biosynthesis inhibitors (SBI) Succinate dehydrogenase inhibitors (SDHI)

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

The Zadoks growth stage (GS) scale was used to determine fungicide application timing as each variety reached GS33. To improve ROI and reduce unnecessary fungicide use, GS33 was selected as the single application timing to protect both the flag –2 and the flag –1 leaves as they emerged, providing early protection from disease in the lower canopy. As the stem elongates, the upper leaves are moved further away from the lower canopy, reducing the opportunity for spores to transfer to the flag leaf. Applying a single fungicide at this critical stage in the crop cycle also reduces the risk of resistance developing.

Table 3. Fungicide treatments and cost per hectare for NFNB, NSW DPIRD, Grafton 2025.

Fungicide treatment number and code	Description[1]	Product cost ($/ha)[2]
1 Control (NIL)	Nil	0.00
2 SYSTIVA.ST	Fluxapyroxad 333 g/L (Systiva®) seed treatment only	41.00
3 SYSTIVA+RO@GS33	Fluxapyroxad 333 g/L (Systiva®) seed treatment + epoxiconazole 250 g/L and azoxystrobin 320 g/L (Radial® Opti) applied at GS33	53.50
4 UIF+AVX@GS33	Azoxystrobin 322 g/L and metalaxyl-M 124 g/L (Uniform®) applied in furrow at planting + 150 g/L prothioconazole and bixafen 75 g/L (Aviator Xpro®) applied at GS33	60.00
5 TILT@GS33	Propiconazole 500 g/L (Tilt®500 EC) applied at GS33	7.00
6 UIF	Azoxystrobin 322 g/L and metalaxyl-M 124 g/L (Uniform®) applied in furrow at planting	25.00

[1] Active ingredient, product and growth stage at application. Products applied at the recommended label rate.

[2] Cost of treatment $/ha based on the 2025 market price of fungicides applied at the recommended label rate.

Experimental design

A randomised, split-plot design with fungicide treatment as the main plot (6 levels) and variety as the sub-plot (5 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 autocorrelations, 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 autocorrelations 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 plots established evenly at the site with a population of 61 plants/m² (Figure 2). Weed competition was low during the season, with management very effective. The crop grew evenly throughout the site during the season (Figure 3).

Figure 2. The NFNB barley experiment on 1 July 2025, 33 days after sowing. Photo: N Moore, NSW DPIRD.

Figure 3. The NFNB barley experiment on 1 September 2025, 62 days after sowing. Photo: S Blanch, NSW DPIRD.

Disease development and severity assessment

The experiment was sown adjacent to a block with retained stubble from a NFNB-infected barley crop in 2024. The Zena CL$^{\oplus}$ buffer plots were inoculated on 1 July 2025, 33 DAS, by sprinkling 150 g of dry NFNB-infected stubble per 20 m into the centre 2 rows of each buffer plot.

Symptoms of NFNB were initially observed in the Zena CL$^{\oplus}$ buffer and untreated control plots on 16 July, 48 DAS, when the varieties in the experiment were between GS30 and GS32.

Weather conditions were conducive to disease development throughout the season and overall disease pressure was moderate (Figure 4) compared with the experiments conducted in 2023 and 2024, which were low to moderate and high, respectively (Blanch et al. 2024; 2025).

Figure 4. Net form net blotch symptoms in lower leaves 62 days after sowing (left) and progressing through the crop cycle (centre) to advanced disease development late in the crop cycle (right). Photos: N Moore, NSW DPIRD.

Isolation of *Pyrenophora teres* f. *teres* (Ptt) was made from leaf lesions, and the pathotype was confirmed by Judy McIlroy (DPI QLD) as NB73. This pathotype is commonly recorded in barley crops in northern NSW and southern QLD.

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

The flag −2 and flag −1 leaf layers were chosen for disease severity assessment as they are the main upper canopy leaves contributing to yield in barley (NSW DPIRD 2025), making them important for disease management. The flag-2 leaf influences grain number per m^2. The flag −1 leaf usually has the largest leaf area of the top 3 leaves and plays a major role in grain fill. The flag leaf is often smaller in barley and contributes to grain filling alongside the ear and acts as a late source of photosynthesis for grain fill later in the season. If the flag-2 and flag −1 leaves are protected from disease, infection of the flag leaf is less likely.

Disease severity was assessed at Zadok GS69. For each plot, 10 randomly selected plants were chosen, and the flag-2 and flag −1 leaf layers were assessed for the percentage of area with NFNB symptomatic tissue. The averages of the 2 layers were then combined to achieve a disease severity assessment for each plot (Table 4).

The highest levels of disease severity in the flag −2 and flag −1 leaf layers at GS69 of the fungicide treatments, ranging from 69.5 to 78.9% infected leaf tissue, were recorded in the SVS-rated variety Zena CL⊕, with no statistical difference between the fungicide treatments of this variety.

The MR-rated variety Rosalind⊕ and the MRMS-rated variety Combat⊕ accounted for the 11 lowest levels of disease severity in the flag −2 and flag −1 leaf layers at GS69 of the fungicide treatments, ranging from 5.5 to 13.7% infected leaf tissue (Table 4). The disease severity scores for the fungicide treatments for these 2 varieties were at least 75% lower than for the SVS-rated variety Zena CL⊕.

The untreated control of variety Rosalind⊕ had the lowest percentage of area of infected leaf tissue, however, these data were derived from one replicate only (as noted in Table 4), as the disease severity score of the other 3 replicates was confounded by downy mildew infection and was, therefore, not included in the analysis.

Table 4. Disease severity at GS69 of 2 leaf layers (flag −2 and flag −1 combined) for 5 barley varieties with different resistance ratings to NFNB, treated with different fungicide combinations and application timing.

Fungicide treatment number and code	Disease severity at GS69 of flag −2 and flag −1 leaf layers (combined % of leaf area with NFNB symptoms)				
	Zena CL (SVS)[1]	Maximus CL (MS)	Fathom (MS)	Combat (MRMS)	Rosalind (MR)
1 Control (NIL)	87.4[2]	61.4	62.8	18.8	4.1[3]
2 SYSTIVA.ST	77.4	27.5	32.9	12.7	5.8
3 SYSTIVA+RO@GS33	69.5	18.5	18.1	8.8	7.1
4 UIF+AVX@GS33	72.4	18.6	16.9	5.2	5.6
5 TILT@GS33	78.9	26.0	35.9	13.1	13.7
6 UIF	76.1	27.4	25.3	9.8	13.2

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

[2] LSD with $\alpha = 0.05$ for disease severity = 13.60.

[3] This value is derived from only one replicate due to the presence of powdery mildew symptoms in the other 3 replicates and should be interpreted with caution.

Yield and economic return on investment for fungicide treatments

Analysed yield data for each variety and fungicide treatment are in Figure 5a.

The yield data for all varieties were aggregated for each fungicide treatment (Figure 5b) and the yield data for all treatments were aggregated for each variety (Figure 5c), with the respective LSD values for each analysis as shown. Treatment yields with the same letter are not significantly different based on the LSD with α=0.05 within each graph.

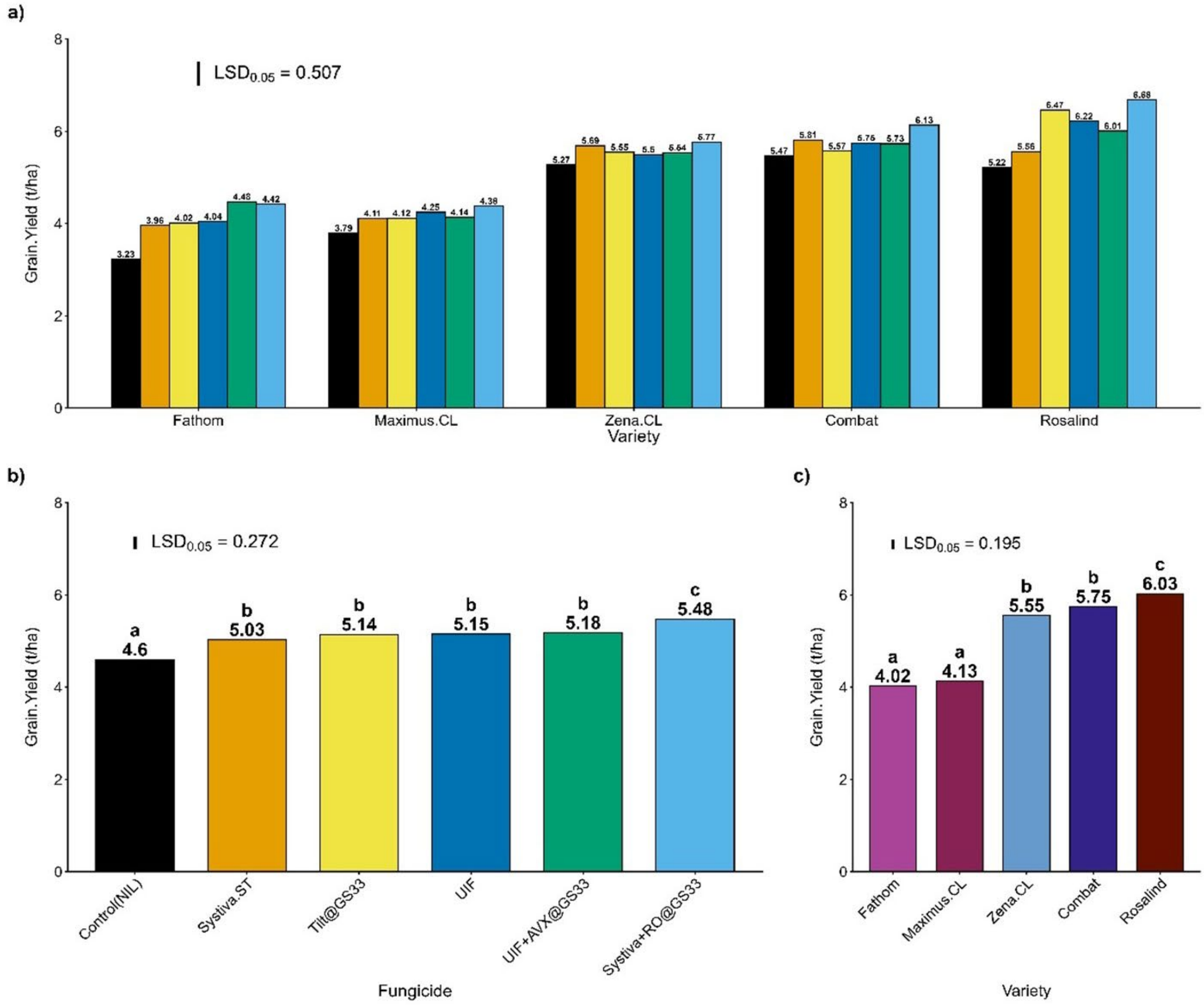

Figure 5. a, top: grain yield for 5 barley varieties with different resistance ratings to net form net blotch, from left to right: Fathom (MS), Maximus CL (MS), Zena CL (SVS), Combat (MRMS) and Rosalind (MR), with fungicide and application timing combinations.

b, bottom left: comparison of fungicide treatments with the aggregated yield of all varieties in the experiment compared to the untreated control (left).

c, bottom right: comparison of varieties with the aggregated yield of all treatments applied to each variety.

Note: [a–c] treatment yields with the same letter are not statistically different based on the least significant difference within each graph.

The decline in grain yield relative to the amount of NFNB disease on the flag −2 and flag −1 leaves at GS69 is shown in Figure 6. In all the varieties tested and, in all treatments, yield decreased as the percentage of diseased area of the flag −2 and flag −1 leaves increased.

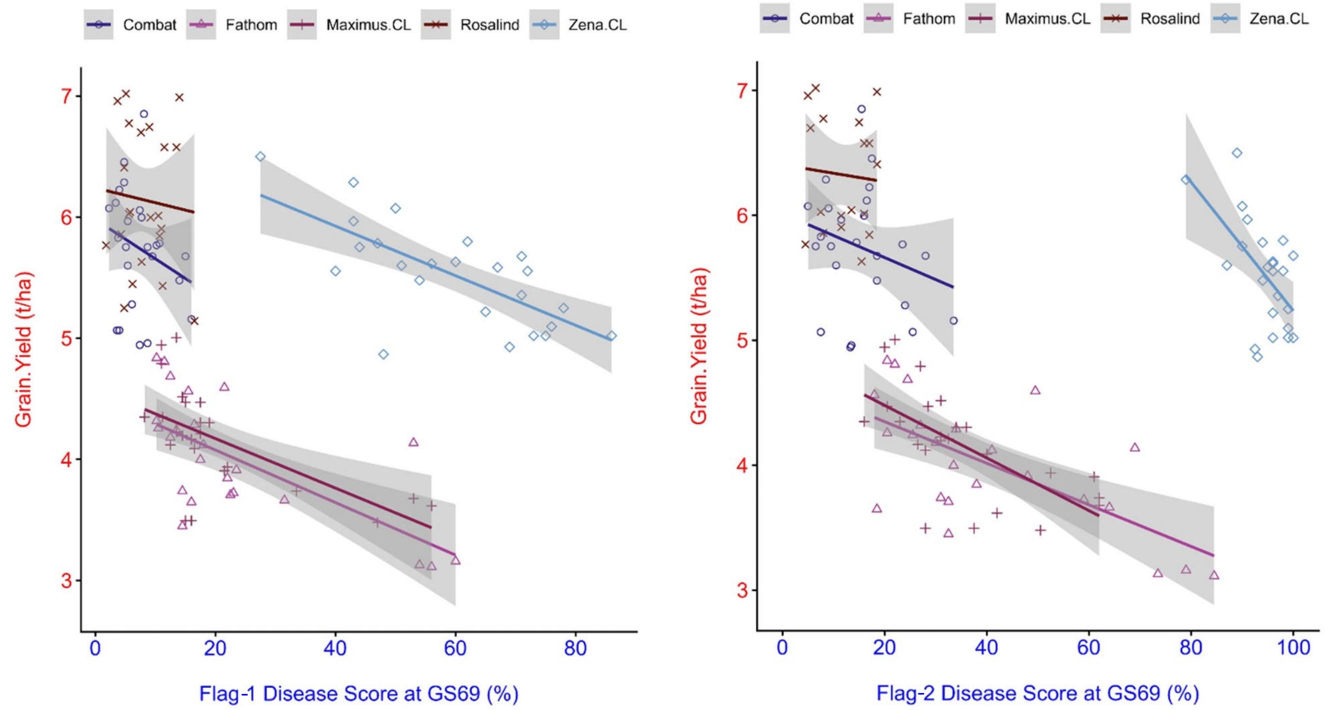

Figure 6. Relationship between grain yield and NFNB disease severity at GS69 for flag −2 (left) and flag −1 (right) leaf layers for 5 barley varieties and 6 fungicide treatments. Disease severity score is a combined percentage of NFNB symptomatic area of the flag −2 and flag −1 leaves.

The analysed yield data with a disease severity score at GS69 and the ROI for each fungicide treatment are in Table 5, with data ranked from the highest to lowest yield. For ROI comparison, actual yield data and an assumed barley grade 2 for grain quality were used (BAR2, screenings <25%, test weight >60 kg/hL; GrainCorp 2025), although this quality was not achieved by all varieties due to seasonal conditions (Table 7). A grain price of $310/t was used (BAR2, December 2025 average) as follows:

ROI = (grain price [$310/t] × yield t/ha) – (fungicide treatment product [cost $/ha]).

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) for each fungicide treatment to manage net form net blotch of barley, NSW DPIRD, Grafton 2025.

Variety	Fungicide treatment code	Disease severity at GS69 (combined % of NFNB symptomatic tissue in flag −2 and flag −1 leaves)	Yield (t/ha at 11% moisture content)	ROI (grain value less cost of fungicide) ($/ha)[1, 2]
Rosalind	Systiva+RO@GS33	7.1	6.68	1,713.42
Rosalind	Tilt@GS33	13.7	6.47	1,960.41
Rosalind	UIF	13.2	6.22	1,772.70
Combat	Systiva+RO@GS33	8.8	6.13	1,572.35
Rosalind	UIF+AVX@GS33	5.6	6.01	1,502.50
Combat	Systiva.ST	12.7	5.81	1,562.89
Zena CL	Systiva+RO@GS33	69.5	5.77	1,480.05
Combat	UIF	9.8	5.75	1,638.75
Combat	UIF+AVX@GS33	5.2	5.73	1,432.50
Zena CL	Systiva.ST	77.4	5.69	1,530.61
Rosalind	Systiva.ST	5.8	5.56	1,495.64
Combat	Tilt@GS33	13.1	5.57	1,687.71
Zena CL	Tilt@GS33	78.9	5.55	1,681.65
Zena CL	UIF+AVX@GS33	72.4	5.54	1,385.00
Zena CL	UIF	76.1	5.50	1,567.50
Combat	Control (NIL)	18.8	5.47	1,695.70
Zena CL	Control (NIL)	87.4	5.27	1,633.70
Rosalind	Control (NIL)	4.13	5.22	1,618.20
Fathom	UIF+AVX@GS33	16.1	4.48	1,120.00
Fathom	Systiva+RO@GS33	18.1	4.42	1,133.73
Maximus CL	Systiva+RO@GS33	18.5	4.38	1,123.47
Maximus CL	UIF	27.4	4.25	1,211.25
Maximus CL	UIF+AVX@GS33	18.6	4.14	1,035.00
Maximus CL	Tilt@GS33	26.0	4.12	1,248.36
Maximus CL	Systiva.ST	27.5	4.11	1,105.59
Fathom	UIF	25.3	4.04	1,151.40
Fathom	Tilt@GS33	35.9	4.02	1,218.06
Fathom	Systiva.ST	32.9	3.96	1,065.24
Maximus CL	Control (NIL)	61.4	3.79	1,174.90
Fathom	Control (NIL)	62.8	3.23	1,001.30
	LSD with α = 0.05	13.60	0.50	

[1] Assumes grain price of $310/t delivered (BAR2).

[2] Cost of treatment ($/ha) is calculated on 2025 product costs applied at the recommended label rate.

[3] This value is from one replicate only as downy mildew symptoms confounded the NFNB score in the other 3 replicates.

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

The 3 highest yielding treatments were produced by variety Rosalind⦶, which also had the 3 highest ROI values. The fungicide applications with yield and ROI for Rosalind⦶ were:

1. fluxapyroxad 333 g/L (Systiva®) seed treatment + epoxiconazole 250 g/L and azoxystrobin 320 g/L (Radial® Opti) applied at GS33 (6.68 t/ha, ROI $1,713/ha)
2. propiconazole 500 g/L (Tilt®500 EC) applied at GS33 (6.47 t/ha, $1,960/ha)
3. azoxystrobin 322 g/L and metalaxyl-M 124 g/L (Uniform®) applied in furrow at planting (6.22 t/ha, $1,773/ha).

The lowest yielding treatments were produced by the untreated controls of varieties Fathom⦶ and Maximus CL⦶, with 3.23 t/ha ($1,001.30/ha) and 3.79 t/ha ($1,174.90), respectively.

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 2025.

		Return on investment for barley varieties ($/ha)				
Fungicide treatment number and code	**Cost ($/ha)**	**Zena CL (SVS)[1]**	**Maximus CL (MS)**	**Fathom (MS)**	**Combat (MRMS)**	**Rosalind (MR)**
1 Control (NIL)	0.00	1,633.70	1,174.90	1,001.30	1,695.70	1,618.20
2 SYSTIVA.ST	41.00	1,530.61	1,105.59	1,065.24	1,562.89	1,495.64
3 SYSTIVA+RO@GS33	53.50	1,480.05	1,123.47	1,133.73	1,572.35	1,713.42
4 UIF+AVX@GS33	60.00	1,385.00	1,035.00	1,120.00	1,432.50	1,502.50
5 TILT@GS33	7.00	1,681.65	1,248.36	1,218.06	1,687.71	1,960.41
6 UIF	25.00	1,567.50	1,211.25	1,151.40	1,638.75	1,772.70

Grain quality

Grain quality results are listed in Table 7. For every variety except Combat⦶, 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. All treatments to variety Rosalind⦶ were the only treatments to achieve BAR2 grade with test weights above the critical level of 60 kg/hL.

Table 7. Grain quality results for 5 barley varieties with fungicide treatments to manage net form net blotch, NSW DPIRD, Grafton 2025. Varieties are listed from highest to lowest resistance rating to NFNB.

Variety	Fungicide treatment number	Grain screenings (mean %)	1,000 grain weight (g)	Test weight (kg/hL)	Grain protein concentration (mean % DMB)[1]
Rosalind	1	8.1	38.2	60.6	13.5
	2	7.9	36.6	60.3	13.6
	3	4.7	36.3	60.3	13.6
	4	5.8	34.0	60.3	13.7
	5	6.2	32.0	61.2	13.4
	6	6.4	36.7	61.0	13.8
Combat	1	4.5	39.9	57.6	13.7
	2	5.1	41.9	56.8	13.8
	3	5.1	38.3	56.3	13.9
	4	3.7	43.0	55.4	13.6
	5	6.6	39.6	55.4	13.7
	6	3.6	44.9	57.7	13.6
Fathom	1	10.4	34.0	52.5	14.6
	2	6.5	36.3	55.6	14.7
	3	4.3	36.1	55.5	14.4
	4	5.1	34.4	54.3	14.4
	5	6.1	34.8	54.0	13.8
	6	4.1	37.8	57.3	14.4
Maximus CL	1	8.8	32.1	52.4	14.9
	2	6.2	35.2	54.4	14.9
	3	5.0	34.9	54.3	14.5
	4	7.8	36.2	53.4	14.9
	5	5.7	34.7	54.8	14.7
	6	6.0	38.6	55.4	14.4
Zena CL	1	8.3	31.6	54.7	13.9
	2	6.2	34.7	55.7	13.7
	3	6.3	37.3	55.9	13.3
	4	8.2	39.5	55.2	13.8
	5	6.4	36.7	55.3	13.4
	6	7.5	35.1	53.1	13.7
LSD with $\alpha = 0.05$		2.68	6.26	2.31	0.60

[1]DMB = dry matter basis.

Conclusions

Disease severity

The combined effect of planting beside NFNB-infected barley stubble from the previous season and inoculating the buffer plots resulted in moderate NFNB disease pressure during the 2025 season, with symptoms visible at 48 DAS.

For all varieties in this study, the fungicide treatments 3 and 4 (Table 3) resulted in the greatest reduction in disease severity in the flag −2 and flag −1 leaves compared with the untreated controls of the respective variety (Table 4). These 2 treatments included fungicide application of the seed or in-furrow at planting as well as a foliar application at GS33 and a combination of multiple fungicide groups (Table 3). Treatment 3 included a seed treatment from Group 7 and foliar application of Groups 3 and 11. Treatment 4 included an in-furrow application from Groups 4 and 11 and a foliar application of Groups 3 and 7.

The lowest disease severity scores on the flag −2 and flag −1 leaf layers at GS69 of fungicide-treated varieties (5.6 to 13.7% infected leaf tissue) were recorded in varieties Rosalind⫚ (MR) and Combat⫚ (MRMS).

The highest disease severity scores on the flag −2 and flag −1 leaves at GS69 of fungicide-treated varieties (69.5 to 78.9% infected leaf tissue) were recorded in variety Zena CL⫚ (SVS). None of the fungicide treatments was able to significantly reduce the disease severity scores in this variety.

Timely fungicide application can reduce NFNB disease in the flag −2 and flag −1 leaf layers by more than 75% in an MRMS or MR variety than an SVS variety, emphasising the importance of resistant varieties as a component of integrated disease management.

Grain yield and quality

In all varieties and treatments, yield decreased as the percentage of NFNB diseased area of the flag −2 and flag −1 leaves at GS69 increased (Figure 6), and the untreated controls produced lower yields than the fungicide treatments of the respective variety (Figure 4a).

The highest yielding treatment (6.68 t/ha) was the MR variety Rosalind⫚ with a combination of fluxapyroxad 333 g/L (Systiva®) seed treatment and a foliar application of epoxiconazole 250 g/L and azoxystrobin 320 g/L (Radial® Opti) at GS33 (ROI $1,713/ha; Table 5).

Variety Rosalind⫚ was the only variety to achieve barley grade 2 (BAR 2) in this experiment. Grain quality was inconsistently correlated with fungicide treatments. Grain screenings, thousand seed weight, test weight and protein concentration showed a trend toward more desirable values in treatments 3 and 4 compared with the untreated controls, however, this was not statistically significant for all the varieties (Table 7). Varietal differences and environment often exert the dominant influence on grain quality rather than the fungicide program alone. For the purposes of calculating the ROI, the actual yield data and an assumed barley grade 2 were used.

Return on investment

The most cost-effective disease management combination in this moderate disease pressure season was produced by the MR-rated variety Rosalind⫚ with a foliar application of propiconazole 500 g/L (Tilt®500 EC) applied at GS33, resulting in an ROI of $1,960/ha (yield 6.47 t/ha; Table 5). It is important to note that reduced sensitivity and resistance to the comparatively less expensive Group 3 fungicides (DMI, triazoles) have been recorded in the NFNB pathogen in southern NSW since 2023 (Baxter et al. 2025).

The MR variety Rosalind⫚ yielded significantly higher than all other varieties in this study and was the only variety to obtain the test weight to achieve BAR2 grade. When comparing this to popular varieties for the northern region (Fathom⫚ and Maximus CL⫚), growers could potentially increase their ROI by more than $500/ha by switching to variety Rosalind⫚, especially in situations where NFNB is a high risk. The susceptibility of variety Rosalind⫚ to other diseases, such as powdery mildew, for example, should be considered.

Slowing the development of fungicide resistance

The fungicide combinations in this study were chosen to avoid repetition of fungicide groups during the season, which is recommended to slow the development of fungicide resistance in the NFNB pathogen. Resistance of Pyrenophora teres f. teres to fungicide Group 3 (DMI, triazoles) and Group 7 (SDHI) has been reported, particularly in barley growing regions of southern Australia. 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, refer to 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*.

Prophylactic ('just in case') spraying when NFNB symptoms are not present in the crop is not best practise. Rotating fungicide groups is strongly recommended to delay fungicide resistance developing in this pathogen in the northern grain region.

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