Yield responses to fungicides in perennial ryegrass seed crops

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Key points

- Left unmanaged, stem rust and other diseases can cause severe perennial ryegrass seed yield losses.
- In ten FAR field trials across Canterbury, fungicide programmes increased perennial ryegrass seed yield by an average of 77%.
- Applying fungicides at GS 32, head emergence and flowering, consistently delivered the highest seed yield improvements.
- A 'flowering +14-day' application should be applied only in seasons with late rust pressure.

Background

Perennial ryegrass (*Lolium perenne* L.) is the main ryegrass species grown for seed in New Zealand, supporting both pasture and turf markets. Canterbury leads production, with around 12,000 ha sown annually. High seed yields are essential for profitability, especially in turf types where grazing returns are low (Rolston et al., 2018).

Stem rust (*Puccinia graminis* subsp. *graminicola*) is the most damaging of the ryegrass diseases, often hitting during stem elongation and heading which are critical stages for seed development. Severe rust can result in yield losses ranging from 10% through to complete crop failure if left unmanaged (Pfender, 2006; Rolston et al., 2009). Other diseases can also contribute to yield loss in perennial ryegrass seed production.

Fungicides are the main control method. Triazoles (DMI) have long been used, with newer options like strobilurins (QoI) and SDHIs added to improve disease control and help to keep both leaves and stems green for longer. New Zealand trials show that starting fungicide applications early, at the beginning of reproductive growth, and using mixes with different modes of action can boost yields by 30–40% compared with untreated crops (Rolston et al., 2009).

This study pulls together results from ten Canterbury field trials to assess how different fungicide programmes and timings affect seed yield. It compares early versus late applications and offers practical advice to help growers improve rust control and maximise returns.

Methods

Trial dataset

Data were compiled from ten individual field trials conducted between the 2017-18 and 2021-22 seasons in Canterbury, New Zealand (**Error! Reference source not found.**). Each trial was originally commissioned with a separate specific objective, such as comparing late-season fungicide products (Trial 1) or evaluating leaf rust control prior to GS 32 (Trial 4). Fungicide applications generally started at plant growth regulator (PGR) timing and were applied via a small plot boom delivering approximately 240 L/ha. Plots were generally 2.3 m wide by 10 – 12 m long. Harvest procedures were consistent across years where plots were windrowed using a modified John Deere windrower at approximately 40% seed moisture content and harvested 6 - 9 days later using a Wintersteiger or Sampo plot combine. A subsample of seed was collected from each plot and machine dressed to meet First-generation seed certification standards (MPI, 2014) and converted into kg/ha.

Table 1. Canterbury ryegrass disease management trials included in this combined analysis

Trial No.	Year	Location	Trial Aim
1	2021	St Andrews	Compare late season fungicide products
2	2021	Chertsey	Compare mid-season fungicide products - dryland
3	2021	Chertsey	Compare mid-season fungicide products - irrigated
4	2020	St Andrews	Compare fungicide products on leaf rust pre GS 32
5	2020	Greendale	Seasonal programmes
6	2019	Greendale	Modelling stem rust progression
7	2019	Chertsey	Compare mid-season fungicide products - dryland
8	2019	Chertsey	Compare mid-season fungicide products - irrigated
9	2018	Greendale	Late season requirements
10	2017	Greendale	Disease progression

Trials 1 and 4 were established in 'Syringa' forage perennial ryegrass while all other trials were set up in turf-type perennial ryegrass cultivars that are considered high-risk for stem rust development. Treatments consisted of fungicide applications at up to five growth stages including components of: Pre-PGR (post-closing), PGR (GS 32, stem elongation), Ear emergence, Flowering, and 14 days post-flowering (+ 14 day). Most programmes were preventative rather than reactive, consistent with best practice for stem rust management (Rolston et al., 2009).

Statistical analysis

To enable cross-trial comparisons, seed yield was expressed as a percentage of the best-performing treatment within each trial. These top treatments typically maintained very low disease levels, providing a reliable benchmark for site yield potential under optimal conditions. This normalisation reduces variability caused by seasonal disease pressure, which strongly influences untreated controls, thereby improving consistency across years and environments.

Analyses of the GS 32 and flowering +14-day treatments involved paired comparisons across trials containing treatments with and without respective applications using a paired *t*-test. Application frequency was analysed as the relative seed yield performance by the number of fungicide applications per programme (0–4), expressed as % of best-treatment. Unbalanced ANOVA was used to test for differences among application frequencies, and LSD groupings were generated for interpretation.

For cross-trial and aggregated analyses, Python (pandas, statsmodels, and scipy) was used to implement ANOVA models, compute LSD values, and perform paired *t*-tests where appropriate. Visualization of results, including error bars and grouping letters, was generated using matplotlib and seaborn.

Results and discussion

Across ten field trials, fungicide applications generally improved seed yield compared with untreated controls, with nine trials showing a positive response. However, the magnitude of improvement varied considerably among sites and seasons (Table 2). On average, untreated plots produced 1,577 kg/ha of seed, while the best fungicide treatment achieved 2,499 kg/ha, representing an overall mean increase of 922 kg/ha or 77%. The large increases were associated with multi-spray programmes incorporating a GS 32 application and subsequent fungicide timings, particularly under high disease pressure and favourable growing conditions.

Table 2. Seed yield of the untreated control and treatment with the best yield response to fungicide programmes in ten field trials investigating different stem rust-focused management programmes on turf-type perennial ryegrass in Canterbury, New Zealand between 2017-18 and 2021-22.

Year of Trial	Trial No.	Treatment No.	Seed Yield (kg/ha)			Percentage increase
			Untreated	Best Treatment	Response	
2021	1	6	3020*	3030	10	0
2021	2	7	1049	1899	850	81
2021	3	4	1629	2419	791	49
2020	4	7	1838*	2112	274	15
2020	5	6	1028	2780	1752	170
2019	6	2	1234	2774	1539	125
2019	7	7	1401	2298	897	64
2019	8	6	1293	1747	454	35
2018	9	3	848	2488	1640	193
2017	10	5	2425	3440	1015	42
	Average		1577	2499	922	77

*****Trial 1 compared late-season fungicide products with 0.4 L/ha Proline® (250 g/L prothioconazole, Group 3 fungicide) applied at GS 32 to all plots while Trial 4 evaluated leaf rust control prior to GS 32 and all plots received 0.4 L/ha Proline® at head emergence and 0.4 L/ha Proline + 0.6 L/ha SEGURIS® Flexi, Group 7) at flowering.

Effect of fungicide application frequency on relative seed yield

When seed yield was expressed as a percentage of the best treatment, analysis showed that frequency of fungicide application influenced relative seed yield ($P < 0.001$). The untreated controls produced 56% of the best treatments. Seed yield performance increased to 87% of the best treatment when one or two applications where applied and up to 95% when three and four applications were applied (Figure 1). There was no difference between one and two or three and four applications. The improvement from two to three applications is driven by benefits of an application during flowering.

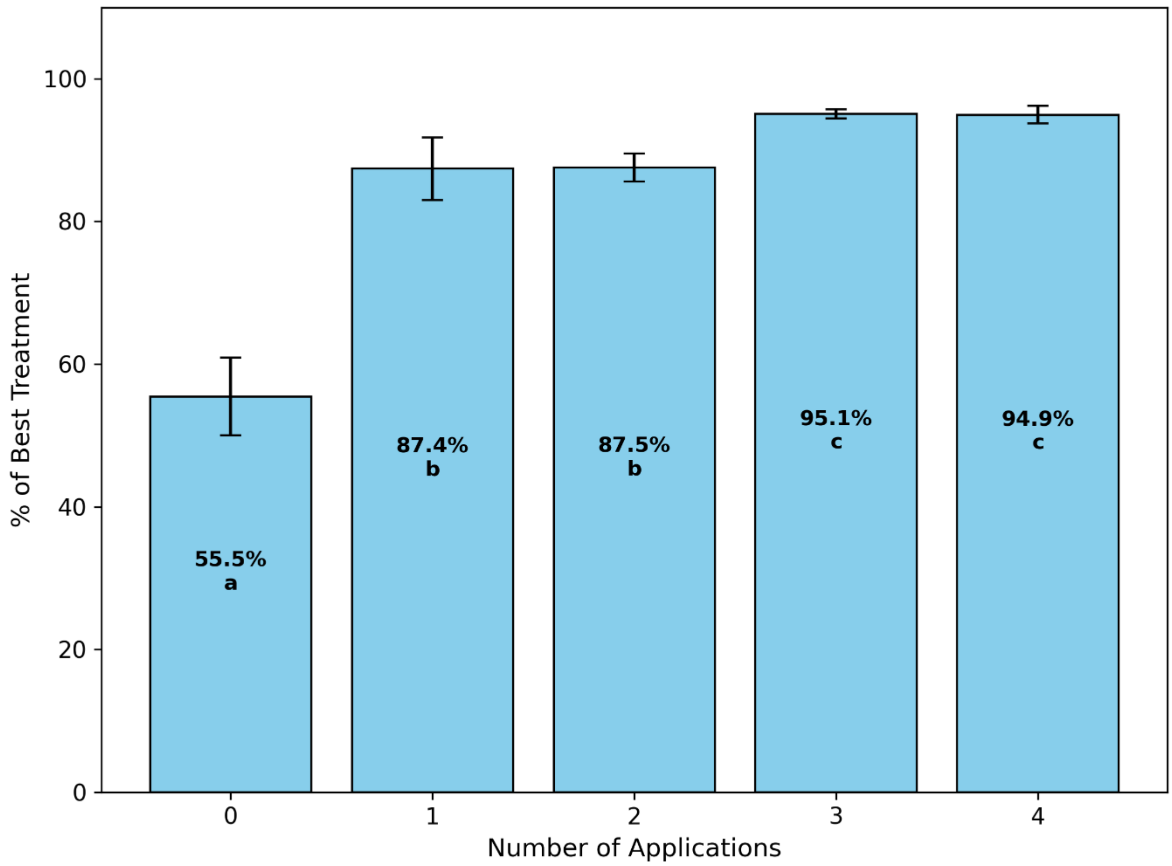

Figure 1. Relative seed yield of turf-type perennial ryegrass expressed as a percentage of the best experimental treatment, grouped by the number of fungicide applications per treatment. Data represent averages from ten field trials conducted in Canterbury, New Zealand, between 2017 and 2021. Error bars represent the standard error of the mean, and letters indicate LSD groupings (**Error! Reference source not found.**).

Impact of fungicide application at GS 32 on seed yield

Between the 2018 and 2022 harvest seasons, five field trials compared treatments with and without fungicide applied at GS 32. Within individual trials, seed yields were often the same whether Proline® (0.4 L/ha) was applied at GS 32 or not. However, when data from all trials were aggregated, the inclusion of a GS 32 fungicide resulted in a seed yield increase of 253 kg/ha ($P = 0.028$). Although the yield advantage was small within individual trials (often within the LSD), it was consistent across experiments and associated with improved performance (**Error! Reference source not found.**). These results support the strategic use of an early season GS 32 fungicide application, especially when disease risk is uncertain, to protect yield potential.

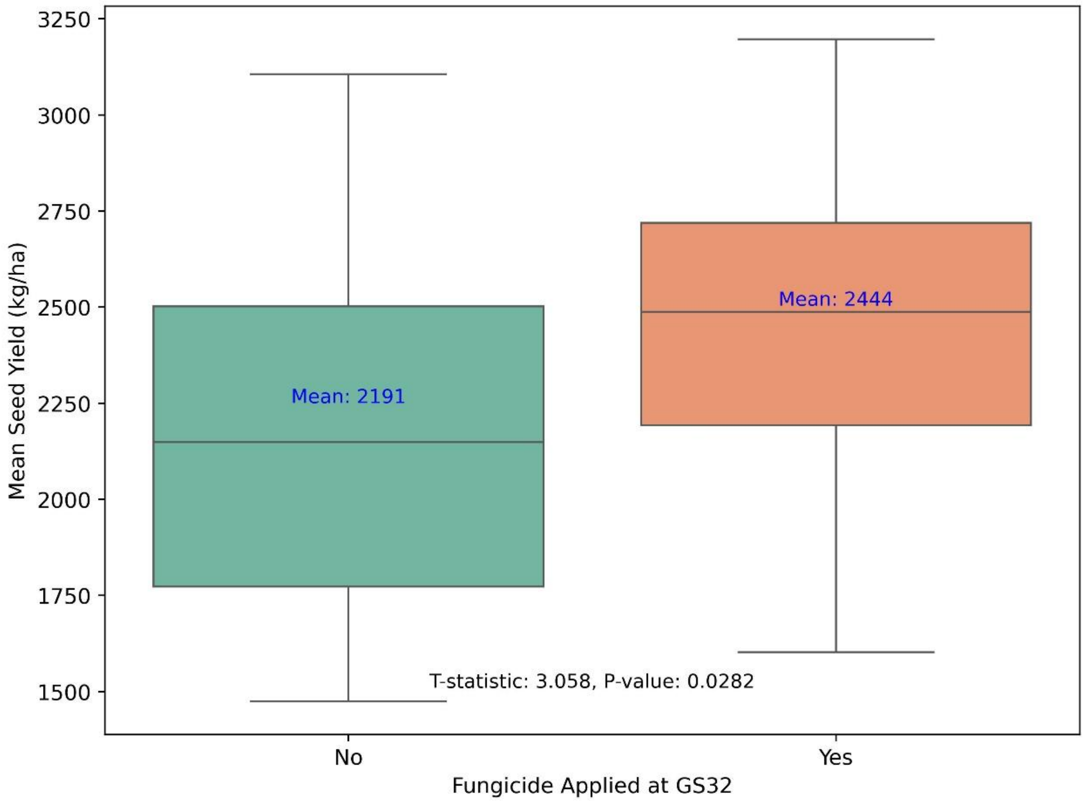

Figure 2. Seed yield of perennial ryegrass when fungicide was either included or excluded from the plant growth regulator applied at GS 32, data from five individual experiments where treatments were followed by identical fungicide programmes.

Flowering +14 days

There were very few direct comparisons for treatments that included a flowering +14-day fungicide application, with only four trials containing programmes of direct comparison. Across these trials, the inclusion of a flowering + 14-day fungicide treatment did not increase ($p = 0.078$) seed yield (**Error! Reference source not found.**). However, it is important to note the small sample size.

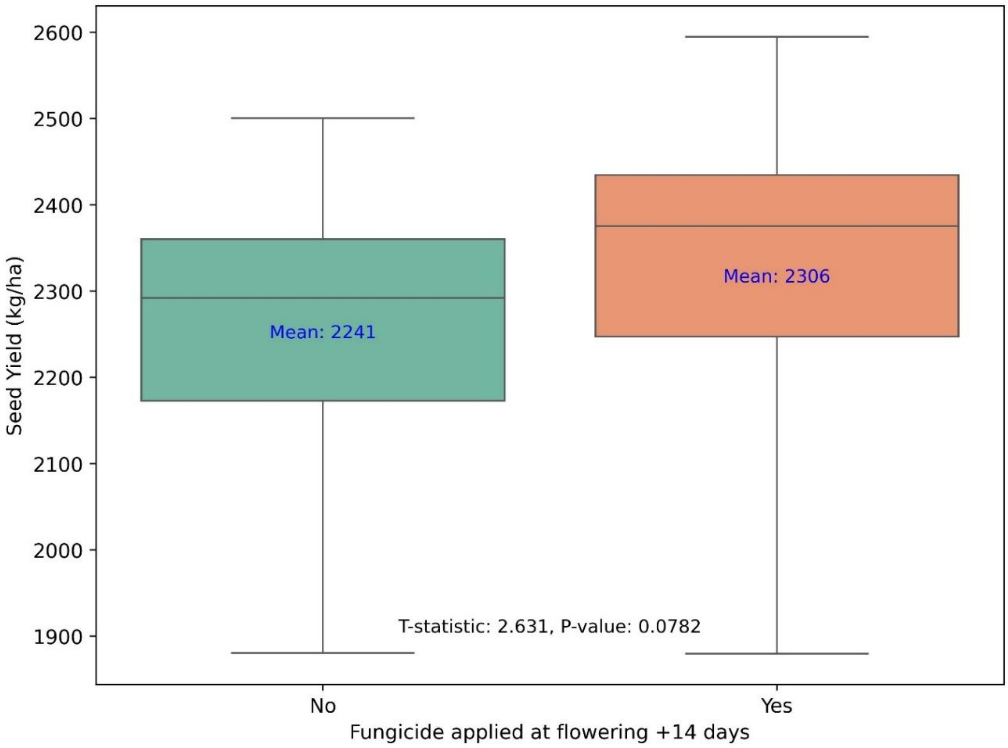

Figure 3. Seed yield of perennial ryegrass when a flowering + 14-day fungicide was either included, or excluded, after a standard three-spray programme including applications at GS 32, ear emergence and flowering. Data from four individual trials.

Summary

The combined results from ten Canterbury field trials clearly demonstrate that strategic fungicide use in perennial ryegrass seed crops can significantly enhance seed yield and profitability. On average, fungicide programmes increased seed yield by 77% compared with untreated plots, with the most effective treatments incorporating multiple applications, particularly at GS 32 and flowering stages. These findings reinforce the importance of proactive disease management, especially for stem rust, which poses a major threat during critical reproductive stages. The data also supports the inclusion of GS 32 applications in an integrated fungicide programme based on crop development stage.

References

MPI, 2014. Pfender, W.F., 2006. Rolston, et al., 2018. Rolston, et al.,2009.

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