Setting crops up to achieve yield potential

Kenton Porker[1] and Kaidy Morgan[2] on behalf of the PYF project team

[1]CSIRO Agriculture and Food, Adelaide, [2]Hart Field-Site Group

Key findings

- Species is a major risk and profit lever. Barley offers greater yield upside when emerged early and aligned with the environment but also carries greater downside risk, particularly for grain quality, when establishment is delayed or nitrogen is misaligned. Wheat is generally more stable across sowing dates and nitrogen strategies.
- You cannot fix crop structure late. Late nitrogen or favourable spring rainfall cannot fully compensate for insufficient canopy development earlier in the season. Crops must be structurally set up before the critical period to convert seasonal upside into grain yield.

Introduction

Profitable Yield Frontiers (PYF)

One of the challenging aspects of agronomy is making early-season decisions when the outcome of the season is still unknown. Sowing time, crop choice, plant density and early nitrogen strategy all shape yield potential well before confidence in rainfall improves. The GRDC Profitable Yield Frontiers (CSP2404-020RTX) is built around this practical challenge. PYF focuses on identifying early decisions that most consistently position crops to achieve a high proportion of their water-limited yield potential to capture upside when seasons turn favourable.

In cereals, yield potential is largely determined during the critical period (CP), from late stem elongation to flowering. Grain number is the main driver of yield and depends on crop growth rate during this window, the duration of the window, and how effectively biomass is allocated to reproduction. However, crop performance during the CP is heavily influenced by earlier decisions. Canopy development, radiation interception, nitrogen status and soil water supply all determine whether the crop has the structural capacity to respond when favourable conditions occur.

The central question becomes, how can we set crops up to convert favourable spring conditions into grain without overspending, and or structurally limiting the crop?

Methodology

Two trials were conducted to examine how early decisions influence critical period performance. At Hart in 2025, plant available water at sowing was low (18 mm).

Soil mineral nitrogen for the trial site was moderate to high, with approximately 92 kg N/ha in the 0–60 cm profile and 110 kg N/ha in the 0–100 cm profile.

Trial 1

Compared contrasting wheat and barley cultivars across two sowing dates in side-by-side factorial. Crops were sown on April 24 (irrigated to ensure establishment), and sown again on May 28, emerging with the June break. This had an overlay of conservative and aggressive N strategies applied early the same as low and high early N in Table 1.

Trial 2

Sown on May 28 and emerged with the break, this trial focused on wheat and examined plant density treated with three nitrogen strategies (Table 1). Three establishment scenarios were created: a suboptimal stand (<50 plants/m²) and a standard stand (~150 plants/m²), along with an increased radiation use treatment (with effectively zero row spacing). We also applied an additional 40 mm of water at flag leaf to capture upside.

Table 1. N strategies at Hart in 2025.

Nitrogen strategy	Total N applied (kg N/ha)	Timing of application	Seasonal target
Low Early N	0	No additional N applied	Conservative (Decile 2 scenario)
High Early N	70	Split across 4 leaf and mid tillering	Aspirational (Decile 8 higher yield target)
Deferred N	70	Single application at flag leaf	Tactical in-season strategy

Results and discussion

Trial 1: Preliminary results

Across treatments, canopy size entering the critical period and grain number was the dominant driver of yield. Despite large canopy differences (Figure 1), small but significant yield responses were measured. Where plant density was suboptimal, rainfed yields were constrained (1.69–1.82 t/ha). Although additional water and nitrogen increased yield, the absolute ceiling remained limited by canopy. Even with deferred nitrogen and supplementary water, small canopies lacked the capacity to fully convert added resources into grain number (Table 2).

Table 2. Rainfed yield (t/ha) and additional yield response to +40 mm water applied at flag leaf (shown in parentheses), Hart 2025. Confidence interval (CI) = 0.23 t/ha.

Wheat plant density configuration	Low Early N	High Early N	Tactical Deferred N
Suboptimal (<50 plants/m²)	1.73 (+0.30)	1.82 (+0.40)	1.69 (+0.68)
Standard (~150 plants/m²)	2.10 (+0.68)	1.94 (+0.84)	2.13 (+0.85)

By contrast, the standard (and zero) plant density treatment established a larger canopy prior to the CP and consistently achieved higher base yields (1.94–2.13 t/ha). Yield responses to the additional 40 mm of water were larger and more reliable (+0.68 to +0.85 t/ha), particularly under high and deferred nitrogen. These crops had the structural capacity to intercept radiation and better sustain growth during the CP.

The key message is that late inputs cannot fully compensate for insufficient canopy development earlier in the season. Crops must be adequately set up before the CP to translate favourable spring conditions into grain yield.

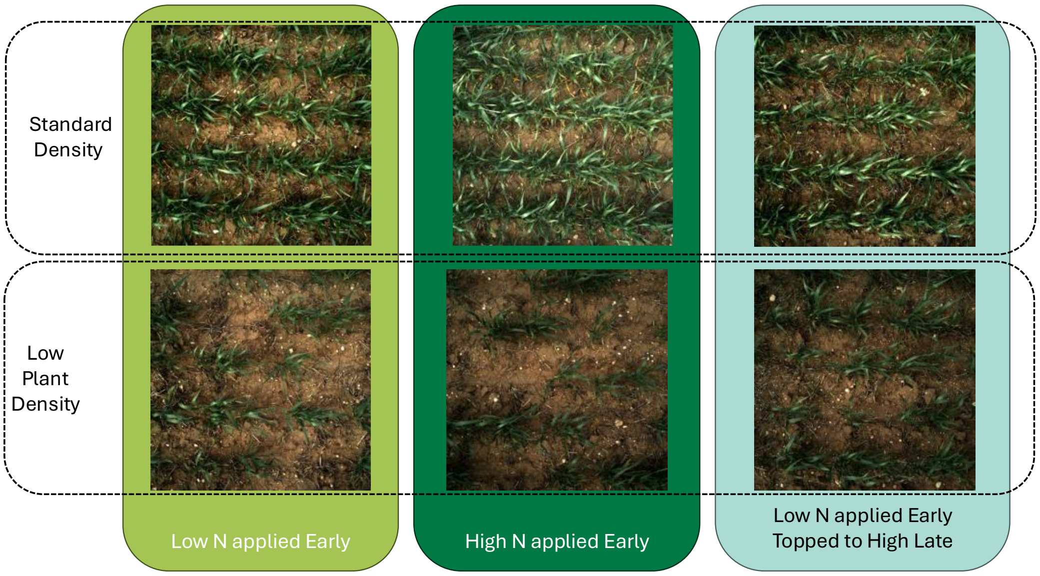

Figure 1. Graphical view of the Shotgun wheat entering the critical period on August 8.

Trial 2: Species is emerging as a major lever for yield and risk management

The highest yielding treatment at this site was early-emerged Bigfoot under a low N strategy (4.16 t/ha). In this seasonal context, maximising yield did not require aggressive nitrogen input. This has clear implications for managing nitrogen risk differently between crop types (Figure 2).

Species choice relative to emergence timing is proving to be one of the biggest levers growers and advisers have for managing both yield potential and seasonal risk. Across sites, early-sown barley delivered clear upside in moderate to high yielding environments.

At Hart, the April 28 germination and low nitrogen barley treatments yielded higher than wheat by a substantial margin. Bigfoot CL achieved 4.16 t/ha, Neo CL 3.77 t/ha and AGTB1010 (winter barley) 3.58 t/ha. In contrast, wheat yielded 2.65 t/ha (Shotgun), 2.42 t/ha (Mowhawk winter wheat) and 2.24 t/ha (AGT Colt). Only early emergence opportunity barley has been shown to have a clear yield advantage.

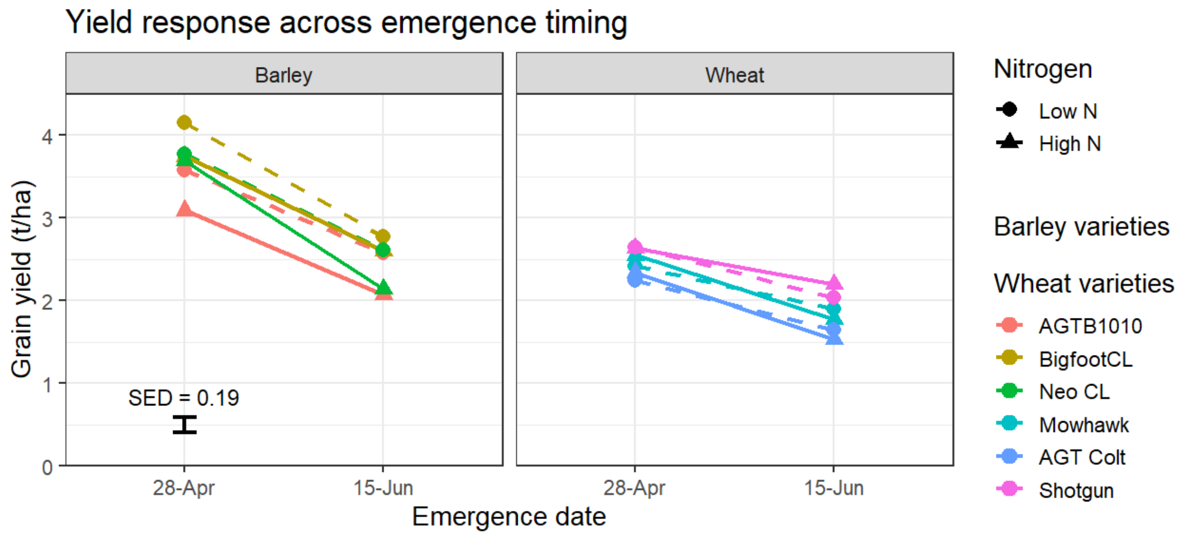

Figure 2. Grain yield (t/ha) of wheat and barley cultivars under two emergence timings (28-Apr and 15-Jun) and two nitrogen strategies (Low N = dashed lines; High N = solid lines). Panels are separated by species.

Despite the yield benefits from early emergence, barley also showed greater sensitivity to delayed emergence. When emergence shifted to June 15 (later break), Bigfoot declined from 4.16 to 2.77 t/ha and Neo CL from 3.77 to 2.61 t/ha. Wheat declines across the same window were smaller (for example, Shotgun declined from 2.65 to 2.04 t/ha). This highlights a strong environment × species interaction that has implications for management.

Barley also appeared more sensitive to nitrogen strategy. Under early sowing, high nitrogen reduced yield in several barley cultivars (e.g. Bigfoot declined from 4.16 to 3.74 t/ha). Wheat responses were more stable across nitrogen strategies. There is some evidence that higher nitrogen under later sowing accelerated yield decline in both species, but the magnitude of these interactions was consistently greater in barley.

Grain quality responses reinforce the trade-off

The yield trade-off in barley becomes even more pronounced when grain quality is considered (Figure 3). Small grain screenings showed a strong sowing date × nitrogen × species interaction. High nitrogen substantially increased screenings in barley, particularly under delayed emergence. For example, Neo CL screenings increased from 9.7% under low N to 24.7% (+15%) under high N when emergence occurred on June 15 and Bigfoot increased from 9.0% to 21.4% (+12%).

These are biologically and economically significant quality penalties. In contrast, wheat cultivars showed smaller and more stable nitrogen responses, typically less than 5% increase in screenings across sowing dates. These results indicate that barley carries greater quality risk under high nitrogen and delayed establishment. Barley offers greater yield upside when emerged early and well aligned with environment, but also greater downside risk, particularly for quality when establishment is delayed or nitrogen is misaligned.

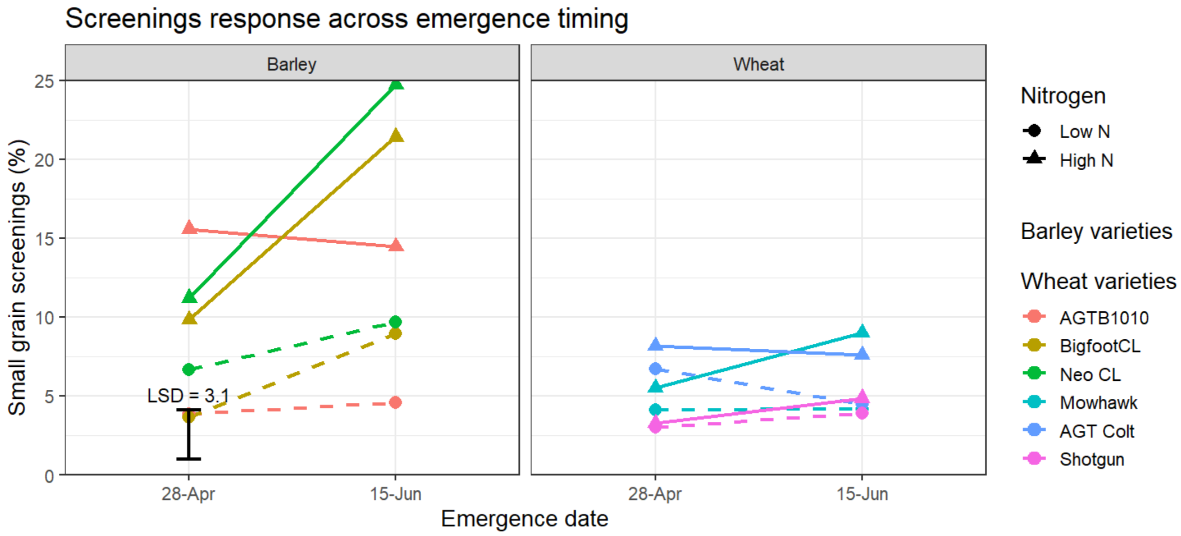

Figure 3. Small grain screenings (%) of wheat and barley cultivars under two emergence timings (28-Apr and 15-Jun) and two nitrogen strategies (Low N = dashed lines; High N = solid lines). Barley exhibited substantially larger increases in screenings under high nitrogen, particularly under delayed emergence, indicating stronger nitrogen-induced quality penalties relative to wheat.

Summary

Yield potential is largely set before flowering. Early decisions, sowing timing, species, plant density and nitrogen, determine whether crops enter the critical period with the structure needed to respond. Barley offers more upside when established early and is well aligned with environment but carries greater yield and quality risk if establishment is delayed or nitrogen is over supplied and this coincides with water stress. Wheat is generally more stable. The physiological reasons for this are being studied.

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