Agronomic drivers of yield in rain fed wheat production systems of Central West NSW – Trangie

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Key findings

- Sowing time for the wheat varieties was found to be the key determinant of yield potential. Delays in sowing date (SD) resulted in yield losses of 34% or 1.20 t/ha for EGA Gregory⁽ᴰ averaged across years.
- Variety selection was also found to be a significant factor influencing yield potential, with the longer season variety Sunvale⁽ᴰ being 16% or 0.6 t/ha lower yielding than LRPB Crusader⁽ᴰ from an early SD. The shorter season variety LRPB Crusader⁽ᴰ performed well across SD options in this environment.
- Increasing targeted plant populations was shown to increase yield potential by ~8% (0.2 t/ha) when SD was delayed, supporting the accepted principle of increasing the target plant population for delayed sowings.
- However, altering variety and/or maturity type, and increasing target plant populations in response to delayed SDs could not fully compensate for yield losses associated with delayed sowings.
- Yield responses to nitrogen (N) and phosphorus (P) fertiliser application rates were variable and influenced by starting soil levels and seasonal conditions. Significant yield responses of around 19% were achieved in response to P application, highlighting the importance of knowing starting soil nutrition values when trying to optimise yield potential.

Introduction

It is currently estimated that growers in the northern grains region (NGR) in NSW are achieving around 49% of water-limited yield potential (www.yieldgapaustralia.com.au). To put this into perspective, leading growers in Australia using best management practices and available technology are estimated to be achieving around 80% of water-limited yield potential indicating that yield is being limited by factors other than available water.

Water-limited yield potential is defined as the potential yield achieved under non-limiting nutrition and biotic stresses (e.g. weed competition) using best management practices, but subject to environmental constraints namely plant available water and temperature.

Based on these observations, there is an exploitable yield gap between actual and attainable yields (i.e. 80% of water-limited yield potential), which is considered the approximation of where grower's yields plateau within most major cropping systems, due to economic constraints and climatic variability.

Identifying the key drivers of yield in water-limited, rain fed environments is clearly an important strategy for reducing the exploitable yield gap and for increasing dryland wheat production. The aim of this research was to benchmark yield potential across a range of growing environments in the NGR of NSW, over two consecutive seasons, and to quantify the impact of genotype (G), management (M) and environment (E) on yield. Possible yield limiting factors investigated included variety selection (maturity type), sowing date (SD), plant population and fertiliser inputs (nitrogen and phosphorus). In addition to these factors crown rot, a major disease of wheat and barley crops in the NGR caused by the fungus Fusarium pseudograminearum (Fp), was also incorporated into this study.

This report outlines findings from dryland wheat experiments conducted at Trangie in the Central West of NSW in 2014 and 2015.

Site details

All sites were soil cored to ~1.2 m before sowing to determine plant available water capacities (PAWC), along with starting soil nutrition and other soil properties.

Locations

Site descriptions including site location, year of experiments and in-crop rainfall (May–October) are outlined in Table 1.

Table 1. Sowing date (SD), growing season rainfall and plant available water holding capacity (PAWC).

Site and year	SD1	SD2	Growing season rain* (mm)	PAWC (mm)
Trangie 2014	15 May	11 June	144	~67[1]
Trangie 2015	7 May	25 May	200	~76

*May to October.
[1]Estimation based on 25% of effective rainfall – November to March

Soil type and nutrition

Soil type, starting soil nitrate nitrogen and Colwell P for each experiment are outlined in Table 2.

Table 2. Soil type, starting soil N (nitrate N) and Colwell P.

Site and year	Soil type	P (Colwell) (mg/kg) 0–10 cm	Soil NO_3 (kg N/ha) 0–120 cm
Trangie 2014	Grey vertosol	76	94
Trangie 2015	Red-brown chromosol	23	127

Trial design

A series of 36 treatment combinations (two times of sowing × 18 treatments) were examined in a partially factorial split-plot design, with three replicates at each site (Table 3).

Table 3. Summary of treatments: sowing dates, variety, plant population, nitrogen and phosphorous rates and crown rot inoculum levels.

Treatment	Details
Two sowing dates (SD)	SD1: early/main season SD2: delayed
4 varieties	EGA Gregory[PBR] (SD1 & 2), LRPB Spitfire[PBR] (SD2), Sunvale[PBR] (SD1), LRPB Crusader[PBR] (SD1 & 2)
3 targeted plant populations	60, 120 or 180 plants/m^2
5 nitrogen rates	0, 50, 100, 150 or a 50 + 50 kg N/ha split application all applied as urea (46% N). Treatments were side banded at sowing, apart from the split application, which was applied at sowing and broadcast at stem elongation (GS31).
4 phosphorus rates	0, 10, 20 or 30 kg P/ha applied as triple super at sowing
4 crown rot (CR) inoculum rates	0, 0.5, 1.0 or 2.0 g/m row sterilised durum grain colonised by at least five different isolates of Fp± added at sowing i.e.; 0, CR+, CR++ or CR+++

Treatments

Treatments were designed similar to an exclusion experiment, with a high input treatment (i.e. 100 kg N/ha, 120 plants/m^2, 20 kg P/ha) aimed at providing the perceived optimum combination of factors and a low input treatment comprising a base set of agronomic factors to benchmark agronomic or management variables.

Four commercial spring wheat (*Triticum aestivum*) varieties widely grown and well adapted to the targeted growing environments were selected and sown at each location. Varieties were from two different maturity groupings: two main season-moderate maturing varieties EGA Gregory[PBR] and Sunvale[PBR] and two fast-moderate maturing varieties LRPB Crusader[PBR] and LRPB Spitfire[PBR]. At each location, varieties were sown on two SDs: an early-main season and a delayed SD (Table 1). Plant populations were grouped as low, moderate (district practice), or high and were targeted at 40, 80 and 160 plants/m^2 respectively.

Results

Experiments were conducted over two consecutive years at the Trangie Agricultural Research Centre. In 2014, the experiment was conducted on a grey vertosol and in 2015 on a red–brown chromosol (Table 2).

Sowing date (SD)

Yield results varied between site and year, ranging from 4.24 t/ha for SD1 in 2015, to 1.82 t/ha for SD2 in 2014, averaged across treatments (Table 4).

Table 4. Mean site yield (t/ha) and corresponding yield range (t/ha) for two sowing dates (SD) averaged across varieties.

Site and year	SD1 mean	Range	SD2 mean	Range
Trangie 2014	3.07	3.07–2.74	1.82	1.92–1.72
Trangie 2015	4.24	4.49–3.59	3.04	3.35–2.74

* All SD contrasts significant ($P<0.05$)

Sowing time was shown to be a key driver of yield, with delayed sowing resulting in a 1.20 t/ha decrease in yield in the across-sites analysis, equating to a 34% decline for EGA Gregory, SD1 vs SD2 (Table 5). When comparing individual site years, delays in SD resulted in yield declines of 42.5 kg/day in 2014 and 69.1 kg/day in 2015.

Table 5. Effect of management and crown rot (*Fp*) on grain yield potential – Trangie across site analysis.

Variety	Population (plants/m²)	Applied N (kg/ha)	Applied P (kg/ha)	*Fp* (CR+++)	Yield (t/ha)	Yield gap (t/ha)
SD1						
LRPB Crusader	80	100	20	0	3.78	
Sunvale	80	100	20	0	3.17	–0.61*
EGA Gregory	80	100	20	0	3.53[1]	ns
SD2						
EGA Gregory	80	100	20	0	2.33[1]	-1.20*
LRPB Spitfire	160	100	20	0	2.58#	
LRPB Spitfire	80	100	20	0	2.38#	–0.20*
LRPB Spitfire	40	100	20	0	2.14#	–0.44*

*Contrast are significant ($P<0.05$); ns = not significant
[1]EGA Gregory SD1 vs. SD2 contrast.
#SD2 contrasts relate to LRPB Spitfire

Variety

Variety selection was found to be a contributing factor to yield potential for the earlier SD1, with the quicker maturing variety LRPB Crusader out-yielding the longer, main season variety Sunvale by 0.61 t/ha, with no significant difference between LRPB Crusader and EGA Gregory (Table 5). Importantly, SD2 results for Trangie in 2015 did show that the faster maturing LRPB Crusader was higher yielding than EGA Gregory: 3.35 t/ha vs. 2.74 t/ha respectively (data not shown).

Crown rot (CR) disease pressure

Although increasing crown rot (CR) disease pressure (±*Fp* applied at sowing) did not result in a significant decline in yield, there was a trend of decreasing yield potential of approximately10% with increasing crown rot disease pressure (+*Fp*).

Nutrition

Varying N and P application rates had limited impact on yield potential, most likely due to high starting soil N and Colwell P values at the sites (Table 2). There was, however, a significant ($P<0.01$) yield response to P application with SD2 at Trangie in 2015 on a red–brown chromosol soil (Colwell P value of 23 mg/kg 0–10 cm), with a 0.54 t/ha increase in yield for the 20 kg P/ha treatment over the nil P treatment with N held constant at 100 kg N/ha (data not shown).

Plant population

Plant populations (40, 80 or 160 plants/m^2) had no effect on yield for SD1 at Trangie. In contrast, population had a significant (P<0.001) effect on yield when sowing time was delayed to SD2, with yield improving with increasing plant population (Figure 1). The low population treatment (40 plants/m^2) was 0.44 t/ha or 17% lower yielding with the 80 plants/m^2 approximately 8% or 0.20 t/ha lower yielding than the high population (160 plants/m^2), with a significant difference between all treatments (Table 5).

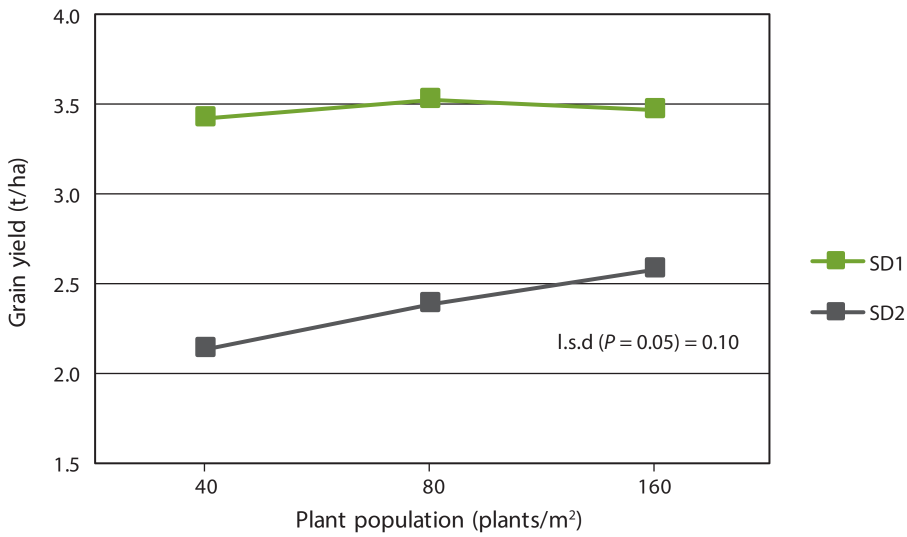

Figure 1. Yield response of wheat to plant population and sowing date – Trangie across site analysis.

Conclusions

Sowing time was found to be the key determinant of yield potential at Trangie with the yield for EGA Gregory^ declining by 34% (1.2 t/ha) averaged across years. The importance of timely sowing in this environment was also evident when looking at yield declines over time. In 2014, a 27-day delay in SD resulted in a yield decline of 42.5 kg/ha per day, with a delay in SD of 18 days in 2015, resulting in a yield decline of 69.1 kg/ha per day. These results underline that when SD is delayed, the growing environment is, in effect, being altered, reducing the length of the growing season along with potentially the timing and extent of environmental stresses, such as terminal drought or heat.

Variety selection was also shown to be a significant factor influencing yield potential, with the longer season variety Sunvale^ 16% or 0.6 t/ha lower yielding than LRPB Crusader^ for SD1. LRPB Crusader^ showed a trend for increased yield potential over EGA Gregory^ with a delayed SD.

Increasing targeted plant populations was shown to increase yield potential when the SD was delayed at Trangie, supporting the accepted principle of increasing targeted plant populations for delayed sowings. At Trangie, for example, for SD2 the yield increased with higher plant populations, with the high targeted population of 160 plants/m^2, out yielding the low (40 plants/m^2) and the district practice rate (8 plants/m^2) by 17% (0.44 t/ha) and ~8% (0.20 t/ha) respectively. Importantly however, changing variety selection in response to delayed SDs and increasing targeted plant populations could not fully compensate for yield losses associated with delayed sowing. These findings further highlight the advantage of sowing well-adapted varieties, in the early part of their optimum sowing window, and also highlights wheat's ability to compensate for lower plant populations under adequate growing conditions (i.e. SD1).

Yield responses to N and P fertiliser application rates at Trangie, were variable and influenced by starting soil levels (comparatively high starting soil N and Colwell P) and, to some extent, seasonal conditions. Importantly however, there was a significant yield response of ~19% or

0.54 t/ha to 20 units of P in 2015, on a soil with a Colwell P value of 23 mg/kg 0–10 cm. This result highlights the importance of knowing your starting soil nutrition values (e.g. Colwell P) when making fertiliser decisions.

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