Does increasing wheat sowing rates to combat weeds lead to yield or quality instability in the low rainfall regions of CW NSW?

Maurie Street[1] & Ben O'Brien[1]

[1] Grain Orana Alliance

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Take home messages

- With ever increasing levels of herbicide resistance, growers need to employ non-herbicide strategies such as increasing crop competition, to aid in the battle against weeds.
- Increasing sowing rates to increase crop competitiveness may be cheaper and easier to adopt than alternates such as reducing row spacings.
- Growers' fears of reduced yields or increased screenings from higher seeding rates has been shown in this study to be uncommon
- Lower sowing rates often resulted in lower yields than higher rates.
- Increasing crop populations had either no impact on screenings or reduced them.
- There is little risk to yield or quality by increasing crop competitiveness by raising sowing rates.
- In 99% of yield and 97% of screenings comparisons there was no negative impacts from moving from the lowest population to the next highest (60-100 or 30-70 plants/m^2)

Background

The farmers' battle with weeds is ageless, with the weapons used continuously evolving. Primitive farmers hand weeded, horses and steel saw the start of mechanised control, with development of herbicides in the mid-20th century creating a revolution to our farming system.

Weed control has steadily improved over time but this trajectory is starting to slow. Through increasing herbicide resistance, weeds are adapting to survive in our modern farming practices and systems that rely heavily on herbicides are challenged.

This was reinforced at recent GRDC National Grower Network (NGN) meetings in Central NSW in 2024 where controlling weeds rating among the highest constraints to growers. Improving control of weeds with advanced herbicide resistance is central to farm enterprise sustainability.

Depending on release of new herbicide chemistries cannot be relied upon for weed control going forward so growers need to look toward alternative, non-chemical tools as part of an integrated weed control program.

WeedSmart is an industry collaboration aimed at educating growers on options to combat herbicide resistance. Based on significant research and development they have developed the 'Big 6' strategy, which comprises of 6 integrated approaches to improve weed control. Increasing crop competition is of one of the 'Big 6' and is based on a large body of research that shows that a competitive crop can reduce weed numbers and hence seed set. Weed Smart states that this can be achieved by changing row spacings, selecting more competitive crops or cultivars and early sowing. Another option is to increase crop density by increasing sowing rates. Increasing sowing rates is relatively easy, cheap and achievable, compared to changing row spacings via machinery modifications or purchase.

Many growers in the lower rainfall areas of Central West (CW) NSW are concerned that by increasing sowing rates, it may result in lower yields or increased screenings, colloquially referred to as 'haying off', 'blowing up' the crop or 'a blowout' in screenings.

Growers in these lower rainfall areas are commonly targeting lower than often recommended sowing rates as a mechanism to combat these perceived risks. It is less clear if growers appreciate that this action could be influencing weeds or affecting yields and grain quality.

Growers in the medium to high rainfall zones tend to sow higher rates, but it could be questioned if improved weed control outcomes could be achieved through further increases and that concerns over yield and quality may also be preventing adoption.

Grain Orana Alliance (GOA), with GRDC' support, has been doing wheat populations trials in CW NSW, since 2018. Initially this work looked at increasing seeding rates in late sowing scenarios toward the end of the drought of 2017-2019 when late breaks and low stored moisture were common.

These experiments were a precursor to the main body of trials that ran from 2020 till 2024, looking specifically at the interaction between wheat population and yield/quality stability over key varieties. The aim of this work was to give growers confidence in low rainfall environments that increasing seeding rates to improve weed control does not lead to increased risk of lower yields or increased screenings. Further to this is suggested that if yields and quality prove to be stable in the low rainfall areas of CW NSW, then growers in higher rainfall areas should also be comfortable with the concept.

Research

This paper details the findings of 12 trials, conducted from 2018 to 2024 in CW NSW. The trials included a range of common wheat varieties, tested for a range of sowing rates and subsequent crop populations to measure the impact on crop yield and quality. These trials were managed to be weed free, so any differences in crop performance would be a function of the population rather than of weed burdens.

The trial was small plot, full factorial randomised complete block design with 4 replicates. Results were analysed by ANOVA with a 95% confidence level.

Varieties

The varieties tested were selected as they were commonly grown in the district and included some contrasting plant types such as tillering and crop height. The varieties chosen are primarily mid-maturity types as only one time of sowing was possible at each site. Details of the varieties grown in each year is detailed in **Table 1**.

Table 1. Number of trials in each year that the variety was tested.

VARIETY	2018	2020	2021	2022	2023
Beckom		2	1	2	2
Condo		2	1	2	2
Coolah		2	1	2	2
Dart	3				
Kittyhawk	3				
LRPB Flanker	3	2	1	2	
LRPB Hellfire					2
LRPB Lancer	3	2		2	2
LRPB Mustang		2	1	2	2
LRPB Raider					2
LRPB Reliant					2
LRPB Spitfire	3	2	1	2	
Scepter		2	1		
Suntop	3	2			
Vixen			1	2	

Sowing rates and plant populations

Four plant populations were targeted in this work (detailed in **Table 2**). The sowing rates for each variety, averaged over trialling years are listed in **Table 3**.

To achieve the decided population each variety had their sowing rates adjusted to reflect differences in seed size (grains/kg) and germination percentage. As targeted populations increased, adjustments were made to reflect a lower establishment rate.

The low-end targeted populations aimed to cover the lower sowing rates commonly used by growers. The high sowing rates were sufficiently high to thoroughly test concerns over negative outcomes often raised with higher rates but would not be considered commercially relevant.

Table 2. Years in which plant populations were targeted

	Targeted plant populations (plants/m^2)							
YEAR	**30**	**60**	**70**	**100**	**110**	**140**	**150**	**180**
2018		✓		✓		✓		✓
2020-2024	✓		✓		✓		✓	

Table 3. Actual sowing rates (averaged over all years) (kg/ha).

	Targeted plant population (plants/m²)							
VARIETY	**30**	**60**	**70**	**100**	**110**	**140**	**150**	**180**
LRPB Dartⓓ		24		45		69		100
LRPB Kittyhawkⓓ		30		56		85		123
LRPB Flankerⓓ	14	24	35	43	60	66	91	96
LRPB Lancerⓓ	13	26	34	49	60	74	92	108
LRPB Spitfireⓓ	14	32	36	59	63	89	96	130
Suntopⓓ	14	35	37	64	65	97	99	142
Beckomⓓ	12		29		51		77	
Condoⓓ	14		36		62		95	
Coolahⓓ	14		35		61		93	
LRPB Hellfireⓓ	16		41		71		108	
LRPB Mustangⓓ	13		33		57		87	
LRPB Raiderⓓ	14		36		63		95	
LRPB Reliantⓓ	14		35		61		94	
Scepterⓓ	13		34		59		91	
Vixenⓓ	16		41		71		109	
AVERAGE	**14**	**29**	**35**	**53**	**62**	**80**	**94**	**117**

The sites:

Concerns around increasing sowing rate around yields and grain quality are greatest in lower rainfall environments with hotter and drier grain filling conditions more common. Additionally, low sowing rates are most common in these areas and more expensive or complex weed control options are often not affordable.

For this reason, trial locations were targeted at the lower rainfall zones, generally on the outer fringe of the cropping areas of CW NSW. In 2018, sites were not necessarily selected on these criteria however the low rainfall received along with low levels of stored soil moisture of the time represented what can happen in drier years, even in traditionally higher rainfall locations.

A range of seasonal conditions has been experienced in this work. Both 2018 and 2023 are characterised as drier years with low starting soil moisture and 2020-22 and 2024 wetter years with good, stored soil moisture. Site details for the long-term average rainfall and the rainfall received in the trial year, both in-crop and over the year are detailed in **Table 4**.

Table 4. Long term average (LTA) and trial year rainfall (mm).

Location	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	In crop rainfall
Coonamble	LTA	56	48	39	31	34	35	32	24	28	37	41	43	448	221
	2024	75	31	22	40	43	66	30	33	13	56	68	62	540	281
Tottenham	LTA	47	46	42	34	37	35	30	30	28	40	38	45	451	234
	2024	82	49	46	60	100	25	45	33	19	31	83	94	666	313
Nyngan	LTA	52	48	42	34	36	35	31	29	28	37	38	41	451	230
	2023	46	0	35	29	2	43	31	3	0	10	80	44	321	118
Warren	LTA	45	44	41	31	35	35	30	26	29	37	38	42	431	223
	2023	42	3	10	29	14	20	30	4	0	12	101	26	292	109
Coonamble	LTA	57	50	40	32	37	37	33	26	29	39	44	46	469	233
	2022	78	28	43	77	73	14	20	64	116	130	83	47	773	494
Tottenham	LTA	49	48	43	35	37	36	33	32	30	42	42	46	472	245
	2022	54	36	53	114	98	5	38	87	81	212	106	22	906	635
Tullibigeal	LTA	41	34	37	33	36	38	36	33	31	42	36	39	435	249
	2021	139	58	110	0	23	82	56	12	53	33	145	43	755	259
Lake Cargelligo	LTA	41	32	38	33	38	38	37	34	31	40	37	37	435	251
	2020	13	49	60	82	13	31	20	42	44	65	19	29	468	297
Nyngan	LTA	47	49	40	29	35	34	29	27	27	35	37	45	434	216
	2020	10	46	101	105	17	18	30	37	35	46	5	66	515	288
Fifield	LTA	48	46	44	35	37	37	33	33	31	43	42	45	475	249
	2018	12	29	11	4	4	43	0	8	15	66	74	99	364	140
Forbes	LTA	42	42	40	35	37	37	37	36	35	42	41	44	468	259
	2018	23	11	2	8	23	34	1	7	6	43	42	33	233	122
Nyngan	LTA	51	48	42	31	34	34	29	28	26	37	38	41	440	219
	2018	54	9	2	3	8	33	0	16	6	75	54	19	278	141

Results

Due to the significant amount of information generated by these trials the full details and results of each trial are not included and can be accessed at: www.grainorana.com.au/documents

The findings from this study presented using comparisons. Each comparison compares statistically analysed responses within any one variety, a location and a year for the 4 plant populations tested. This approach allows for 90 comparisons to be made over 5 years and the 12 trials conducted.

To summarise the impacts on yields and screenings across the populations ranges, results have been grouped into 4 characterisations.

- **Increasing:** yields or screenings increased with increasing populations.
- **Decreasing:** yields or screening decreased with increasing populations.
- **Nil:** no change in yields or screenings from changes in populations.
- **Inconsistent:** impacts on yields and screenings were variable under increasing populations.

The following categories are considered a positive outcome.

- Yields: either **increasing** or **nil** effect.
- Screenings: either **decreasing** or **nil** effect.

Established plant populations
Seeding rates were adjusted for seed size, germination percentage and a predicted establishment rate. In most cases the establishment achieved was close to the desired plant populations, with clear contrasts between the 4 established populations for all sites.

Crop competitiveness
Vegetation index (VI), measured by handheld normalised differential vegetation index (NDVI) meter was undertaken across all sites and it is suggested to be used as a proxy measure for crop competitiveness.

The effects of plant population on VI is illustrated in **Figure 1** . In all instances increasing plant populations increased the mean VI (not statistically analysed), suggesting increased competitiveness from increased plant populations. Some varieties had higher VI than others (at the date of measurement) Furthermore the rate of increases in VI levels in response to increasing plant populations was also different between varieties.

Impacts on yield

The effect on yields is set out in **Figure 2.**

- In 71% of comparisons (64 out of 90), yields either **increased** as populations increased or there was **nil** effect.
    - In 42% of comparisons (38 out of 90) yields **increased**.
    - In 29% comparisons (26 of the 90) there was **nil** impact of plant populations.
- In 21% comparisons (19 out of 90) responses were **inconsistent** to population increases.
- In 8% of comparisons (7 out of 90), yields **decreased.**

Impacts on screenings

The effects on screenings % is set out in **Figure 3**.

- In 68% of comparisons (61 out of 90), screenings either **decreased** as populations increased or there was **nil** effect.
    - In 19% comparisons (17 out of 90) screenings **decreased** when populations increased.
    - In 49% of comparisons (44 out of 90), plant populations had no **nil** impact on screenings.
- In 20% of comparisons (18 out of 90), the impact was **inconsistent**.
- In 12% of comparisons (11 out of) screenings **increased** as populations increased,

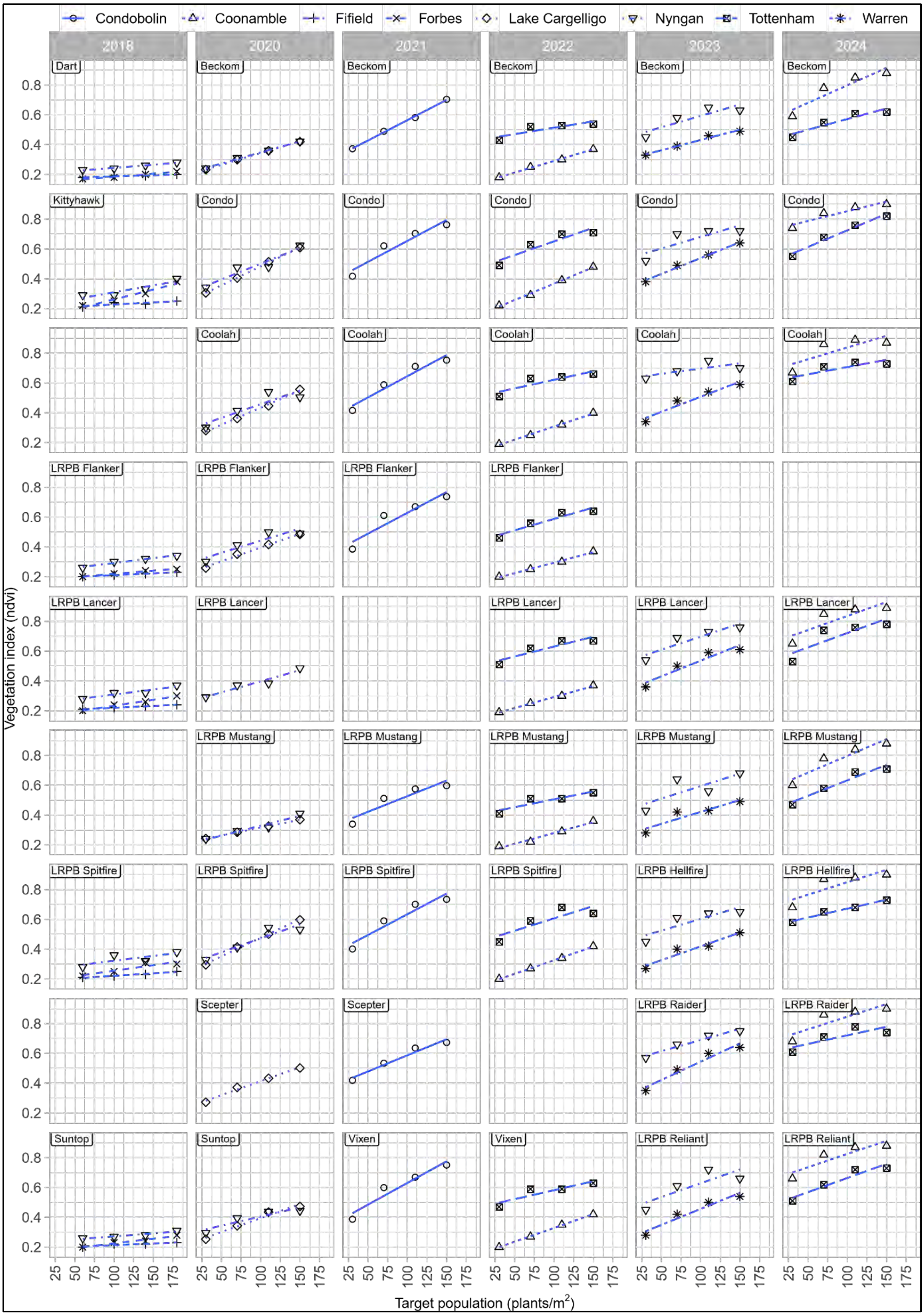

Figure 1. Impact on VI across varieties, locations and years in response to changes in targeted plant populations

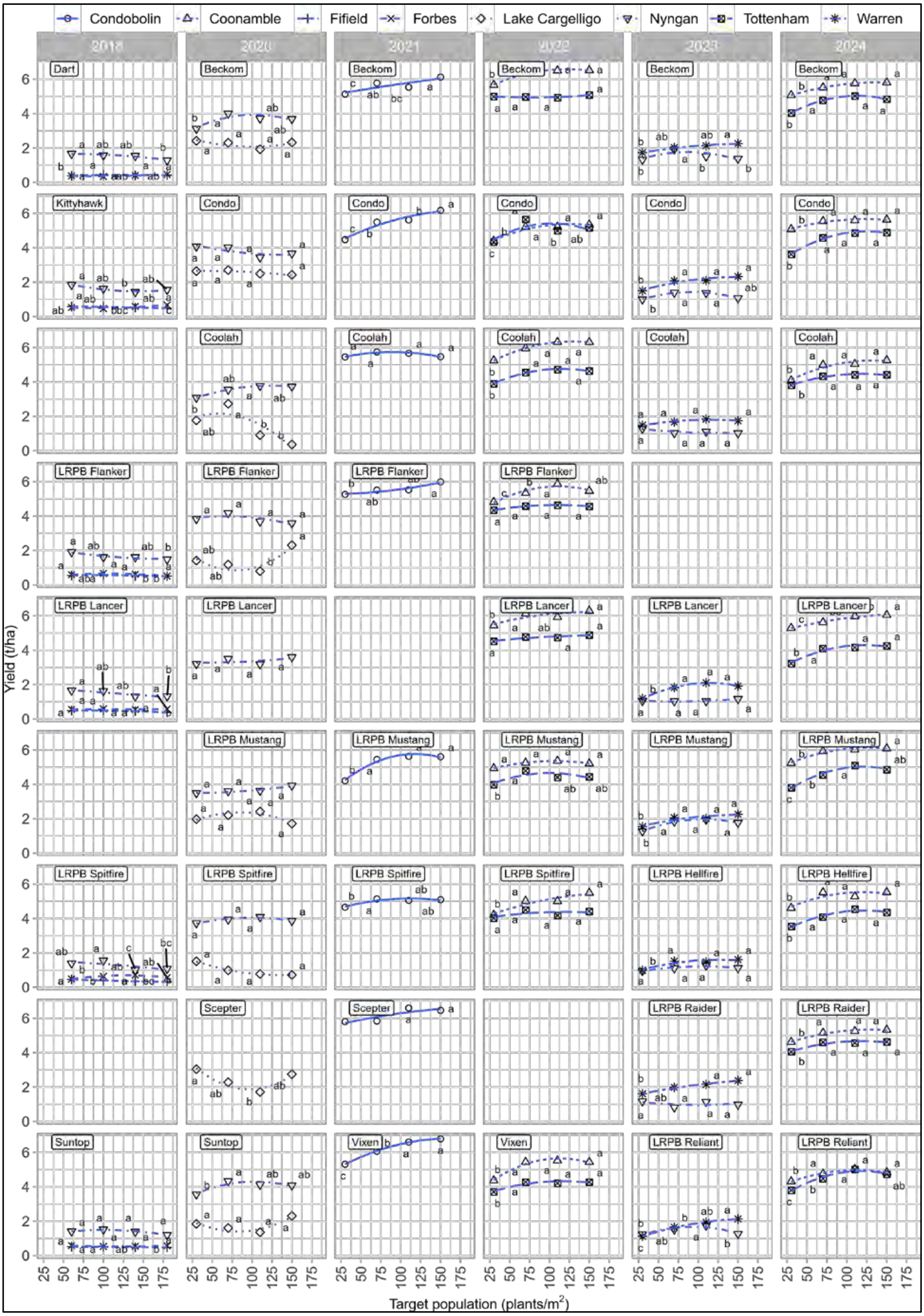

Figure 2. Impact on yield (t/ha) across varieties, locations and years in response to changes to targeted plant populations

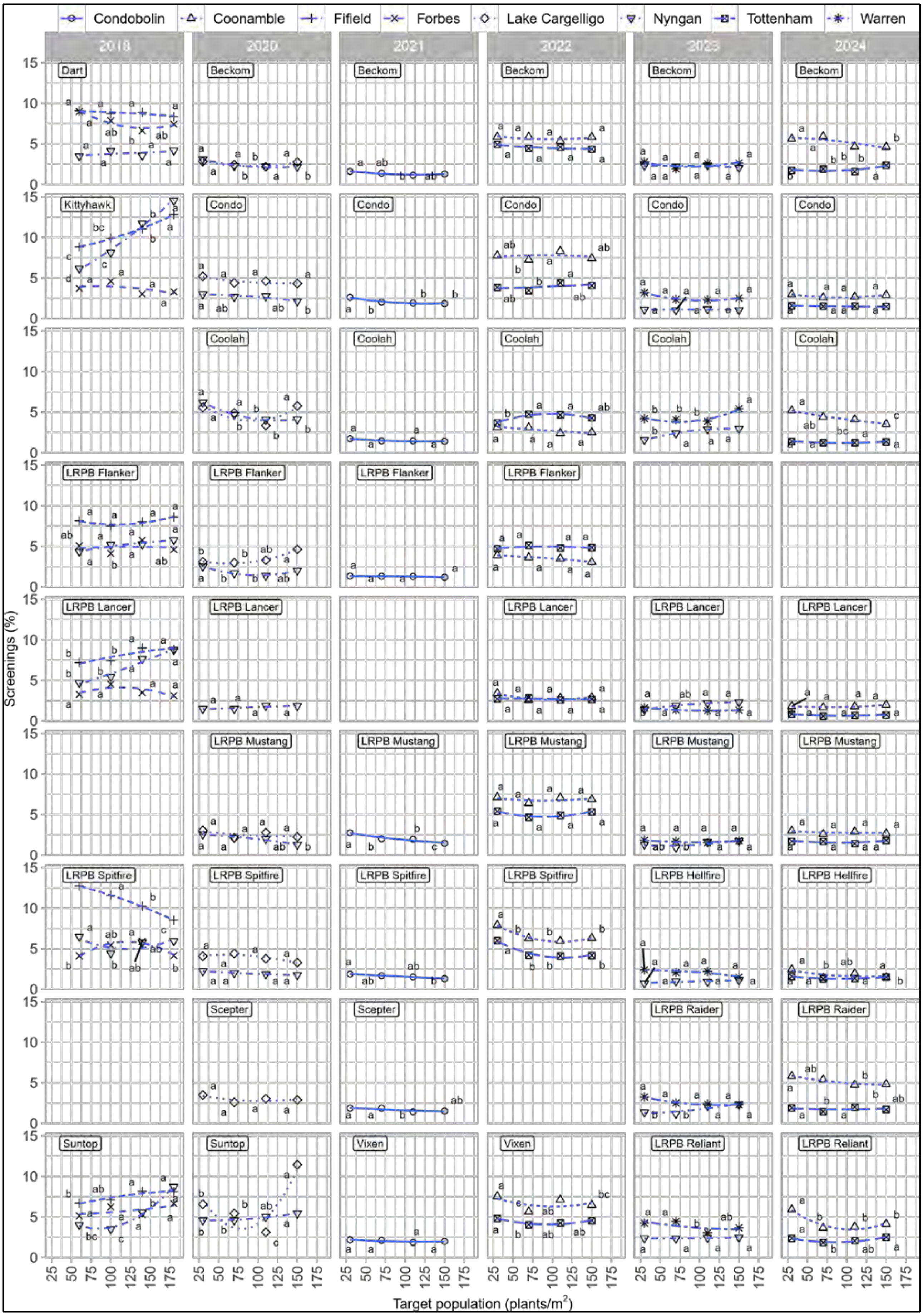

Figure 3. Impact on screenings (%) across varieties, locations and years in response to changes to targeted plant populations.

Discussions

Vegetative index.

Crop VI increased consistently across the populations tested correlating to improved weed competition. Because of this relationship, any increase in sowing rates has potential to improve crop competition against weeds. However, it is suggested the most effective gains would be achieved from increases from the lowest populations.

Varietal differences were also measured for VI with some varieties showing higher VIs for the same sowing date, suggesting some may be better for weed competition earlier in the crop cycle which is weeds first establish and compete the most.

Additionally, the rate of VI change with increasing plant populations also differed between varieties suggesting some may be more responsive to increasing populations than others.

Yields

In the context of increasing plant populations primarily to increase weed competitiveness the impact on yields was shown to be good outcome. Overall, 71% of comparisons showed either increasing plant populations (and weed competitiveness) to result in either no impact on yield or to increase them. Yields increased in 42% of comparisons with an average of 0.67 t/ha improvement or up to 1.7t/ha in some comparisons. Yields were improved most frequently when the population was increased from 30 to 70 plants/m^2.

The mechanism by which this improvement was achieved was not investigated by this study but may likely be related to insufficient biomass and tiller production to take full advantage of the resources (e.g. soil, nutrition and water) available.

In most comparisons further increases in yields in response to populations >70 plants/m^2 where not common. Which agrees with many other bodies of research.

Nineteen comparisons or 20% had inconsistent effects. Yields both went up and down in response to increasing populations. However, in all but one of these, the yields from the highest populations (150-180 plants/m^2) was not different to or higher than that from the lowest population, challenging the perceived risk that high sowing rates result in lower yields. In this study, sowing wheat at a high sowing rate was equal or better than a low sowing rate (30 plants/m^2).

On the negative, in the 8% of comparisons where yield reductions occurred, all were sown very late (5 July) in the 2018 drought year. In 4 of these treatments, yield reductions were <130kg/ha. In the 3 other comparisons yield reductions were up to ~430kg/ha (or ~ 22%). The lowest yield was achieved from the highest but from arguably an extreme population of 180 plants/m^2, at the other 3 more moderate populations (60, 100 and 140 plants/m^2) yields were not different. For these 3 treatments the varieties, LRPB Dart$^{\phi}$, LRPB Flanker$^{\phi}$ and LRPB Lancer$^{\phi}$ had the highest seeding rates at 100, 96 and 108 kg/ha respectively. Very high rates considering the 5 July sowing date.

As such growers increasing target very low populations should not interpret this as any evidence that increasing rates to a more moderate level are any more risky for yield and screenings.

Only one comparison out of 90 demonstrated a yield decrease with increasing plant populations from very low levels to a more moderate populations.

Screenings

For screenings %, in 68% of comparisons, there was either no impact from increasing plant populations or a reduction in screenings suggesting growers could either benefit from or there be no impact to wheat quality from increasing sowing rates.

For 20% (n=18) of comparisons there were inconsistent impacts on screenings, but the effect was often small varying only +/- 2%. In only 2 comparisons did screenings vary more than 5%, Both occurring in Suntop[(b]. In 15 comparisons- screenings were lower under the highest populations compared to the lowest.

In 12% (n=11) of comparisons did screenings increase with populations. In only 2 comparisons did the variation in screenings exceed 4%, and one with 8.4% variation across the range of populations. In only 4 out of 11 comparisons where screenings increased with populations, would bin grade changed in response to changes in screenings alone. As the data has shown in most comparisons the impact of increasing populations has either been beneficial or neutral. Of the comparisons with variable or negative outcomes the impacts have been relatively small in terms of the level of influence of even economically where binned grade would have changed in response.

In a more practical consideration of the plant populations tested there was practically no evidence of downside risks to yields and screenings when considering moving from lower populations to more moderate ones. In 99% of yield comparisons and 97% of screenings comparisons there was no negative impact from moving from the lowest population to the next highest bracket (60-100 or 30-70 plants/m^2). In the very dry 2018 conditions there was only one case where there was a yield decline (~60kg/ha) when moving from 60-100 plants/m^2 and one case where screenings increased which was less than 2% . This should give growers in lower rainfall environments confidence to move towards the higher target plant populations recommended by NSW DPIRD in these areas, i.e. 70 – 90 plants/m^2.

Summary

Increasing plant populations through increased sowing rates consistently increased crop competitiveness. Regardless of what seeding rates growers in the lower rain zones are currently using, considering many are employing low rates now, any increase to them will likely bring improved competition against weeds.

In this series of trials, increasing plant populations showed in most cases (68% and 71%) to either have a positive or neutral influence on both yield and quality. In a further ~20% of cases, both yields and screenings showed inconsistent impacts of increasing populations, but the interrogation of the evidence does not support the likelihood of the negative outcomes' growers are often concerned with.

Of the cases where there was a negative impact from increasing populations on yield or screenings the impacts were relatively small particularly when compared to the potential upside from increasing plant populations.

A clear learning from this set of 12 trials is that growers should increase sowing rates to >30 plants/m^2, as yield loss at this sowing rate was common, even in lower rainfall years environments. Increasing populations above 70 plants/m^2 may results in higher yields but the main benefit is improved weed competition. Therefore, as recommended in the Weedsmart Big 6, growers can increase their sowing rates and without excessive risks to yields and screenings.

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Contact details

Maurie Street
Grain Orana Alliance
Maurie.street@grainorana.com.au

Ben OBrien
Grain Orana Alliance
ben.obrien@grainorana.com.au