GOA trial site report

Validation of the benefits of deep placement of phosphorus fertiliser in Central Western NSW.

Grain Orana Alliance

Trial code:	GONU014-1
Season/Year:	Autumn 2018
Location:	Leichart, Geurie
Trial partners:	Brett Robinson
Trial establishment date:	4/06/2018

Keywords

GANU014, Phosphorous, nutrition, Collwell, deep placement, stratification

Take home messages

- Applying phosphorus (P) at or close to the soil surface results in yields as good as or better than deep placed P.
- Positive results to deep P placement in Queensland were not consistently achieved in the Central West (CW) trials.
- There were no instances where a combination of deep plus annual P applications was better than an annual application only.
- There was no additional yield where P was applied both deep and annually.
- There was no yield or economic advantage from deep P application. The deep P application was at an economic disadvantage due to the costs associated with P application at depth.
- There was no difference in yields between the ripped and unripped treatments.

Background

Research from Queensland (QLD) has shown that deep application of P fertilisers has improved yields in annual grain crops in some situations. Stemming from this research several guidelines have been developed which aim to predict responsiveness to deep applied P. Validation of such responses has been very limited in the CW of NSW.

GOA trial site report

Soil testing undertaken by Grain Orana Alliance (GOA) during their existing trial programs identified paddocks predicted to respond to deep applied P based on these guidelines. Recent work by other organisations have identified similar circumstances where P concentrations appear to be stratified close to the soil surface with limited P availability at depth.

Overlaying these guidelines is whether our environment and rainfall patterns could impact the relative responsiveness of soils that should respond to deep P and have demonstrated responses in QLD and Northern NSW trials.

The frequency of rainfall within the winter growing season increases as you move north to south in eastern Australia. With this move from north to south, the reliance on deep stored moisture from the fallow period decreases. This theoretically allows the P in the shallower soil layers where it is applied or accumulating to be more accessible than in the northern environment This could lead to decreased responses to deep applied P, despite there being little P at depth and the crop responding to applied P.

Aims

Validate the responsiveness of crops in the CW of NSW to deep applied P were predicted by the current thresholds. Compare this response against a more typical application to depths of 2-8 cm.

Methodology

Trial design		
	Type	Small plot (~12m x 2 m)
	Design	Randomized split plot
	Replications	3
	Analysis	ASREML
	Confidence interval	95%

Site Selection:

This site was selected because it was thought to be P responsive. Testing of soils from this site (Table 1) showed that the topsoil had modest levels of Colwell P, declining to very low levels deeper in the profile. Research on vertisols in the QLD predicts that yield responses to subsoil application of P is more likely where the Colwell and BSES P is less than 10 and 30 respectively (in the 10-30 cm soil layer). This site meets this criterion.

Table 1. Soil P levels, tested prior to application of fertiliser treatments in 2018.

Location	Analyte/Assay	Unit	0-10 cm	10-30 cm	30-60 cm	60-90 cm
Geurie	Phosphorus (Colwell)	mg/kg	14	<5	<5	<5
Geurie	Phosphorus (BSES)	mg/kg	27	5	<5	9
Geurie	Phosphorus Buffer Index		120	200	210	160

Rainfall

Since the trial was established, there has been a range of seasonal conditions, 2018 and 2019 were dry to very dry with no crop harvested in these years. 2020, 2021 and 2022 were above average rainfall years. Rainfall details are in Table 2.

Table 2. Monthly rainfall[2] (mm) and long-term average (LTA) at trial site.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2018	45	16	8	8	14	16	3	32	9	74	80	34	**339**
2019	55	43	56	2	20	13	6	10	14	11	26	4	**260**
2020	66	96	120	140	32	37	72	45	44	74	26	70	**822**
2021	55	76	174	9	20	117	58	37	37	45	181	65	**874**
2022	124	16	69	187	75	13	80	113	93	193	53	14	**1030**
LTA	62	52	52	45	43	46	45	42	42	52	56	54	**591**

Treatments

The trial tested a range of annual P rates to establish a yield response curve. Placement depth and spacing were also tested as follows:

Deep applied P

MAP applied in the Autumn of 2018 as follows:

- depths: 10 and 20 cm
- row spacing: 27.5 cm and 50 cm
- initial (deep placement) P rates: 0, 25 and 50 kg P/ha (as MAP).

Annual applied P

MAP applied annually at sowing as follows:

- depths: 4-6 cm (at sowing depth for wheat, banded below canola seed)
- row spacing: 27.5 cm
- Rates 0, 12.5 and 25 kg P/ha (as MAP).

The trial was established in 2018 which turned into a very dry year. The surrounding paddock was fed to livestock, while the trial was fenced off and sprayed out in September. Drought conditions ensued with the trial not sown in 2019.

Trials were then sown and harvested from 2020 to 2022.

The trial was not continued in 2023 as the farmer returned the paddock to a pasture phase.

The treatments and crop history at the site are detailed in Table 3.

Table 3. Trial cropping and treatment history.

Year	Crop	Phosphorous	Phosphorous rates (kg/ha)
2018	Trial initiation	Deep	0, 25, 50
2018	Fallow	None	nil
2019	Wheat (failed)	Annual (drought)	0, 12.5, 50
2020	Canola (44Y90)	Annual	0, 12.5, 50
2021	Wheat (Beckom)	Annual	0, 12.5, 50
2022	Wheat (Beckom)	Annual	0, 12.5, 50

The trial was designed using a factorial structure. The full treatment list is outlined in Table 4 and includes the cumulative P applied to each treatment.

Table 4. Treatments and cumulative application rates (kg/ha). Highlighted treatments are detailed in this report.

Rip/P placement		Initial P pate	Annual P rate					Cumulative
Width	Depth	Deep	2018	2019	2020	2021	2022	total P
55	20	50	0.0	0.0	0.0	0.0	0.0	50
	20		12.5	12.5	12.5	12.5	12.5	100
	20		25.0	25.0	25.0	25.0	25.0	150
	20	25	0.0	0.0	0.0	0.0	0.0	25
	20		12.5	12.5	12.5	12.5	12.5	75
	20		25.0	25.0	25.0	25.0	25.0	125
	20	0	0.0	0.0	0.0	0.0	0.0	0
	20		12.5	12.5	12.5	12.5	12.5	50
	20		25.0	25.0	25.0	25.0	25.0	100
	10	50	0.0	0.0	0.0	0.0	0.0	50
	10		12.5	12.5	12.5	12.5	12.5	100
	10		25.0	25.0	25.0	25.0	25.0	150
	10	0	0.0	0.0	0.0	0.0	0.0	0
	10		12.5	12.5	12.5	12.5	12.5	50
	10		25.0	25.0	25.0	25.0	25.0	100
27.5	10	50	0.0	0.0	0.0	0.0	0.0	50
	10		12.5	12.5	12.5	12.5	12.5	100
	10		25.0	25.0	25.0	25.0	25.0	150
	10	0	0.0	0.0	0.0	0.0	0.0	0
	10		12.5	12.5	12.5	12.5	12.5	50
	10		25.0	25.0	25.0	25.0	25.0	100
No rip	0		0.0	0.0	0.0	0.0	0.0	0
	0		12.5	12.5	12.5	12.5	12.5	50
	0		25.0	25.0	25.0	25.0	25.0	100

Results

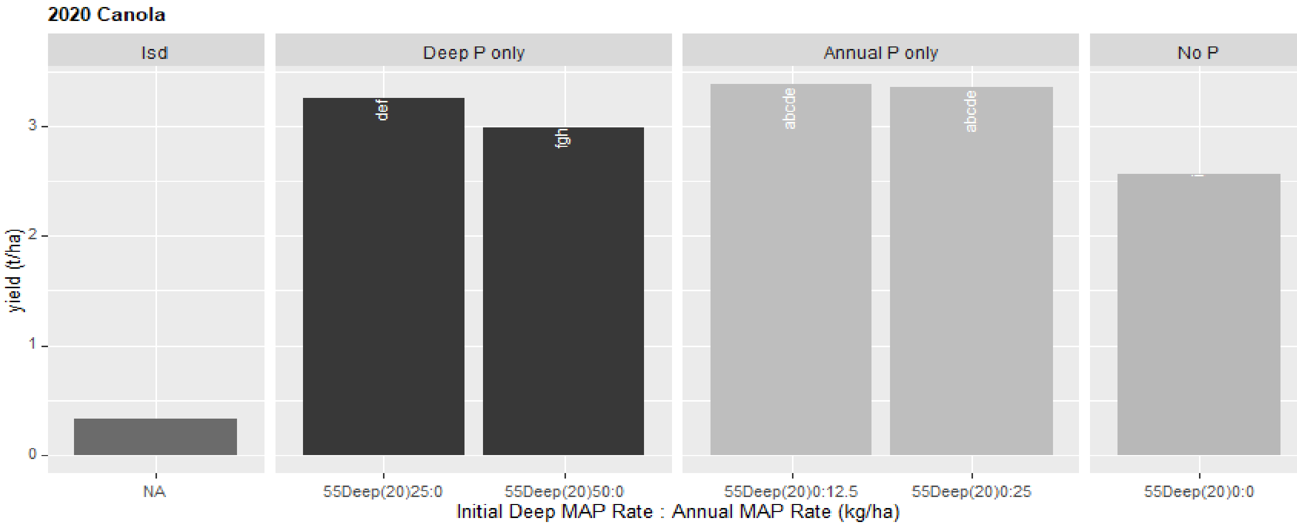
Yield

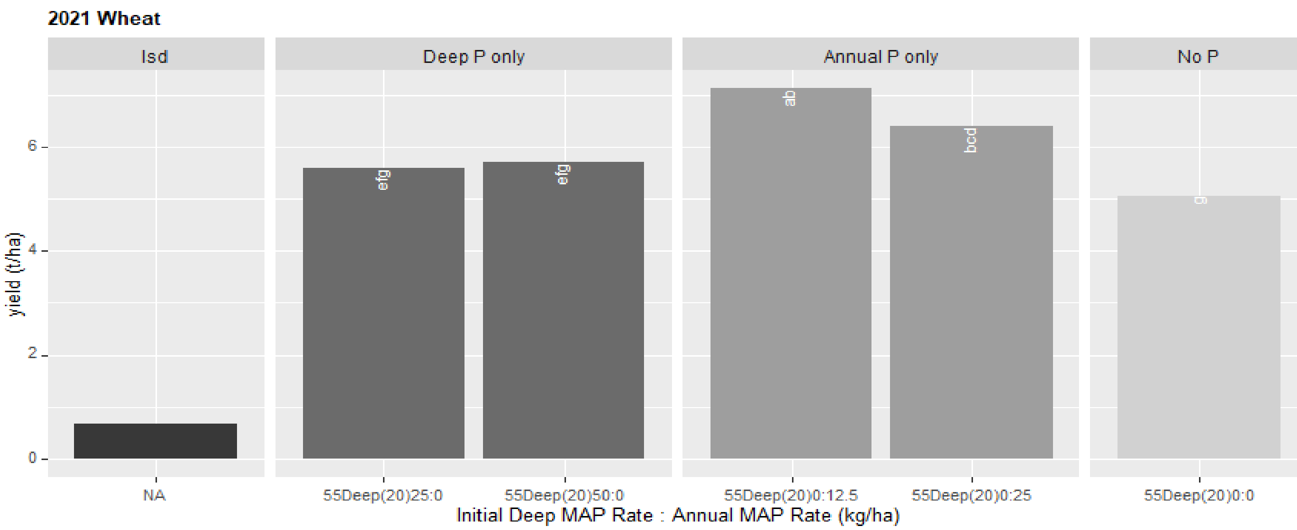
In the 3 years of the trial, there was a response to applied P with higher yields where P was applied compared to zero P. Comparing the effects of deep applied P and annual P did not show any benefit from deep application compared to shallow over the 3 years of crops (Figure 1).

Crop 1: The canola crop in 2020 was high yielding, the average site yield was 3.3 t/ha (Figure 1) and oil was 42%. There was no yield difference between where 25 kg/ha P was applied deep and the 2 annual treatments (these had a cumulative application of 37.5 and 75 kg P/ha for the 12.5 and 25 kg/ha treatments respectively). The deep treatment with 50 kg P/ha had a lower yield than either of the annual only treatments.

Crop 2: The 2021 wheat crop was also very high yielding; the average site yield was 6.3 t/ha and protein was 11%. The 12.5 kg P/ha treatment yielded >7 t/ha, ~ 1 t/ha more than either of the deep P only treatments, keeping in mind that the annual treatments had a cumulative P application of 50 kg/ha (same as the higher rate, deep P only treatment).

Crop 3: The wheat crop in 2022 was also high yielding, the average site yield was 5.2 t/ha and protein was 9.8%. The deep P only treatment at the lower rate (25 kg P/ha) had a similar yield to both the annual treatments.


2020 Canola
lsd
Deep P only
Annual P only
No P
def
fgh
abcde
abcde
yield (t/ha)
3
2
1
0
NA
55Deep(20)25:0
55Deep(20)50:0
55Deep(20)0:12.5
55Deep(20)0:25
55Deep(20)0:0
Initial Deep MAP Rate : Annual MAP Rate (kg/ha)


2021 Wheat
lsd
Deep P only
Annual P only
No P
efg
efg
ab
bcd
g
yield (t/ha)
6
4
2
0
NA
55Deep(20)25:0
55Deep(20)50:0
55Deep(20)0:12.5
55Deep(20)0:25
55Deep(20)0:0
Initial Deep MAP Rate : Annual MAP Rate (kg/ha)

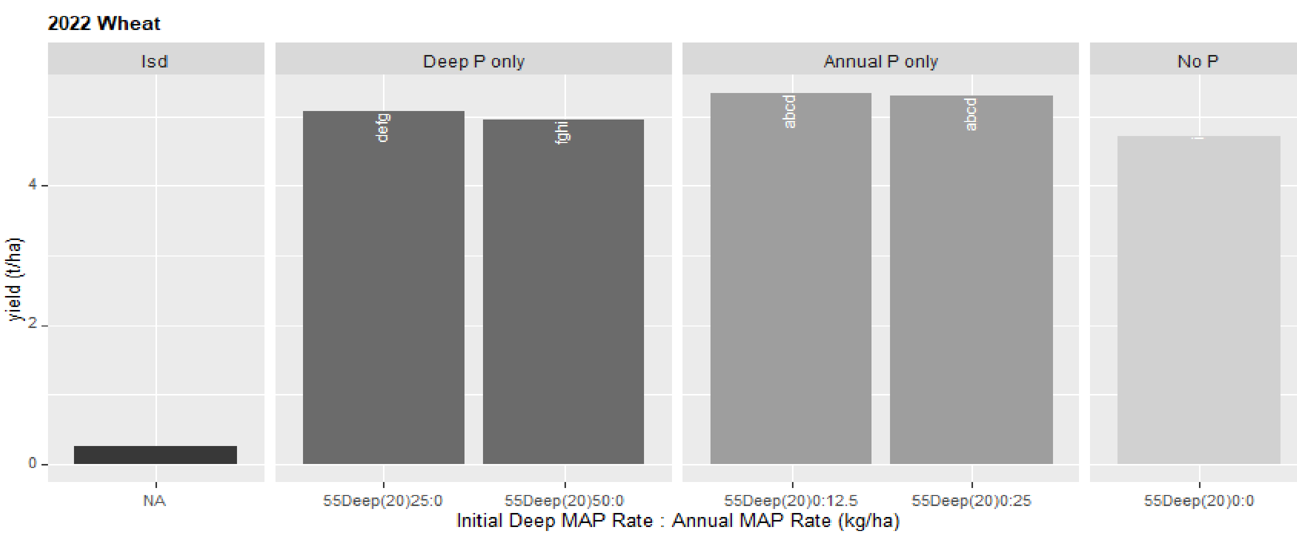
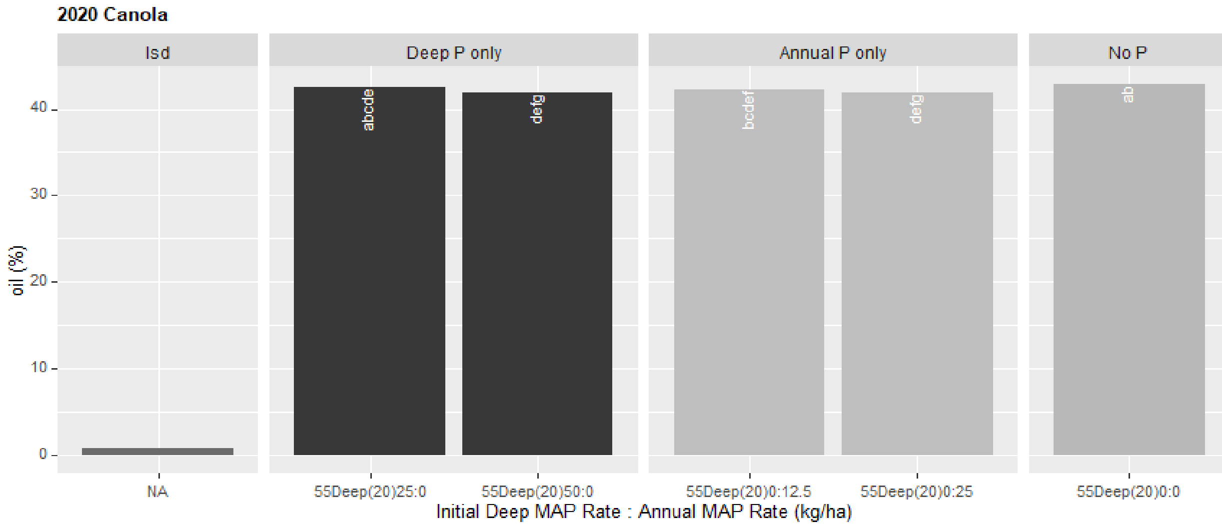
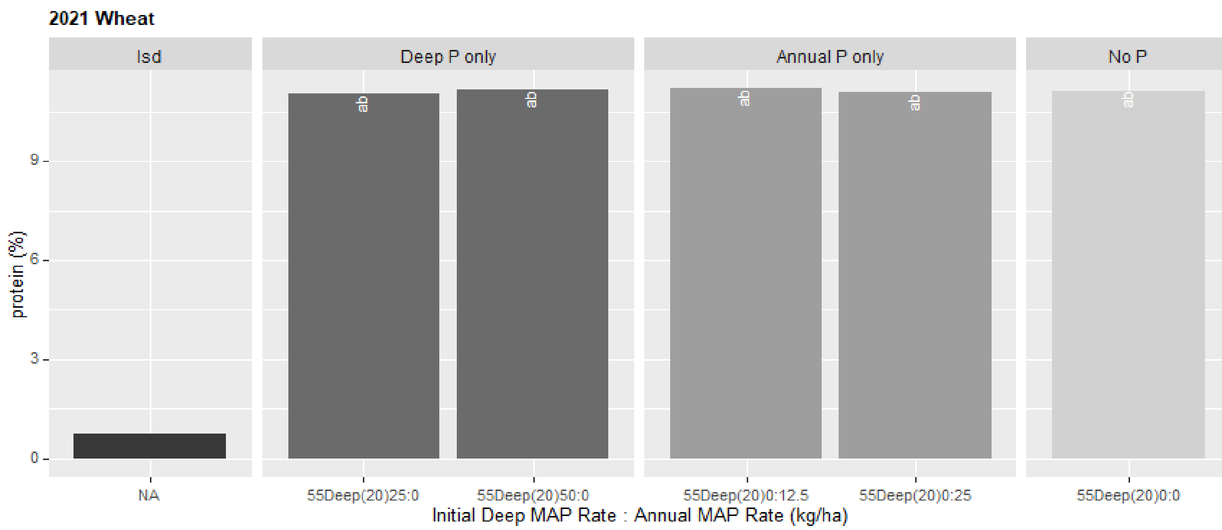

2022 Wheat
lsd
Deep P only
Annual P only
No P
defg
fghi
abcd
abcd
yield (t/ha)
4
2
0
NA
55Deep(20)25:0
55Deep(20)50:0
55Deep(20)0:12.5
55Deep(20)0:25
55Deep(20)0:0
Initial Deep MAP Rate : Annual MAP Rate (kg/ha)

Figure 1. Yield (t/ha) for canola in 2020, wheat in 2021 and 2022 for selected treatments. Treatments with the same letter are not significantly different.

Oil and Protein

There was no difference in grain quality between the deep and shallow treatments (Figure 2).


2020 Canola
lsd
Deep P only
Annual P only
No P
oil (%)
0
10
20
30
40
abcde
defg
bcdef
defg
ab
NA
55Deep(20)25:0
55Deep(20)50:0
55Deep(20)0:12.5
55Deep(20)0:25
55Deep(20)0:0
Initial Deep MAP Rate : Annual MAP Rate (kg/ha)


2021 Wheat
lsd
Deep P only
Annual P only
No P
protein (%)
0
3
6
9
ab
ab
ab
ab
ab
NA
55Deep(20)25:0
55Deep(20)50:0
55Deep(20)0:12.5
55Deep(20)0:25
55Deep(20)0:0
Initial Deep MAP Rate : Annual MAP Rate (kg/ha)

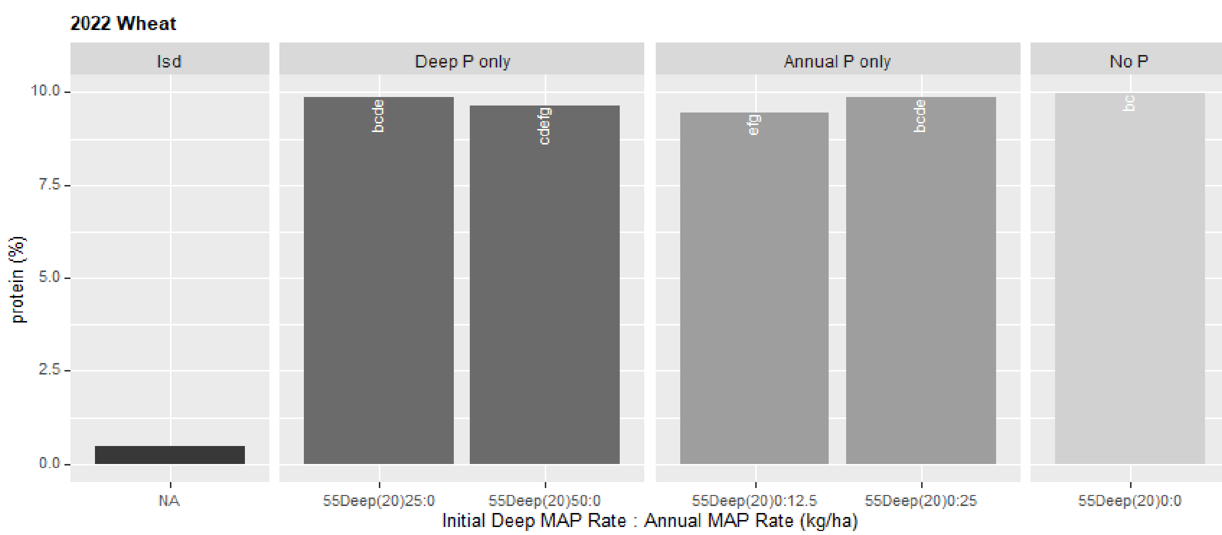

2022 Wheat
lsd
Deep P only
Annual P only
No P
protein (%)
0.0
2.5
5.0
7.5
10.0
bcde
cdefg
efg
bcde
bc
NA
55Deep(20)25:0
55Deep(20)50:0
55Deep(20)0:12.5
55Deep(20)0:25
55Deep(20)0:0
Initial Deep MAP Rate : Annual MAP Rate (kg/ha)

Figure 2. Grain quality, oil and protein (%) for canola in 2020, wheat in 2021 and 2022 for selected treatments. Treatments with the same letter are not significantly different.

Discussion

The ripping and deep application of P went into very dry soil, bringing up large and very hard clods. These subsequently took a long time to break down under the very dry conditions resulting in a far from an ideal seedbed for the 2018 sowing, despite this a crop was established. In September, both the trial and the surrounding crop were sprayed out due to a lack of moisture. There was no effect from deep ripping on stored fallow moisture for the trial, with no yield difference between the ripped and non-ripped treatments, nor any treatment effect of the rip spacing. It is possible that the working required to apply deep P and to establish a seedbed would affect the performance of the subsequent crop, and should be taken into consideration when deciding to deep apply P.

The drought broke in 2020 with a wetter year and there was little or no response in the canola crop to applied P. Similar yields were obtained where no P was applied versus the higher P rates, regardless of when or how it was applied.

The starting levels of P (2018 background Colwell P of 14 ppm) would have suggested that very high yields achieved in both 2020 and 2021 should have been limited, however this was not the case. This could be due to a combination of:

1. mineralization that occurred in the previous 2018/2019 drought
2. canola's deep root system can penetrate soil faster (~2cm/day) and for longer than wheat”[1], and was able to access P through the whole profile.

At this site, the annual treatments have received 4 fertiliser applications over 3 crops (due to the drought in 2018-19) and may have benefited from the additional fertiliser. It is also possible that the concentrations of P in the plant row were now very high, particularly in the 25 kg P/ha annual treatments where 100 kg/ha P (~456 kg/ha MAP) has been drilled into the plant line during the trial.

There was a yield response to both deep and annual applied P in the 2020 canola, remembering that the annual plots had P applied in 2019 to a failed wheat crop, up to where 12.5 kg P/ha was applied (or a total of 25 kg/ha assuming residual from the failed crop of 2019). There was no additional yield where P was applied both deep and annually. There was also no yield difference between the 2 ripping depths (10 cm and 20 cm) nor the 2 ripping spacings (27.5 cm and 50 cm). No ripping effects were recorded (non-ripped treatments were included).

In the 2021 wheat crop, there was a yield response where annual P was applied. However, there was no difference between the deep P and zero P treatments. There was also no additive effect where both deep and annual P were applied. By 2021, the annual 12.5 kg treatment had received a total of 37.5 kg P/ha, still less than the 50 kg P/ha deep P treatment and yielded 1.4 t/ha more.

[1] Canola’s deep roots - agronomy to capture benefits and manage legacies - GRDC

In 2022, a P response remained. However, regardless of the depth or width of the P placement, there was no combination that included deep P which had a better yield than where P was applied at sowing, with the seed. There remained no yield differences between the ripped and unripped treatments.

The results from this trial suggest that in wetter growing seasons, the application of deep P may not be justified, and deep P use may be more suited to growing winter crops in summer-dominated rainfall areas.

What is unusual at this site is the very high yields achieved in both 2020 and 2021 despite the very low starting levels of P, which would have suggested that crop yields should have been limited.

Conclusions

The first crop after a deep application of P can respond in a similar manner to conventional applications. Longer term benefits were not realized in the second or third crop post application. It is possible that the wetter seasons may allow crops to better forage P in such seasons where they have access to the full soil profile.

Acknowledgements

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DISCLAIMER — TECHNICAL

Appendix

Results

Table 5: Results 2020 (canola)

Phosphorous rates Deep (initial) (kg/ha)	Annual	Yield (t/ha)		Oil (%)		Protein (%)		Admix (%)	
27.5 Deep(10)0	0	2.9	ghi	43.1	a	22.0	efgh	0.7	abc
	12.5	3.5	abcde	42.6	abcde	22.1	defgh	0.6	abc
	25	3.4	abcde	42.0	cdefg	22.2	cdefgh	0.7	abc
27.5 Deep (10)50	0	3.3	bcdef	42.1	bcdefg	22.5	bcdefgh	0.4	bc
	12.5	3.4	abcde	41.8	efg	22.4	bcdefgh	0.5	bc
	25	3.5	abcd	41.9	defg	22.0	efgh	0.4	bc
55 Deep (10)0	0	2.8	hi	42.6	abcd	21.9	fgh	0.7	abc
	12.5	3.5	abcde	42.7	abc	22.2	cdefgh	0.5	abc
	25	3.2	def	42.1	bcdefg	22.1	defgh	0.5	abc
55 Deep (10)50	0	3.2	efg	42.2	bcdef	22.6	bcdefg	0.5	abc
	12.5	3.7	a	42.4	abcdef	22.1	defgh	0.7	ab
	25	3.2	efg	41.7	fgh	21.7	h	0.9	a
55 Deep (20)0	0	2.6	i	42.8	ab	21.8	h	0.5	abc
	12.5	3.4	abcde	42.2	bcdef	22.4	bcdefgh	0.5	abc
	25	3.4	abcde	41.9	defg	22.6	bcdef	0.5	abc
55 Deep (20)25	0	3.3	def	42.6	abcde	22.0	efgh	0.6	abc
	12.5	3.6	ab	42.8	ab	22.7	bcde	0.5	bc
	25	3.4	abcde	40.9	h	23.0	ab	0.5	abc
55 Deep (20)50	0	3.0	fgh	41.9	defg	22.8	bcd	0.4	bc
	12.5	3.7	a	41.8	fg	22.9	abc	0.6	abc
	25	3.6	abc	41.4	gh	23.6	a	0.5	abc
NoRip0	0	2.8	hi	42.6	abcd	22.2	defgh	0.3	c
	12.5	3.3	cdef	42.4	abcdef	21.8	gh	0.8	ab
	25	3.4	abcde	41.8	fg	21.8	h	0.4	bc
lsd		0.3		0.7		0.8		0.4	

Table 6: Results 2021 (wheat)

Phosphorous rates Deep (initial) (kg/ha)	Annual	Yield (t/ha)		Test weight (kg/hl)		Protein (%)		Screenings (%)	
27.5 Deep (10)0	0	5.3	fg	75.0	a	11.5	ab	2.5	abcd
	12.5	6.7	abc	72.9	cde	11.3	ab	2.6	abcd
	25	6.7	abc	72.4	defg	11.2	ab	2.1	d
27.5 Deep (10)50	0	5.9	def	73.7	b	11.2	ab	2.9	abcd
	12.5	6.2	cde	72.0	g	11.1	ab	2.8	abcd
	25	7.1	ab	72.6	cdefg	11.7	a	3.1	ab
55 Deep (10)0	0	5.3	fg	74.9	a	11.5	ab	2.8	abcd
	12.5	6.8	abc	72.3	efg	11.4	ab	2.4	bcd
	25	7.1	a	72.3	efg	11.6	ab	2.7	abcd
55 Deep (10)50	0	5.4	fg	73.2	bc	11.1	ab	2.6	abcd
	12.5	6.7	abc	72.3	efg	11.4	ab	2.2	cd
	25	6.7	abc	72.6	cdefg	11.3	ab	2.3	bcd
55 Deep (20)0	0	5.1	g	74.9	a	11.1	ab	2.4	bcd
	12.5	7.1	ab	72.7	cdef	11.2	ab	2.4	bcd
	25	6.4	bcd	72.2	fg	11.1	ab	2.4	bcd
55 Deep (20)25	0	5.6	efg	73.7	b	11.0	ab	2.9	abcd
	12.5	6.7	abc	72.6	cdefg	11.5	ab	2.6	abcd
	25	6.8	ab	72.3	efg	11.5	ab	2.7	abcd
55 Deep (20)50	0	5.7	efg	73.0	cd	11.2	ab	3.0	abc
	12.5	7.1	a	72.4	defg	11.5	ab	2.9	abcd
	25	6.5	abcd	72.1	fg	11.2	ab	2.9	abc
NoRip0	0	5.3	fg	75.0	a	11.6	ab	3.3	a
	12.5	6.8	abc	72.1	fg	11.5	ab	2.4	bcd
	25	6.9	ab	72.4	defg	10.9	b	2.5	abcd
lsd		0.7		0.7		0.8		0.8	

Table 7: Results 2022 (wheat)

MAP rates Deep (initial) (kg/ha)	Annual	Yield (t/ha)		Test weight (kg/hl)		Protein (%)		Screenings (%)	
27.5Deep(10)0	0	4.8	hi	76.5	abc	10.1	b	4.6	bcdefg
	12.5	5.2	bcde	75.3	g	9.8	bcde	5.0	abcdefg
	25	5.4	abc	75.5	efg	9.5	defg	4.8	bcdefg
27.5 Deep (10)50	0	5.2	cdef	76.2	abcde	9.8	bcde	5.2	abcdef
	12.5	5.3	abcd	75.8	bcdefg	9.3	fg	4.3	g
	25	5.2	bcde	75.6	defg	9.6	cdefg	4.8	bcdefg
55 Deep (10)0	0	4.9	ghi	76.6	abc	10.6	a	5.1	abcdefg
	12.5	5.3	abcd	76.1	abcdef	9.8	bcdef	4.3	fg
	25	5.5	ab	75.4	fg	9.9	bcde	5.9	a
55 Deep (10)50	0	5.0	efgh	76.4	abc	9.8	bcdef	4.9	abcdefg
	12.5	5.5	a	75.8	cdefg	9.6	cdefg	5.0	abcdefg
	25	5.4	ab	75.5	efg	9.3	g	4.5	efg
55 Deep (20)0	0	4.7	i	76.6	ab	10.0	bc	4.5	efg
	12.5	5.3	abcd	75.9	bcdefg	9.4	efg	4.9	abcdefg
	25	5.3	abcd	75.2	g	9.9	bcde	5.5	ab
55 Deep (20)25	0	5.1	defg	76.3	abcd	9.9	bcde	4.5	defg
	12.5	5.6	a	75.4	fg	9.9	bcd	5.3	abcde
	25	5.3	abcd	75.3	g	9.7	bcdefg	5.1	abcdefg
55 Deep (20)50	0	5.0	fghi	76.7	a	9.6	cdefg	4.6	cdefg
	12.5	5.5	a	75.5	efg	9.7	bcdefg	5.2	abcdefg
	25	5.5	ab	75.4	fg	9.9	bcde	5.4	abcd
lsd		0.3		0.7		0.5		0.9	
	0	4.8	hi	76.5	abc	10.7	a	4.7	bcdefg
	12.5	5.4	ab	75.5	efg	9.8	bcdef	5.4	abc
	25	5.5	ab	75.6	defg	9.5	defg	4.5	cdefg