GOA trial site report

Comparing organic and inorganic sources of phosphorus in canola and wheat

Grain Orana Alliance

GOA code:	GONU030
Season:	Winter 2022-24
Property name:	The Wilgas
Location:	Wongarbon
Grower:	Maurie Street
Collaborators:	The University of Queensland

Keywords

GONU030, phosphorus, manure, starter fertiliser, organic fertiliser, canola, wheat

Note

This report contains background crop performance data to supplement the in-depth analysis contained in this paper: "The nutritional value of manures and other organic phosphorus (P)[1] sources and uptake over time[2]".

Take home messages

- Crop responses to P from chicken manure were like that of mono-ammonium phosphate (MAP) when all other nutrients were non-limiting across multiple years in canola wheat rotations.
- A 'balanced' or replacement P strategy was not sufficient to optimise yields.

[2] McLaren, T., Bell, M., Shome, S., Street, M., O'Brien, B., & Kopittke, P. (2025, February 27). *The nutritional value of manures and other organic phosphorus sources and uptake over time*. Grains Research and Development Corporation. https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2025/02/the-nutritional-value-of-manures-and-other-organic-phosphorus-sources-and-uptake-over-time

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Background

The cost of P fertilisers (MAP and DAP) has been increasing and the trade tensions with China (world's largest supplier of P fertilisers) that started in 2020 may hamper supply into the future. Chicken and cattle manure, which contain usable fractions of P, are becoming more readily available in some production areas. Manures present an alternative P source for grain crops that is attracting the interest of some growers.

Comparing performance of manures against more traditional P sources such as MAP or DAP can be difficult, the P content tends to vary from product to product (i.e. chicken litter, versus chicken manure (CM)) and there are larger freight and application costs. To further complicate matters, manures tend to have differences in the relative availability of other nutrients.

Anecdotal evidence, mostly from growers, suggests that there is a greater crop response from the application of manures. However, how the P component performs under paddock conditions (compared to MAP) is not well known. Questions are raised as to how quickly the P might be released from the organic compounds in the manure.

A better understanding of the relative performance of the alternate sources of P should allow more informed decisions when adopting and managing these fertiliser alternatives.

Aims

- To compare the relative crop performance for yield and quality in wheat and canola to an organic P source in the form of chicken manure to the more traditional, high analysis inorganic, MAP.

Treatments

- Treatments included 8 fertiliser rates (0, 5, 10, 15, 30, 50, 70, and 90 kg P/ha) and 2 fertiliser types (CM and MAP).
- CM was sourced from a poultry shed near Temora, NSW, and had a gravimetric water content at sample collection of 44%, and a concentration of total P and nitrogen (N) on a dry-weight basis of 1.8% and 5.5%, respectively.
- Fertiliser was spread on the surface and then incorporated using offsets to a depth of ~10 cm.
- The first field experiment, wheat-canola-wheat (WCW) included wheat (2022)/canola (2023)/wheat (2024) rotation.
- The second field experiment canola-wheat-canola (CWC) included a canola (2022)/wheat (2023)/canola (2024) rotation.
- The CM and MAP treatments were only applied in 2022, and in subsequent years all plots received 5 kg P/ha as MAP at planting.
- Basal additions of N, potassium (K), sulphur (S), and micronutrients were applied throughout the duration of the field experiment when needed.

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Table 1 outlines the total P and N applied to the 2 experiments over the lifetime of the project.

Table 1. Product (CM chicken manure and MAP), phosphorus, and nitrogen application (kg/ha) over the lifetime of the project.

	Phosphorous				Nitrogen (kg/ha)							
	(kg/ha)				W-C-W rotation				C-W-C rotation			
Product	**2022**	**2023**	**2024**	**total**	**2022**	**2023**	**2024**	**total**	**2022**	**2023**	**2024**	**total**
MAP	**0**	5	5	10	183	115	117	415	328	137	117	582
	5	5	5	15	183	115	117	415	328	137	117	582
	10	5	5	20	183	115	117	415	328	137	117	582
	15	5	5	25	183	115	117	415	328	137	117	582
	30	5	5	40	183	115	117	415	328	137	117	582
	50	5	5	60	183	115	117	415	328	137	117	582
	70	5	5	80	183	115	117	415	328	137	117	582
	90	5	5	100	183	115	117	415	328	137	117	582
CM	**0**	5	5	10	183	115	117	415	328	137	117	582
	5	5	5	15	183	115	117	415	328	137	117	582
	10	5	5	20	183	115	117	415	328	137	117	582
	15	5	5	25	183	115	117	415	328	137	117	582
	30	5	5	40	183	115	117	415	328	137	117	582
	50	5	5	60	183	115	117	415	328	137	117	582
	70	5	5	80	183	115	117	415	328	137	117	582
	90	5	5	100	183	115	117	415	328	137	117	582

Site Selection:

This site came out of a degraded lucerne pasture in 2018 with historically limited P applications. The cropping history was 2019 wheat ~ 0.5t/ha, 2020 canola ~ 3 t/ha, 2021 wheat ~ 5 t/ha and approximately 75 kg/ha MAP was applied each year prior to the trial establishment.

Soil testing (Table 2) confirmed that the site was very low in P at 19 mg/kg and was tending towards being acidic with a pH of 4.9 combined with elevated aluminium 1.9%.

Table 2. Soil test results (IPL)

Analyte	Units	0-10[a]	10-30[a]	Total
pH (1:5 $CaCl_2$)	PH scale	4.9	5.5	-
Nitrate nitrogen	mg/kg	36.0	4.2	-
Ammonium N	mg/kg	4.9	1.1	-
Available N[b]	kg/ha	57	15	72
Phosphorus (Colwell)	mg/kg	19	<5	
Aluminium saturation	%	1.9	<1.0	
[a] Depth from soil surface (cm)				
[b] Calculated				

Rainfall

- The 2022 and 2024 seasons were wetter with 573.1 and 283.6 mm respectively.
- 2023 was a relatively dry season, the in-crop rainfall was approximately 165.3 mm, however there was considerable soil moisture left over from 2022 and the 2022/23 summer fallow.
- Rainfall details are in Table 3 while in crop rainfall is outlined in Table 3.

Table 3. Monthly rainfall[3] (mm) and long-term average (LTA) at trial site

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2021	54	81	148	5	26	110	74	34	44	50	173	56	**855**
2022	119	21	92	164	72	13	74	118	100	184	57	10	**1024**
2023	60	31	22	39	6	45	33	15	4	31	96	51	**433**
2024	94	75	56	84	43	57	56	66	13	46	103	67	**760**
LTA	64	54	53	44	44	47	46	44	45	57	56	54	**608**

Key dates and in crop rainfall are listed in Table 4

[3] Gridded data for the trial site from: Access Gridded Data | LongPaddock | Queensland Government

Table 4. Sowing and harvest dates and in crop rainfall for the project period.

	W-C-W		C-W-C		
Year	**Sowing date**	**Harvest date**	**Sowing date**	**Harvest date**	**In crop rain (mm)**
2022	25/05/2022	20/12/2022	25/04/2022	23/11/2022	573.1
2023	28/04/2023	04/11/2023	28/04/2023	04/11/2023	165.3
2024	24/04/2024	22/10/2024	16/04/2024	22/10/2024	283.6

Results: wheat - canola – wheat rotation

Grain yield:

W-C-W rotati**on:** 2022 season (wheat):

- lowest yields were in the control treatment (see Figure 1).
- the highest yield was with 7.95 t/ha.
- there was approximately 1.25t/ha between the highest and lowest yielding treatments.
- there was a positive response to added P, however this wasn't expressed to rates of 30 kg P/ha and higher.
- using a standard of 3kg P removal/ton of grain[4], approximately 19 and 28 kg P/ha was removed for the control and the CM 70 respectively.
- there were no yield differences between products except for the 70 kg P/ha rate where the CM out yielded the MAP by 0.47 t/ha.

[4] GrowNote-Canola-North-5-Nutrition.pdf

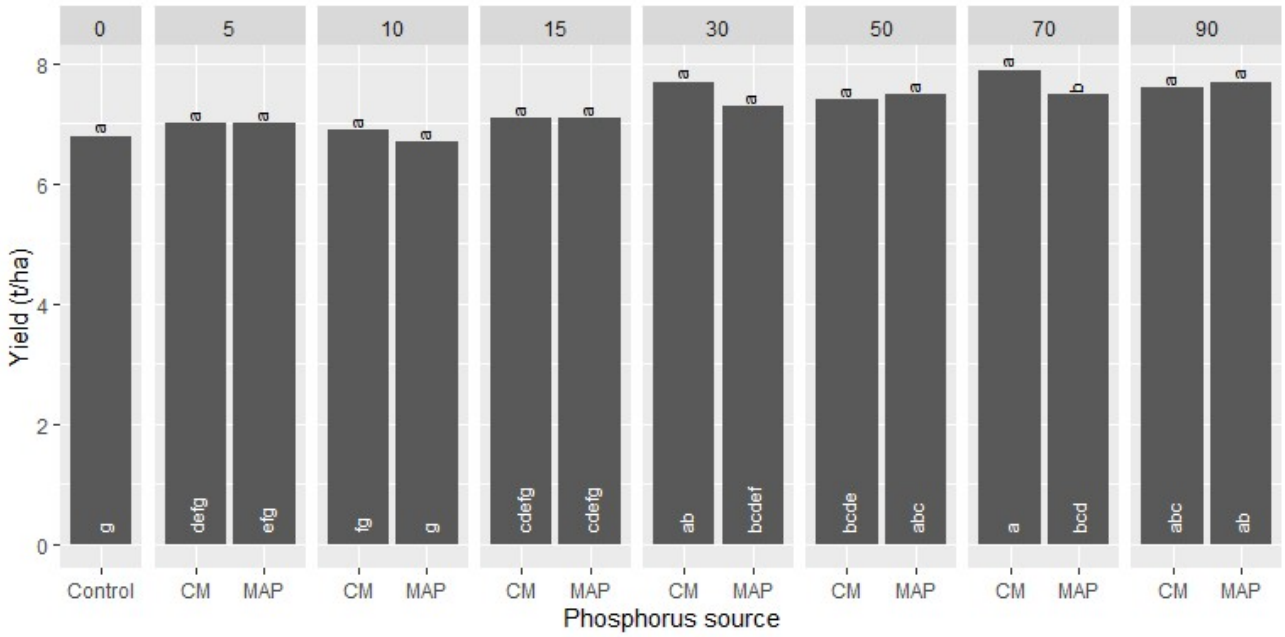

Figure 1. 2022 wheat yield (t/ha). Treatments within a P Rate with the same letter at the top of the bars are not significantly different. Treatments with the same letter at the bottom of the bars are not significantly different across all P rates and products.

W-C-W rotation: 2023 season (canola):

- lowest yields were in the control treatment (Figure 2).
- highest yield was the CM 70 with 1.8 t/ha.
- there was ~ 0.84 t/ha between the highest and lowest yielding treatments.
- there was a strong positive response to added P, however this wasn't expressed to rates over 15 kg P/ha.
- where 70 kg P/ha was applied the CM had a higher yield than the MAP.
- using a standard of 7kg P removal/ton of canola grain[5], approximately 7 and 12.6 kg P/ha was removed for the control and the CM 70 respectively.

[5] GrowNote-Canola-North-5-Nutrition.pdf

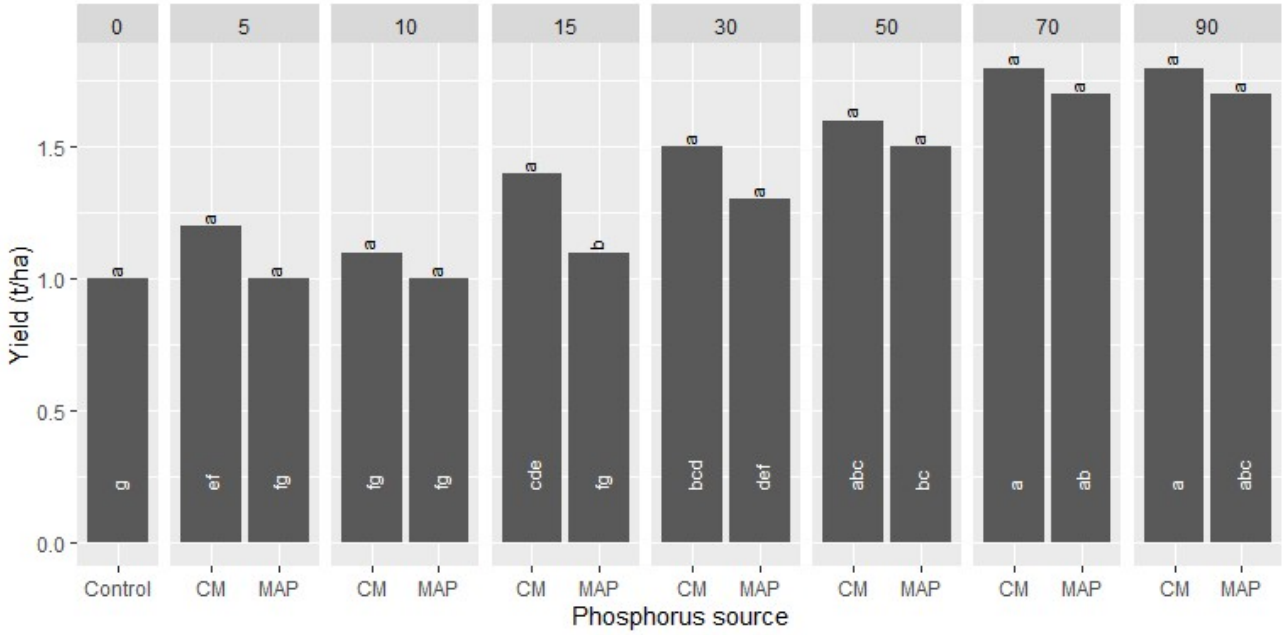

Figure 2. 2022 canola yield (t/ha). Treatments within a P Rate with the same letter at the top of the bars are not significantly different. Treatments with the same letter at the bottom of the bars are not significantly different across all P rates and products.

W-C-W rotation: 2024 season (wheat):

- lowest yields were in the control treatment (see Figure 3).
- highest yield was the MAP 70 with 4.73 t/ha.
- there was approximately 0.73 t/ha between the highest and lowest yielding treatments.
- there was a positive response to added p, however this was not expressed to rates of 15 kg p/ha and higher.
- using a standard of 3 kg p removal/ton of grain[6] , approximately 12 and 14 kg p/ha was removed for the control and the MAP 70 respectively.
- there were no yield differences between products except for the 30 kg p/ha rate where the cm out-yielded the MAP by 0.32 t/ha.

[6] GrowNote-Canola-North-5-Nutrition.pdf

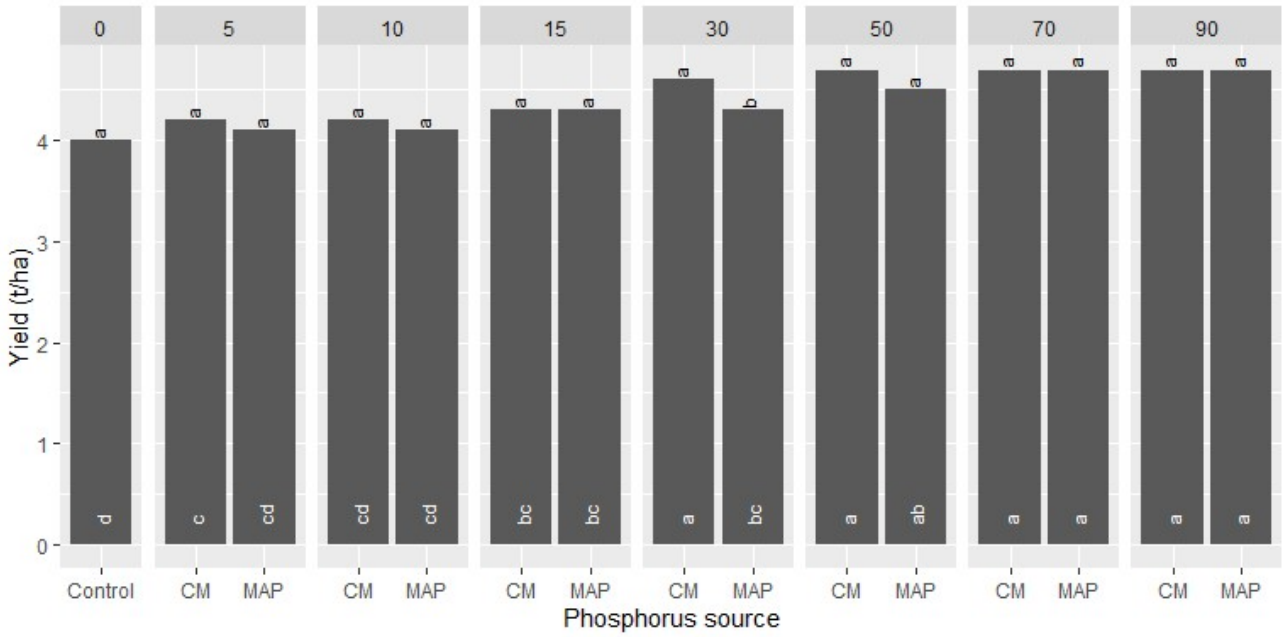

Figure 3. 2024 wheat yield (t/ha). Treatments within a P Rate with the same letter at the top of the bars are not significantly different. Treatments with the same letter at the bottom of the bars are not significantly different across all P rates and products.

Grain quality:

W-C-W rotation: 2022 season (wheat) - Variations in protein content were driven by yield dilution (i.e. higher yields had lower protein content).

- Highest protein was the Control 0: 11.6%.
- Lowest protein was CM 90: 9.9%.

W-C-W rotation: 2023 season (canola) - variations in oil content were driven by yield dilution (i.e. higher yields had lower oil content).

- Highest oil was the Control 0: 44.1%.
- Lowest oil was MAP 90: 42%.

W-C-W rotation: 2024 season (wheat) - variations in protein content were driven by yield dilution (i.e. higher yields had lower protein content).

- Highest protein was MAP 5 - 13.7%.
- Lowest protein was CM 90 - 13%.

Results: canola – wheat – canola rotation

Grain yield

C-W-C rotation: 2022 season (canola):

- lowest yields were in the nil treatment (Figure 4).
- highest yield was the MAP 70 with 4.01 t/ha.
- there was approximately 1.31t/ha between the highest and lowest yielding treatments.
- there was a strong positive response to added P.
- there were no yield differences between products.

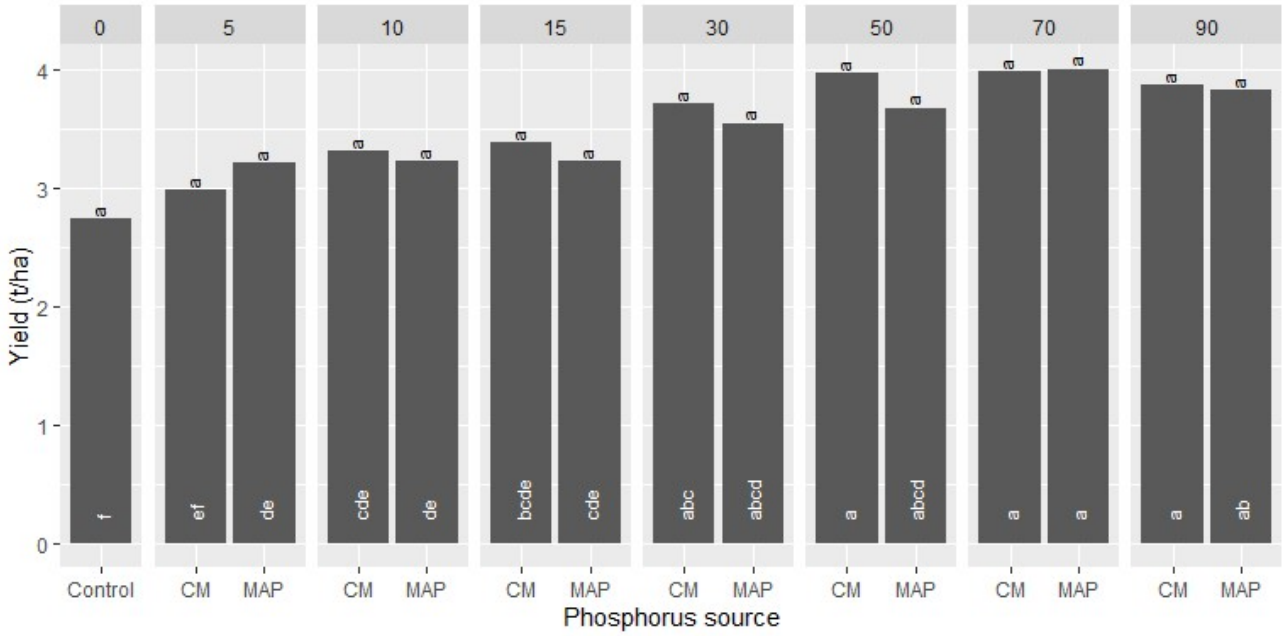

Figure 4. 2022 canola yield (t/ha). Treatments within a P Rate with the same letter at the top of the bars are not significantly different. Treatments with the same letter at the bottom of the bars are not significantly different across all P rates and products.

C-W-C rotation: 2023 season (wheat):

- lowest yields were in the nil treatment (Figure 5).
- highest yield was the MAP 70 with 2.96 t/ha.
- there was approximately 0.66 t/ha between the highest and lowest yielding treatments.
- there was a strong positive response to added P.
- where 5 and 50 kg P/ha was applied, the MAP had a higher yield than the CM.

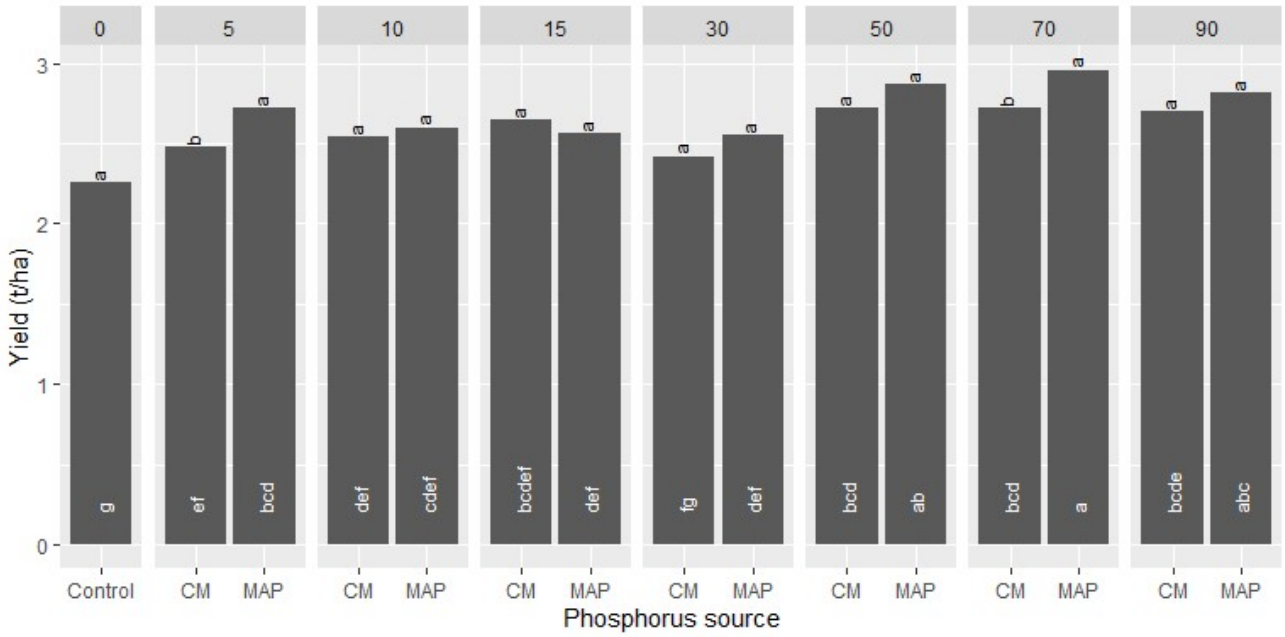

Figure 5. 2023 wheat yield (t/ha). Treatments within a P Rate with the same letter at the top of the bars are not significantly different. Treatments with the same letter at the bottom of the bars are not significantly different across all P rates and products.

C-W-C rotation: 2024 season (canola):

- lowest yields were in the nil treatment (

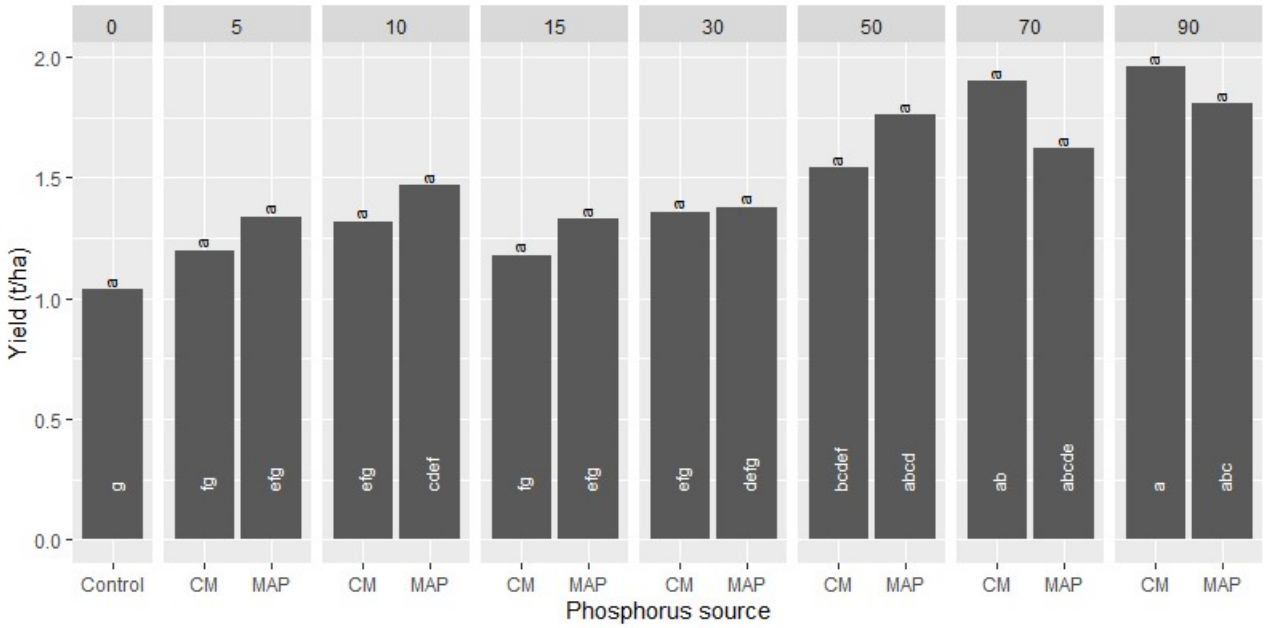

Figure 6).

- highest yield was the CM 90 with 1.96 t/ha.

- there was approximately 0.96 t/ha between the highest and lowest yielding treatments.
- there was a strong positive response to added P.
- there were no yield differences between products.

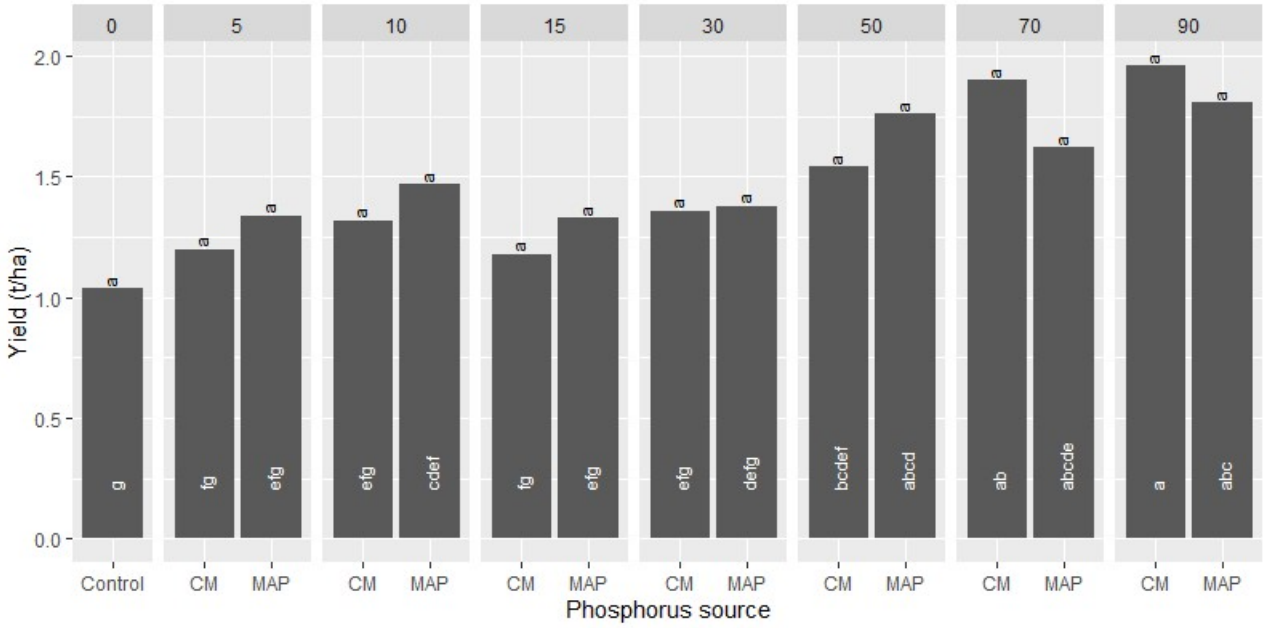

Figure 6. 2024 canola yield (t/ha). Treatments within a P Rate with the same letter at the top of the bars are not significantly different. Treatments with the same letter at the bottom of the bars are not significantly different across all P rates and products.

C-W-C rotation grain quality

C-W-C rotation: 2022 season (canola):

Variations in oil content were driven by yield dilution (i.e. higher yields had lower oil content).

- Highest oil was MAP 10: 44.7%
- Lowest oil was CM 50: 43%.

C-W-C rotation: 2023 season (wheat):

Variations in protein content were driven by yield dilution (i.e. higher yields had lower protein content).

- Highest protein was MAP 70: 14.7%
- Lowest protein was Control 0: 13.3%

C-W-C rotation: 2024 season (canola):

Variations in oil content were driven by yield dilution (i.e. higher yields had lower oil content).

- Highest oil was MAP 10: 45.5%
- Lowest oil was CM 15: 45%

Discussion

Wheat-canola-wheat rotation

WHEAT 2022:

2022 was a wet season, and yields were very high compared to normal district averages (~1.8 t/ha). The trial had an average yield of ~ 7.26 t/ha, protein was ~ 11%.

There was a strong P response resulting in over 1.25 t/ha yield difference between the highest and lowest yielding treatments.

CANOLA 2023:

2023 was a below average rainfall which limited canola yields, however the trial still averaged~ 1.35 t/ha, oil was ~ 43.3%. There was a strong P response resulting in over 0.84 t/ha yield difference between the highest and lowest yielding treatments.

WHEAT 2024:

2024 was a wet season, and yields were very high compared to normal district averages (~1.8 t/ha). The trial averaged ~ 4.37 t/ha, protein was ~ 14%. There was a strong P response resulting in over 0.73 t/ha yield difference between the highest and lowest yielding treatments.

Canola-wheat-canola rotation

CANOLA 2022:
2022 was a wet season, and canola yields were very high compared to normal district averages (~1.8 t/ha). The trial averaged ~ 3.49 t/ha, oil was ~ 44%. There was a strong P response resulting in over 1.31 t/ha yield difference between the highest and lowest yielding treatments.

WHEAT 2023:

The 2023 season had below average rainfall which limited wheat yields; however, the trial still managed an average yield of ~ 2.58 t/ha, protein was ~ 14%. There was a strong P response resulting in over 0.66 t/ha yield difference between the highest and lowest yielding treatments.

CANOLA: 2024

2024 was a wet season, despite this canola yields were lower than expected compared to the normal district averages (~1.8 t/ha). The trial averaged ~1.45 t/ha, oil was ~ 45%. There was a strong P response resulting in over 0.96 t/ha yield difference between the highest and lowest yielding treatments.

Both rotations:

In most cases, there was no difference in the yields between the 2 sources of P over the 3 years of this project. There were big yield responses to applied P, validating its requirement in low P paddocks. The yield response from both crops grown in 2022 showed increased up to where ~50 kg P/ha had been applied. By 2024 (after the third crop) yield responses were still observed but limited to where rates were initially higher than 30 kg P/ha. For levels below this, it appeared that yields were limited in the third crop.

In all years there was a very strong P response validating the site as suitable for comparison of the products. When comparing the products there was one difference in the first crop where CM resulted in higher yields than MAP. However, overall, the products did not behave differently.

Over the life of the project (2 rotations, 3 crops in each) the P balance and yield trends were similar. Aggregating this data provides some useful insights for optimising P fertiliser strategies. A 'balanced' or replacement strategy was not sufficient to optimise yields. The P balance was between initial application rates of between 15 and 30 kg/ha and had yield improvements over 0P of 15-23%. An initial P application rate of 70 kg/ha had over 30% yield improvement over 0P control, with a calculated surplus P balance of 22 kg/ha. These results suggest that in paddocks with low Colwell P, higher rates of P might be required (than current practices) to optimise yields, as some of the applied P maybe tied up.

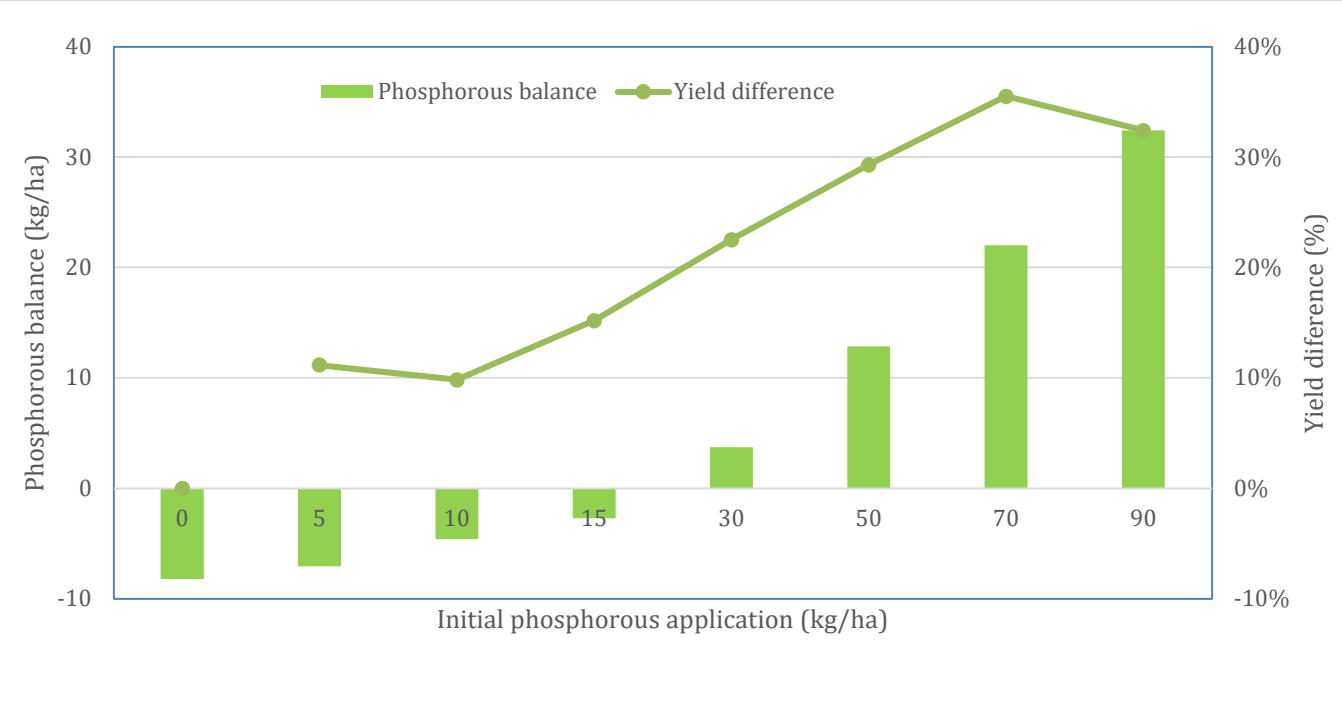

Figure 7. Phosphorous balance (assuming removal of 7 and 3 kg/t for canola and wheat respectively)[7] and yield difference (compared to where no P was applied).

[7] GRDC Canola GROW NOTES Norther. GrowNote-Canola-North-5-Nutrition.pdf. https://grdc.com.au/__data/assets/pdf_file/0032/369275/GrowNote-Canola-North-5-Nutrition.pdf

Conclusions

- P sourced from chicken manure (note this was manure, without litter) can be used as a substitute for organic sources of P such as MAP.
- If chicken manure is the sole source of P, adjust the application rate apply to reflect the P requirement.
- In low P paddocks, high rates of fertiliser may be required to optimise yields in above average seasons.

Acknowledgements

The research undertaken as part of this project is made possible by the significant contributions of growers through both trial cooperation and the support of the Grains Research and Development Corporation (GRDC). The authors would like to thank them for their continued support. Special thanks go out to Maurie Street who hosted this trial.

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Appendix Results

Table 5. Results: W-C-W rotation

Phosphorous		Yield 2022		Protein 2022		Yield 2023		Oil 2023		Yield 2024		Protein 2024	
Rate (hg/ha)	Product	(t/ha)		(%)		(t/ha)		(%)		(t/ha)		(%)	
0	Control	6.8	g	11.6	a	1.0	g	44.1	a	4.0	d	13.7	a
5	CM	7.0	defg	11.3	abc	1.2	ef	43.4	abc	4.2	c	13.6	abc
	MAP	7.0	efg	11.4	abc	1.0	fg	44.0	ab	4.1	cd	13.7	a
10	CM	6.9	fg	11.3	c	1.1	fg	43.6	ab	4.2	cd	13.5	abcd
	MAP	6.7	g	11.5	abc	1.0	fg	43.2	bcd	4.1	cd	13.5	abcd
15	CM	7.1	cdefg	11.3	bc	1.4	cde	43.7	ab	4.3	bc	13.4	abcd
	MAP	7.1	cdefg	11.5	ab	1.1	fg	43.7	ab	4.3	bc	13.5	abcd
30	CM	7.7	ab	11.3	c	1.5	bcd	43.4	abcd	4.6	a	13.7	ab
	MAP	7.3	bcdef	11.3	abc	1.3	def	43.6	ab	4.3	bc	13.5	abcd
50	CM	7.4	bcde	11.0	d	1.6	abc	42.5	de	4.7	a	13.3	cd
	MAP	7.5	abc	11.3	c	1.5	bc	43.8	ab	4.5	ab	13.5	abcd
70	CM	7.9	a	10.6	e	1.8	a	42.2	e	4.7	a	13.5	abcd
	MAP	7.5	bcd	11.4	abc	1.7	ab	43.3	bcd	4.7	a	13.3	bcd
90	CM	7.6	abc	9.9	f	1.8	a	42.6	cde	4.7	a	13.2	d
	MAP	7.7	ab	11.2	c	1.7	abc	42.0	e	4.7	a	13.3	bcd
lsd	lsd	0.5	-	0.3	-	0.3	-	0.9	-	0.3	-	0.4	-

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Table 6: Results: C-W-C rotation.

Phosphorous		Yield 2022		Oil 2022		Yield 2023		Protein 2023		Yield 2024		Oil 2024	
Rate (hg/ha)	Product	(t/ha)		(%)		(t/ha)		(%)		(t/ha)		(%)	
0	Control	2.74	f	44.63	a	2.26	g	13.30	f	1.04	g	44.68	c
5	CM	2.99	ef	44.65	ab	2.48	ef	14.10	abcde	1.20	fg	44.95	abc
	MAP	3.22	de	44.62	ab	2.72	bcd	14.00	bcde	1.34	efg	45.43	a
10	CM	3.32	cde	44.38	abc	2.54	def	14.28	abcd	1.32	efg	44.70	bc
	MAP	3.23	de	44.70	a	2.60	cdef	13.73	cdef	1.47	cdef	45.53	a
15	CM	3.39	bcde	44.17	abc	2.65	bcdef	13.60	ef	1.18	fg	44.55	c
	MAP	3.23	cde	44.65	ab	2.56	def	13.68	def	1.33	efg	44.88	abc
30	CM	3.72	abc	44.67	a	2.42	fg	13.73	cdef	1.36	efg	45.05	abc
	MAP	3.55	abcd	44.23	abc	2.55	def	13.73	cdef	1.38	defg	45.25	ab
50	CM	3.97	a	43.13	d	2.72	bcd	13.73	cdef	1.54	bcdef	45.10	abc
	MAP	3.68	abcd	43.78	cd	2.87	ab	14.43	ab	1.76	abcd	45.08	abc
70	CM	3.99	a	43.88	cd	2.72	bcd	14.18	abcde	1.90	ab	45.08	abc
	MAP	4.01	a	43.95	bc	2.96	a	14.73	a	1.62	abcde	45.03	abc
90	CM	3.87	a	43.20	d	2.70	bcde	14.23	abcde	1.96	a	44.98	abc
	MAP	3.83	ab	43.18	d	2.82	abc	14.38	abc	1.81	abc	45.35	ab
lsd	lsd	0.47	-	0.70	-	0.23	-	0.65	-	0.39	-	0.65	-