Optimising canola establishment and performance by phosphorus fertiliser placement

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Take home message

- Traditional methods of applying phosphorus-based starter fertilisers with the seed is often reducing canola establishment, in some cases, by well over 50%
- This is costing growers through the need to increase seeding rates to compensate for losses, reduced yields through low populations or, in extreme cases, the need to resow crops
- Placing fertiliser away from the seed, either below or broadcast on the soil surface either before or after sowing largely eliminated the negative impacts on crop establishment
- These alternate application placement options produced similar yield responses as the traditional option of putting the fertiliser with the seed
- Applying phosphorus fertilisers by these alternate methods may also offer some logistical advantage in timing of operations
- Dry soil conditions may hinder access to applied phosphorus in the surface applied options, but in these trials, there was limited occurrences at commercial rates of phosphorus.

Background

Phosphorus (P) is an important nutrient to optimise canola production. Traditionally, P fertiliser has been applied at planting, banded near the seed. This approach is likely to be based on the premise that P is relatively immobile in the soil and needs to be placed close to the developing root systems of crops to be readily accessible early in the crop cycle.

However, damage to establishing crops by placing fertiliser close to seed has long been accepted. Trials in 2013, by Jenkins and Brill from the Department of Primary Industries demonstrated significant reductions in canola establishment with increasing rates of P (up to 20 kg/ha) applied at seeding. However, yields still increased with increasing rates of P despite the suppression in emergence, demonstrating the ability of canola to compensate for lower plant populations in the circumstances tested.

So, if the crop can compensate and maintain yield despite lower establishment, what is the problem?

Firstly, seed costs for growing canola can be high. When only a fraction of the seed purchased results in an established plant, this inefficiency represents a significant cost, particularly where seed can cost more than $80/ha. Secondly, the impacts on plant establishment can be variable and un- predictable which has resulted in growers increasing seeding rates to cover the possibility of decreased establishments. Thirdly, in extreme cases crop establishment impacts may be so severe, that yields are impacted, or crops need resowing.

Recent changes to farming systems may further increase risk of damage. The adoption of wider row spacings and sowing with knife points or disc seeders all have the effect of increasing fertiliser

concentration within the drill line, thus increasing potential for damage. Furthermore, the move to earlier sowing, into warmer and potentially more rapidly drying soils could only be thought to further exacerbate the risks of variable crop establishment.

A field survey undertaken in 2017 (McMaster, C. 2019) assessed canola establishment across 95 commercial crops in the central west of NSW. This survey showed that crop establishments ranged from as low as 17% up to 86% with an average of 48%. Whilst the report suggested that seed size had the greatest influence over establishment it also mentioned several other factors also correlated well, including stubble loads, sowing speed, seeding depth and starter fertiliser and its proximity to the seed.

So how do we apply enough P to optimise yields, without a negative impact on establishment while maintaining or even improving P fertiliser efficiencies? Could altering our way of applying P fertilisers to canola crops also improve the reliability of crop establishment which is a key deterrent to many growers from growing canola (GRDC Grower Network, 2020)?

Trial work undertaken by GOA under the Grower Solutions Group Project since 2015 has been investigating alternate options for applying conventional P fertilisers in canola to address these key questions.

This paper details the outcomes from this series of trials and proposes alternate ways to apply P in winter grown canola crops.

Methodology

The hypothesis was 'can we apply P fertiliser in an alternate manner to the standard approach of banding it with the seed, that minimises the impact on crop establishment whilst maintaining the fertiliser response in crop performance (yield)?'.

A series of 15 trials have been run since 2015 investigating alternate methods of P starter fertiliser placement as detailed below-

- With seed (with)- fertiliser applied through the same seed boot as the seed is delivered
- Below seed (below)- delivered though a second boot set to deliver the fertiliser below the seed with at least 2-3 cm separation from the seed position
- Incorporate by sowing (IBS)- fertiliser was broadcast just prior to sowing and incorporated by the seeder (knife point and press wheel- 27cm row spacing)
- Top-dressed- fertiliser was broadcast just after seeding to the soil surface with no incorporation.

Initially the P fertiliser used was Trifos (triple super) because of the absence of N in its makeup. However, this product is now largely unavailable, and many growers were simply using ammonium phosphate fertilisers such as DAP or MAP as their P source and as such MAP, was used in more recent trials. Details of the fertiliser type, rates tested, and the range of placements is detailed in Table 1 below. Although this report does report the treatments in terms of the rate of P applied, it should be considered that with P supplied as MAP there is an associated amount of N delivered with that rate of P. This Nitrogen may be also contributing to damage but as most starter fertilisers contain both these elements, apportioning the blame to P or N is difficult but also somewhat academic.

However, in trials where MAP was used, the differing nitrogen levels applied were balanced out with urea across all rates to ensure any yield responses were not influenced by differences in N rates applied.

Table 1. Details of trial site and treatments

Year	Location	Site Colwell P (0-10cm)	Fertiliser tested	P rates applied kg P/ha	Fertiliser placement treatments
2015	Wellington	21 ppm	Trifos	0, 10, 20	With, below, IBS
2015	Gilgandra	12 ppm	Trifos	0, 10, 20	With, below, IBS
2016	Gilgandra	18 ppm	Trifos	0, 15, 30, 45	With, below, IBS, top-dressed
2016	Alectown	10 ppm	Trifos	0, 15, 30, 45	With, below, IBS, top-dressed
2017	Nyngan	33 ppm	Trifos	0, 15, 30, 45	With, below, IBS, top-dressed
2017	Jemalong	19 ppm	Trifos	0, 15, 30, 45	With, below, IBS, top-dressed
2017	Gilgandra	21 ppm	Trifos	0, 15, 30, 45	With, below, IBS, top-dressed
2017	Geurie	<5 ppm	Trifos	0, 15, 30, 45	With, below, IBS, top-dressed
2018	Wellington	20 ppm	Trifos	0, 10, 20, 40	With, below, IBS, top-dressed
2018	Canowindra	36 ppm	Trifos	0, 10, 20, 40	With, below, IBS, top-dressed
2019	Gilgandra	23 ppm	MAP	0, 10, 20, 40	With, below, IBS, top-dressed
2020	Gilgandra	39 ppm	MAP	0, 10, 20, 40	With, below, IBS, top-dressed
2020	Gollan	23 ppm	MAP	0, 10, 20, 40	With, below, IBS, top-dressed
2020	Wongarbon	32 ppm	MAP	0, 10, 20, 40	With, below, IBS, top-dressed

Results

Table 2 summarises the statistically analysed responses on two main measures- plant population and yield response to P rate and placement. As the traditional method of P placement is 'with' this is a common comparison made. Further detail on individual trial reports can be found at www.grainorana.com.au.

The '>' indicate the yields from the aforementioned treatment exceeds the following treatment, '&' between two treatments indicates there was no difference between those treatments. Alternate placement methods in **bold** highlight only cases where yields are lower than the traditional 'with' placement.

Table 2 also details the rainfall received for the 60 days following seeding for each site/year, as this is thought to influence nutrient access for some of the placement methods. The yield range of the site is also included for the reader to consider the nutrient requirement for the crop as a pseudo indicator of crop growing conditions throughout the year.

Table 2. Trial results from 15 trials on P rate and placement in canola, summarising the impact on plant population and yield when P fertiliser was applied 'with seed', 'below seed', top-dressed or incorporated by sowing (IBS).

Site/year	Impact on plant populations	Impact on yields	Rainfall 60 days post planting ^	Yield range t/ha
Wellington 2015	P rate applied or placement had no impact	P rate applied or placement had no impact	118 mm	1.4- 1.9
Gilgandra 2015	20 kg/ha P 'with seed' resulted in lower populations than 10 kg/ha. 'Below seed' & IBS had no impact on populations regardless of P rate	Site was rate responsive when P was applied 'with seed' 10 & 20 kg/ha > Nil P At 10 kg/ha P- No impact of placement At 20 kg/ha P- 'with seed' & 'below seed' > **IBS**	159 mm	1.3 – 2.1
Gilgandra 2016	All rates of P applied 'with seed' resulted in lower plant populations by around 30%, compared to 'below seed', IBS & top-dressed in all but one case.	Site was rate responsive when P was applied 'with seed' 30kg/ha > 15 & 45kg/ha > Nil P At 15kg/ha P- No impact of placement At 30kg/ha P- No impact of placement At 45 kg/ha P- IBS, top-dressed & 'below seed > 'with seed'	256 mm	1.8- 2.7
Alectown 2016	At 30 & 45 kg/ha of P 'with seed' resulted in up 40% lower plant populations than 'below seed, IBS or top-dressed which were not different to one another At 15 kg/ha P 'with seed' was lower than IBS & 'below seed' but not different to top-dressed	Site was rate responsive when P was applied 'with seed' 30 kg/ha > 45, 15 kg/ha & Nil At 15kg/ha P- no impact of placement At 30kg/ha P- No impact of placement At 45 kg/ha- IBS & top-dressed > 'with seed & 'below seed'	172 mm	2.3 – 3.4
Nyngan 2017	At 45kg/ha of P 'with seed' or 'below seed' plant populations were reduced by 65% and 40% respectively compared to the best treatment, top-dressed.	Site was rate responsive when P was applied 'with seed' 15, 30 & 45 kg/ha > Nil At 15 kg/ha P- no impact of placement At 30 kg/ha- 'below seed' > IBS, top-dressed & 'with seed'	27 mm	0.3 – 0.5

Site/year	Impact on plant populations	Impact on yields	Rainfall 60 days post planting ^	Yield range t/ha
	At 15kg/ha & 30 kg/ha of P 'with seed' there was no impact by placement.	At 45 kg/ha- 'with seed' & top-dressed > **IBS** & '**below seed'**		
Jemalong 2017-	P rate applied, or placement had no impact	P rate applied or placement had no impact	13 mm	0.3 – 0.9
Gilgandra 2017-	P rate applied, or placement had no impact	Site was rate responsive when P was applied 'with seed' 45 kg/ha & 30 kg/ha >15kg/ha > Nil At 15 kg/ha P- No impact of placement At 30 kg/ha- 'below seed', 'with seed' & top-dressed > **IBS** 45 kg/ha- 'below seed' > 'with seed', IBS and top-dressed	11.6 mm	0.9 – 1.4
Geurie 2017-	P rate applied, or placement had no impact	Site was rate responsive when P was applied 'with seed' 45 kg/ha, 30 kg/ha > 15 kg/ha > Nil At 15 kg/ha P- 'below seed' > 'with seed' & top-dressed > l**BS** At 30 kg/ha P- 'below seed' & 'with seed' > **top-dressed** & **IBS** 45 kg/ha P- 'below seed' & 'with seed' > **IBS** & **top-dressed**	47 mm	0.2 – 1.2
Wellington 2018	At 45 kg/ha P applied 'with seed' resulted in a lower plant population (~37%) than when applied 'below seed', IBS or top-dressed At 10 or 20 kg/ha there was no impact of placement.	Site was not rate responsive when P was applied 'with seed' At 10 kg/ha P- no impact of placement At 20 kg/ha P- 'with seed', 'below seed' & top-dressed > **IBS** At 40 kg/ha P- no impact of placement	37 mm	1.0 – 1.4
Canowindra 2018	At 40 kg/ha P 'with seed' resulted in lower plant populations than top-dressed and IBS At 20 kg/ha there was	Site was rate responsive when P was applied 'with seed' 40 & 20 kg/ha > 10 kg/ha & Nil At 10 kg/ha P- below> 'with seed', top-dressed & IBS At 20 kg/ha P- top-dressed & 'below	31.5 mm	0.4 – 0.5

Site/year	Impact on plant populations	Impact on yields	Rainfall 60 days post planting ^	Yield range t/ha
	no impact of P placement. At 10 kg/ha 'with seed' & 'below seed' resulted in lower plant populations.	seed' > 'with seed' & IBS At 40 kg/ha P- 'below seed' & 'with seed'> **top-dressed** and **IBS**		
Gilgandra 2019	At all rates of P applied 'with seed' resulted in the lower plant populations than IBS, top-dressed & 'below seed' except at 10 kg/ha P where 'below seed' only was no different to 'with seed'.	Site was rate responsive when P was applied 'with seed' 40 kg/ha >10, 20 kg/ha & Nil At 10 kg/ha P- no impact of placement At 20 kg/ha P- top-dressed & 'below seed' > 'with seed' & IBS At 40 kg/ha P- 'below seed' &, top-dressed > IBS & 'with seed'	18.6 mm	0.6 – 0.9
Gilgandra 2020	At any rate of P applied 'with seed' resulted in the lowest plant population. At 40 kg/ha placed 'with seed' the seed reduced establishment by 81% compared to top dressed	There was an inverse response to P rate when applied 'with seed' # No impact when applied by the alternate placements. At 10 kg/ha P- no impact of placement At 20 kg/ha P- top dressed, IBS & 'below seed' > 'with seed' At 40 kg/ha P- IBS, top-dressed & 'below seed' > 'with seed'	52 mm	1.7 – 2.4* *Site was hail damaged prior to harvest- treat results with caution*
Gollan 2020	At any rate of P, establishment was lowest when applied 'with seed'. At 40 kg/ha establishment was reduced by ~58% compared with IBS, top-dressed & 'below seed'. At both 20 & 40 kg/ha there was no difference between IBS and top-dressed but better than 'with seed'	Site was P rate responsive when applied 'with seed' 40 kg/ha >20 kg/ha>10 kg/ha > Nil At 10 kg/ha P- no impact of placement At 20 kg/ha P- no impact of placement At 40 kg/ha P- no impact of placement	58 mm	2.2 – 3.7
Wongarbon 2020	At 10 kg/ha 'with seed', 'below seed' &	Site was P rate responsive when applied 'with seed'- 40, 20 & 10 kg/ha	93.6 mm	3.7 – 4.1

Site/year	Impact on plant populations	Impact on yields	Rainfall 60 days post planting ^	Yield range t/ha
	top-dressed had lower plant populations than IBS, at 20 & 40 kg/ha 'with seed' was lower than IBS and top-dressed all which were no different	> nil At 10 kg/ha P- no impact of placement At 20 kg/ha P- no impact of placement At 40 kg/ha P- 'with seed', IBS and top-dressed > 'below seed'		

*- *Site was hail damaged prior to harvest- treat results with caution*

#- *Increasing P applied 'with' the seed reduced yields suggested to be because of very significant reductions in plant populations.*

^- *rainfall data from the nearest BOM or other automatic weather stations*

Summation of trial outcomes

As evidenced above, the P placement and rate can impact on plant populations (crop establishment), and it can be variable. In 11 out of 15 trials, plant populations were lower when P fertiliser was placed 'with the seed' when compared with alternate placements tested, in some cases by up to 80%. In general, the negative impact on plant populations increased as the P rate increased, but in some cases as little as 10 kg/ha of P was sufficient to reduce plant establishment.

Three trials in 2017 showed no impact of P rate or placement on plant populations, but all sites experienced very dry soil conditions just after planting. The only other site to show no impact of P on plant population was Wellington in 2015. This site was also not yield responsive to P rate or placement.

In contrast, where fertiliser was placed away from the seed using either IBS or top-dressed, there was no reduction in plant populations. In all cases, plant populations were comparable to where nil fertiliser was applied (data not shown), suggesting that any impact of P fertiliser on plant population had been negated by changing its position relative to the seed.

Placing P fertiliser below the seed did sometimes, but not always avoid impacts on plant populations.

In eight out of the 15 sites the yields of the alternate placements matched the performance of the traditional 'with seed' placement and in a small number of cases yields were improved.

Three sites, Gilgandra 2015 & 2017 and Wellington in 2018 had instances where only the IBS option had lower yields than the 'with seed' treatment. At Gilgandra in 2017, only the 30 kg/ha of P IBS treatment had lower yields. At all other rates (15 & 45 kg/ha) 'with seed' performed equally or worse than the alternates. At Gilgandra 2015 and Wellington 2018 the difference in the IBS treatment was only apparent at 20 kg/ha of P. At all other rates there no difference between placements.

Two sites had instances where the IBS and top-dressed had lower yields than the 'with seed' treatment, although only at the higher rates of 30 & 40 kg/ha , but not at the lower, 'more commercial' rates tested. It should be noted that most of these cases where differences occurred were in the drier years of 2017 and 2018.

The remaining two sites were non-responsive to both placement and rate for yield and establishment (Wellington 2015 and Jemalong 2017).

This body of work demonstrates that if P fertiliser is placed away from the seed, either IBS or top-dressed and to a lesser extent below the seed, this avoids the negative impacts on plant populations.

It has also shown that in most cases, the yield response to the applied rate of P, matched the response where the P was applied 'with' the seed.

The placement 'below seed' resulted in only two cases where the yield was lower than the 'with seed' treatment, though this effect was only evident at the highest rate (45kg/ha) of P, rates that may be considered experimental rather than commercial. This however is not unexpected given the fertiliser was directly under the seed separated by only 2-3 cm where roots would naturally extend through this fertiliser band. However, placement of P 'below seed' did not always avoid reduction in plant populations as did IBS or top-dressed.

Interestingly, in most cases both the IBS and top-dressed treatments recorded a yield responseeven thoughthe resting position of the fertiliser would have been above and or to the side of the seed. Large proliferations of surface roots were commonly observed in these trials, and it is assumed that these facilitated crop P uptake in sufficient quantity and time frame so as not to penalise crop performance.

The notable exception was the drier years, primarily 2017 where the rainfall received in the 60 days post planting was very low and may have limited the development and ability of surface roots to access fertiliser. It these years, in some cases, the 'with seed' or 'below seed' treatments did outperform the IBS and top-dressed options, but only at the higher rates tested of 30-45 kg/ha. At the more commercially relevant rate of 15 kg/ha, there was no impact of P placement. In a stark contrast, in many other trials applying such high rates of P with the seed was highly detrimental to plant populations and in some cases yields.

Given that not all farmers have the option to apply fertiliser below the seed and there may be some cases, in dry years when IBS and top-dressing may risk underperforming, another option may be to 'split' the starter fertiliser application. That is, apply a proportion of the P fertiliser at sowing, say 5-10 kg P/ha, with the seed and apply the balance IBS or top-dressed. In this scenario smaller amounts of P applied with the seed may be sufficient to meet crop requirements in a dry period/season, while reducing the impact on establishment. The remainder of the fertiliser applied IBS or top-dressed, becoming available if wetter (and higher yielding) conditions prevail.

This 'split' approach has been tested on a limited basis in the past few years, but further work is needed before this can be recommended.

What does this mean to canola growers?

Clearly placing fertiliser away from seed improving the rate and reliability of establishment of canola crops is a key advantage of this alternate approach. However, there may be further advantages.

In the case of surface applications growers may be able to apply most of their canola P fertiliser requirements ahead of seasonal breaks or the busy sowing periods and this will have significant logistic advantages. The low sowing rates of canola combined with reduced rates (if split) or nil P fertiliser will greatly increase the area that can be sown in any given period, as the number of seeder refills could be greatly reduced.

For growers that have very low seed bed utilisation (wider row spacing, knife points or disc openers), this approach may be the most practical option to apply higher rates of P fertiliser to canola crops without the associated risks and downsides. An alternative that is often considered is applying higher rates in the previous crop. However, this may increase the risk of nutrient tie up and it will extend the time until cash invested in fertiliser is recouped.

Conclusions

The traditional placement of P fertilisers such as MAP/ DAP or other high analysis starter fertilisers can reduce crop establishment by 50% or more. Factoring in these typical losses combined with the need for increased seed rates could potentially be costing growers more than $45/ha. In extreme cases the

costs could be greater where yields are impacted or resowing is required. The impact of P fertilisers with seed is also likely to be contributing to the variable establishments growers often experience.

Over five years and 15 trials GOA has looked at alternate placements of P to avoid this issue. This work has shown that reductions in plant populations can be avoided by moving P away from intimate contact with the seed. This work has also shown that in most cases fertiliser efficiency has been maintained and in some cases of high rates of P, improved.

Placing the fertiliser below the seed maybe preferred if growers have suitable machinery. However, for growers who do not have this option, simply broadcasting the fertiliser and incorporating it by sowing (IBS), or even top-dressing post sowing has proven to be similarly effective.

The risk for the latter two approaches is likely to occur when dry soil conditions occur post sowing, which limit the crops ability to forage for that fertiliser, as was experienced in the drought year of 2017. However, in those years, crop fertiliser requirement was less, and yield differences were not apparent at commercial rates of 15 kg/ha. These alternate surface application approaches will have logistical advantages by offsetting some of the fertilising task from away sowing, which alone may be a key attraction.

GOA is planning to fine tune an approach of splitting the P fertiliser application, i.e. small basal amount with the seed and the balance applied to the soil surface. It is hypothesised that this approach may deliver the following advantages: minimise crop establishment impacts, reduce risks in dry conditions whilst maintaining fertiliser responses and improve sowing efficiencies (logistics).

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