How well does canola fit into northern farming systems?

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Take home message

- Canola offers a range of rotational benefits for disease management, weed management, and the potential to widen sowing windows
- Understand when canola would most likely fit into your system to maximise its benefits and mitigate its risks – that is, when you should put it in your mix of crop choices
- Farming system data shows significant opportunities for canola, but risks are still significant
- Canola won't suit all situations – several aspects need to line up to mitigate risk and maximise benefits. Critical aspects to consider include:
  - Soil water at sowing – threshold of > 150 mm in most locations to mitigate risk of low crop yields
  - Sowing window – understand your optimal sowing window to manage the risk of frost and heat stress during critical periods
  - Disease or weed issues – use canola where you are going to reap the benefits in subsequent years (e.g., winter grass problems, high *Pratylenchus thornei* nematode populations)
  - Ensure sufficient N is available – avoid situations with low starting soil N, as this will be difficult to address in northern systems with applied fertilisers at sowing or in season.
  - Preceding crops – be cautious of crops that host sclerotinia which increases disease risk (e.g., chickpea)
  - Following crops – use canola leading into disease-sensitive crops/varieties, N availability is likely to be a little higher than after cereals, consider following with another break crop, i.e., a 'double-break' to 'reset' the system.

Introduction

Northern farming systems are challenged by a lack of reliable break crops that offer effective weed management options and help with reducing soil-borne diseases such as nematodes, Fusarium crown rot, and charcoal rot. Canola is one winter crop option that provides these benefits. Canola is a highly profitable staple crop in southern farming systems and a range of historical work has explored the wider potential of expanding its use further north (see Holland et al. 2001, Robertson et al. 2004). However, canola has traditionally been perceived as a risky crop in northern farming systems due to the greater frequency of high/low temperatures during grain filling, which often result in significant yield, quality and oil content downgrades.

Despite this history, there is now a wide range of varieties that fit a diverse range of niches in the farming system, ranging in phenology (or growing season length) to fit different sowing windows, and herbicide tolerance packages. Alongside improved planting equipment with better depth control, these advances address some of the limitations to using canola more widely in northern grain systems.

Recent research in the 'Optimising Canola Profitability' project has established a range of extension material to help guide the management of canola crops in the north, covering; crop planning and preparation, matching varieties with sowing dates, crop protection, nutrition, and harvest management (see 20 Tips for profitable Canola). The paper compliments this information by addressing the questions; 1) Is it worth it – what is the opportunity vs the risk? 2) When and how would it fit into my system? 3) What are the likely legacy impacts I need to consider?

Crop reliability & risk mitigation

Sowing opportunities & establishment

As canola has relatively small seed that must be planted shallow (<40mm depth), this limits the duration of the sowing window to plant into surface moisture. The reliability and frequency of suitable sowing events in the right window for canola can be a critical constraint to incorporating it more reliably into northern farming systems. Below (Figure 1) we compare the frequency that a sowing event is likely to occur in different fortnightly windows through autumn at a selection of locations. A sowing event is defined as a rainfall event exceeding potential evaporation over a 7-day period. This shows that in more temperate, winter dominant rainfall locations where canola is widely used (e.g., Young), a sowing opportunity occurs during mid-April to mid-May in over 70% of years. In contrast, in northern NSW and southern Qld, with less and more variable autumn rainfall, the frequency of this sowing event is significantly lower at around 40-50% of years. Whilst this is likely to limit the frequency that canola could be effectively established in the north, it does show that in around half the years we are likely to still receive conditions that should allow canola to be sown in a viable window. This also shows that at many of our locations there are often sowing opportunities in early April (about 1-in-4 to 1-in-5 years), which may allow longer season canola cultivars to be used.

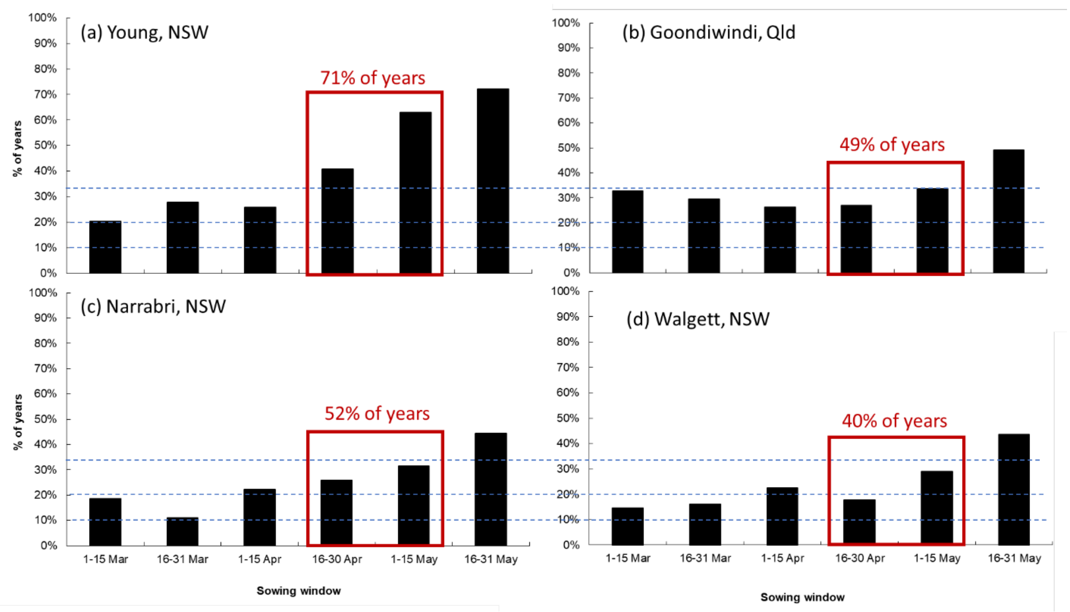


Figure 1. Historical (1956-2015) analysis of frequency of a sowing event (i.e. rainfall exceeding evaporation over 7 day period) across fortnightly sowing windows comparing a southern NSW site (Young) with 3 northern locations. The red box depicts the optimal canola sowing window in late April and early May and the total frequency that such an event occurs in this period.

Crop yields and soil water use

As part of the northern farming systems research sites over the past 6 years, canola has been grown on 9 unique occasions across southern Qld, central NSW, and northern NSW under a diversity of seasonal conditions (see Table 1). This provides a useful snapshot of what might be expected for canola performance in the northern region. From these sites, 3 of the 10 site-seasons achieved low yields (<0.5 t/ha), which were attributable to a frost event during early pod-fill (Narrabri 2017) and very dry conditions after sowing in 2019, when less than 200 mm of water (as rain or stored water) was available to the crop throughout the season. Five of the 9 site-seasons achieved grain yields of 2.5-3.5 t/ha, which occurred under conditions where the crop had access to over 350mm of water during the season. Most of these crops started with soil profiles >60% full prior to reaching the sowing window, which contributed around 30% of the water used by the crop. This was augmented by additional in-crop rain at around the long-term average winter season rainfall across these locations (i.e., 200-300mm) except for Trangie in 2020 on a Red soil with a low plant available water content (PAWC), these high yielding crops all started with >150 mm of PAW prior to sowing. The harvest index (0.23-0.27) and grain water use efficiency (WUE) (≤ 8.0) measured in these studies were less than those that are typically expected in more traditional canola-growing regions.

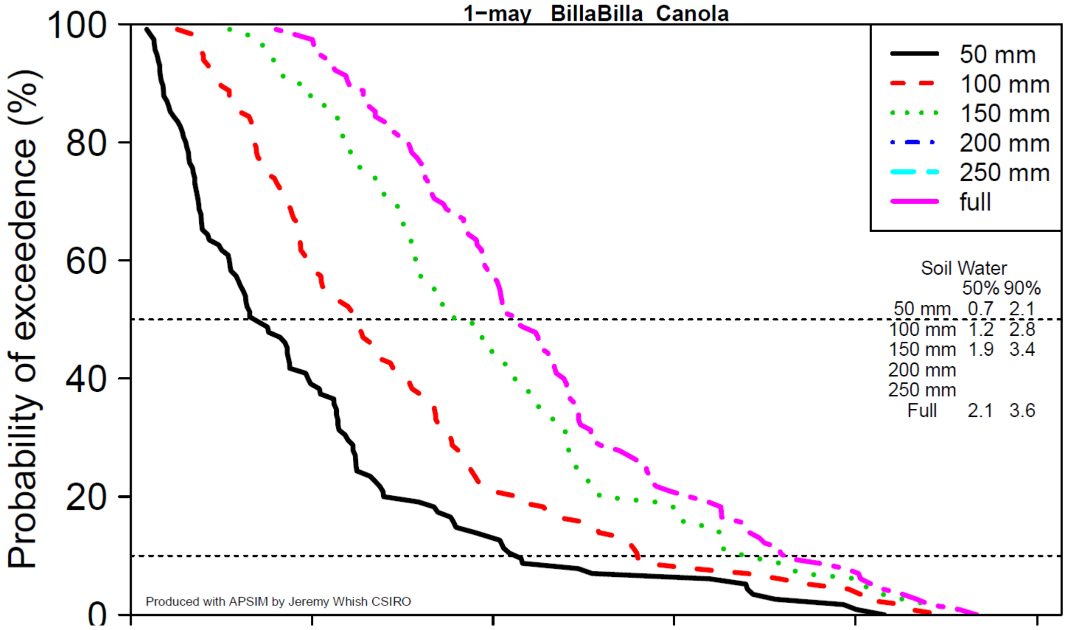
Table 1. Canola crop productivity (grain yield and biomass produced) & water used across farming systems experiments conducted 2015-2021.

Site-Year	Year	Yield (t/ha)	Biomass (t/ha)	Harvest Index	Water used (mm)	Pre-sow PAW (mm)	Biomass WUE (kg DM/mm)	Grain WUE (kg DM/mm)
NARRABRI	**2017**	0[A]	8.0	0	320	146	25	0
NOWLEY	**2019**	0.21	1.9	0.10	183	53	10	1.1
TRANGIE RED	**2019**	0.44	1.8	0.25	139	22	13	3.2
BILLA BILLA	**2018**	1.46	6.0	0.24	255	114	24	5.7
TRANGIE GRAY	**2020**	2.70	13.6	0.20	403	148	34	6.7
TRANGIE RED	**2020**	2.94	10.8	0.27	371	63	29	7.9
NARRABRI	**2016**	3.06	10.5	0.29	642	225	16	4.8
PAMPAS	**2021**	3.18[B]	16.5	0.19	392	205	42	8.1
PAMPAS	**2015**	3.55	15.2	0.23	517	152	29	6.9

[A] – Frost damage during early podding; [B] – Mouse damage removed 10-20% of pods.

Predicted yields and soil water

As shown in Table 1, seasonal variability and the availability of soil water at sowing are key drivers of yield expectations for canola in the northern region. In particular, soil water at sowing is far more important than in southern environments which receive more reliable winter rainfall. Figure 2 (below) highlights the extent to which different starting water conditions impact yield potential for canola in some example northern locations. This shows that the median yield increases by about 0.5 t/ha for every 50mm of extra PAW in the soil profile at sowing. To achieve a canola grain yield potential of >1. 5t/ha (a benchmark break-even yield under typical price-input scenarios) in >60% of years, soil water at sowing would need to exceed 150mm at Mungindi or Goondiwindi and exceed about 100mm at Narrabri. When PAW at sowing is <100mm, the likelihood of achieving grain yields >2.0 t/ha is low (i.e., less than 1 in 5 years at most locations).



1−may BillaBilla Canola
Probability of exceedence (%)
100
80
60
40
20
0
50 mm
100 mm
150 mm
200 mm
250 mm
full
Soil Water
50% 90%
50 mm 0.7 2.1
100 mm 1.2 2.8
150 mm 1.9 3.4
200 mm
250 mm
Full 2.1 3.6
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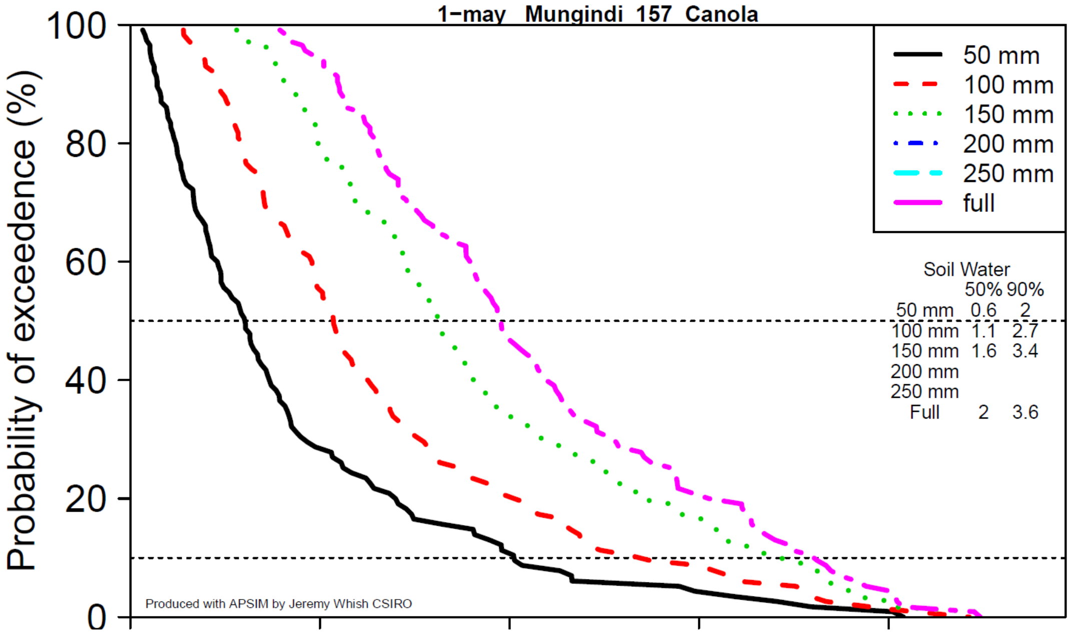

1−may Mungindi 157 Canola
Probability of exceedence (%)
100
80
60
40
20
0
50 mm
100 mm
150 mm
200 mm
250 mm
full
Soil Water
50% 90%
50 mm 0.6 2
100 mm 1.1 2.7
150 mm 1.6 3.4
200 mm
250 mm
Full 2 3.6
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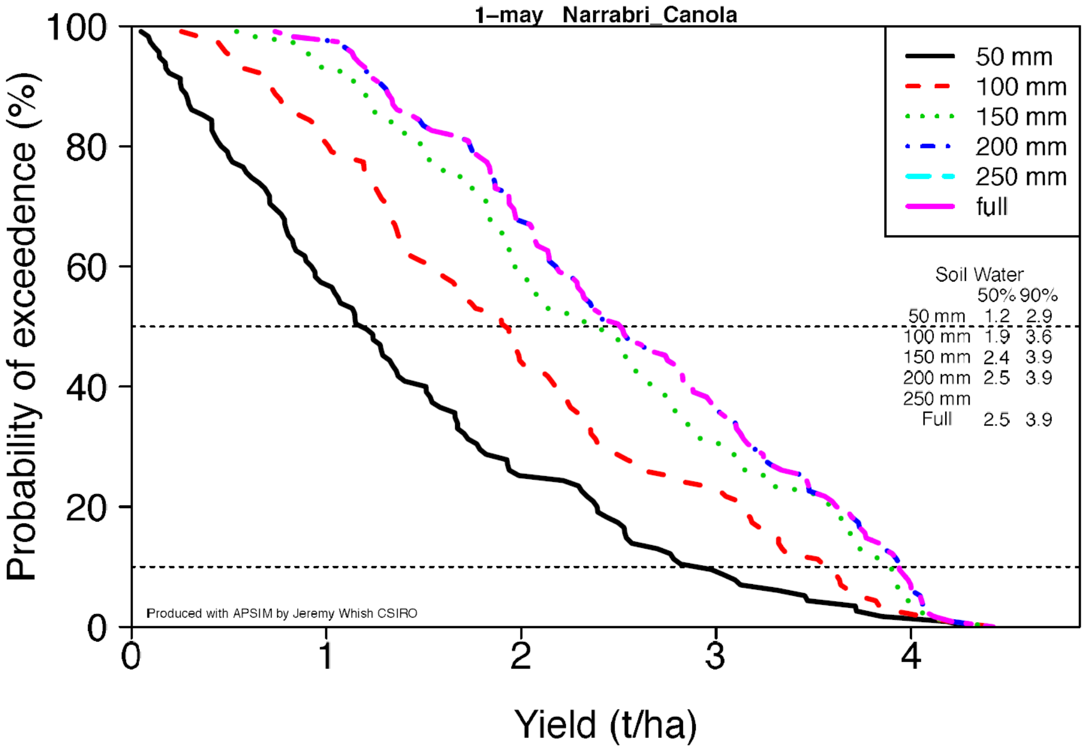

Figure 2. Simulated water-limited yield potential for canola across environments in northern NSW & southern Qld with different plant-available soil water conditions at sowing (indicated by different colours) (Top = Billa Billa, middle = Mungindi, bottom = Narrabri).

Mitigating risk of heat/frost stress

Mitigating the risks of frost and heat stress at flowering is critical for maximising canola yield. In particular, the period 200–400-degree days after flowering (i.e., at peak flowering) is a key stress point when the crop is particularly susceptible to temperature or water stress (Kirkegaard – GRDC update paper Wagga etc). Table 2 (below) shows the predicted optimal flowering windows for canola across various locations in southern Qld and northern NSW compared to a 'typical' canola growing region in southern NSW (Young – shown in bold). Firstly, the optimal window is typically shorter in our northern environments due to a shorter period when frost and heat stresses are minimised. This results in narrow sowing windows for canola to hit the narrow optimum flowering window. Secondly, the optimal flowering window varies significantly across environments – from the earliest situations at Mungindi in the west, to later at Warwick in the east. This means it's particularly important to look at this for your environment and select canola varieties with the appropriate phenology to hit this optimal flowering window for a particular sowing date. These issues can be explored for your location and specific situation using the Canola Flowering Calculator at: https://www.canolaflowering.com.au/

Table 2. Predicted optimal window to start flowering and sowing date for an example variety with early/fast phenology across various environments spanning the northern grains region compared to a traditional canola region at Young, NSW.

Location	Optimal window to start flowering	# Days in window	Optimal sow date for an early cultivar (e.g., Stingray)
Young	**13 Aug – 15 Sept**	**33**	**1 May – 17 May**
Narrabri	18 July – 15 Aug	28	1 May – 15 May
Moree	10 July – 8 Aug	29	26 Apr – 10 May
Goondiwindi	6 July – 2 Aug	27	20 Apr – 3 May
Walgett	12 July-6 Aug	25	26 Apr – 8 May
Mungindi	26 Jun- 23 July	27	19-26 April
Warwick	2 Aug -25 Aug	23	12 May – 20 May
Condamine	17 July – 12 Aug	26	3 May-15 May

Nitrogen management

Canola has a high nitrogen demand compared to other crops. Hence, understanding the nutrient status of paddocks planned for canola production is likely to be of particular importance to maximise yield potential. Current recommendations are to budget 70-80kg of N per tonne of target grain yield. So, for a 2.5 t/ha grain yield, a canola crop needs to have access to at least 175kg of N/ha. Relying on application of fertilisers at sowing to meet this large demand can be problematic, particularly in the northern region where in-crop rainfall required to move this fertiliser N into the soil profile is less reliable. There is also a high risk of seedling damage from high application rates of N fertilisers at sowing. Therefore, canola is likely to fit best when sown in situations where there's likely to be significant residual N through the soil profile at sowing. Applying 30-40% of budgeted N as a top-up around stem elongation is recommended to spread the N application out and enable N inputs to be adjusted to seasonal conditions.

Performance and legacy of canola compared to other crops

At various farming system sites, canola has been grown under comparable conditions to other winter crops, providing insights into its relative performance in terms of grain yield and legacies such as extraction and replenishment of soil water and N availability in subsequent crops.

Firstly, despite the variability in canola productivity shown above, canola has produced grain yields between 34 and 70% (average of 55%) of those achieved in wheat under the same seasonal conditions. Canola yields have typically equalled those achieved in chickpeas under comparable seasons. Of course, the relative prices and input costs required between these crops will influence a direct comparison of profitability.

Canola left similar amounts of soil water at harvest compared to winter growing cereal crops or grain legumes in the same season. Some small differences (<20 mm) occurred in some seasons where canola left 15-30mm more water than the winter cereals; often due to earlier termination of canola while the cereal was still finishing. Despite there often being a slightly lower fallow efficiency achieved after canola than following a winter cereal, in the seasons with comparisons of PAW at the end of the subsequent fallow, there was little if any significant difference compared to either the cereals or legumes.

One clear and consistent observation was that the nitrogen that accumulated during the subsequent fallow after canola was often 20-35kg N/ha higher than following a cereal. Similar results have been consistently reported in southern regions. This occurs because canola leaf residue has a lower C:N ratio, and hence breaks down more quickly and releases more N than from cereal residues.

Table 3. Differences between canola relative to a winter cereal (wheat, barley) or a winter legume (chickpea, fababean) grown in the same season in terms of grain yield, residual soil water (SW) at harvest, soil water and N mineralised over the following fallow.

Site-Year comparison	**Canola yield (%) relative to:**		**Canola harvest SW (mm) relative to:**		**Canola SW at sow next crop (mm) relative to:**		**Canola fallow N mineralisation (kg/ha) relative to:**	
	Wheat	Chickpea	Cereal	Legume	Cereal	Legume	Cereal	Legume
Trangie-Red 2019	34		+20		+17		+18	
Trangie-Red 2020	42		-8		-4		+30	
Narrabri 2017[A]	0		+20		+17		+35	
Pampas 2015	68	95	-4	-9	+4	+2	+28	-10
Billa Billa 2018	60	108	+14	+3				
Trangie Gray '20	57	300	+28	-20				
Pampas 2021	70	123						
Narrabri 2016	-	108	-	0	-	-18	-	-10
Spring Ridge 2019	-	-		0		-14		+34

[A] – Frost damage during early podding

Crop rotational implications

Weed and pathogen management

Clearly an important rationale for using canola in a crop sequence is to achieve some rotational benefits such as reducing populations of cereal or legume pathogens (e.g., root lesion nematodes, Fusarium crown rot), providing an alternative weed control option, and/or opportunities for using (or coping with) alternative herbicide chemistry.

Consistent with previous understanding, our farming system data has shown that canola does not host the root lesion nematode, *Pratylenchus thornei* (*Pt*), the main problem species in the northern region. Hence, the population of this pathogen continues to slowly reduce under a canola crop whilst it will increase significantly under host crops like wheat or chickpea. The benefit for supressing *Pt* populations is further enhanced if the period of growing non-host crops can be extended for >24 months (Figure 3). Hence, growing canola in combination with non-host crops like durum wheat, cotton, or sorghum provides an effective mechanism for reducing the population of *Pt* to low levels in problem fields. However, it should be noted that canola is a host of a different root lesion nematode species *Pratylenchus neglectus* (*Pn*) which is more dominant on lower clay content soils in central and southern NSW. Hence, canola is not a good option for lowering *Pn* populations in these regions. Canola has also been shown to be a valuable alternative crop in northern cropping systems to reduce levels of Fusarium crown rot following winter cereal crops (Kirkegaard et al. 2004).

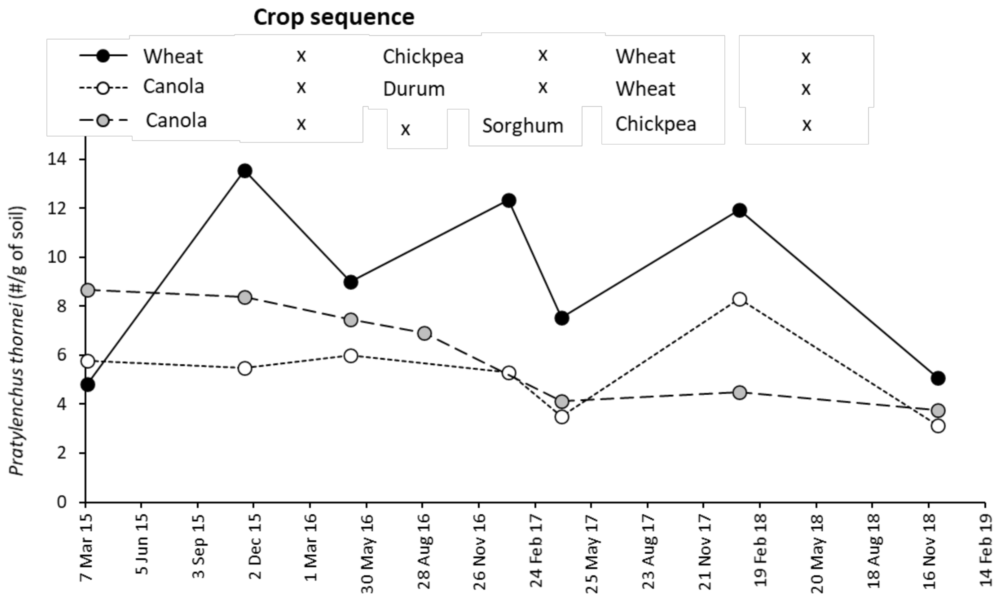

Figure 3. Root lesion nematode (*P. thornei*) populations in the soil over different crop sequences – shows the slow decline in numbers during non-host crops like canola coupled with durum or sorghum to provide a double break, compared to a rotation of host crops like wheat and chickpea.

Other crop rotational impacts/considerations

While canola can offer several positive legacy benefits in a farming system, there are some potential risks to consider in subsequent crop management and selection. Firstly, canola doesn't host beneficial arbuscular mycorrhizal fungi (AMF), so there's a risk that these populations will be reduced during a phase of canola, especially if it is preceded or followed by a long fallow, creating a long period without a host plant. Hence, on sites with low or marginal soil P, it is probably best to avoid following canola with a more AMF dependent summer (cotton, sunflower, mungbean and maize) or winter crop (linseed, chickpea and fababean). Secondly, several herbicides used in canola can have significant plant-back restrictions for some crop choices. This is important to consider in situations with double-crop opportunities into summer crops (e.g., mungbeans, sorghum). Finally, volunteer canola plants, particularly when growing herbicide tolerant canola varieties, can be difficult to control in some subsequent crops and fallows. This can sometimes require more expensive herbicides be used to clean up canola volunteer plants in fallows or control these in the following crop.

Conclusions

Canola offers many potential benefits of crop diversification in a farming system; widening sowing windows, disease and weed management. Both experimental data and modelling suggest there are opportunities to use canola in northern farming systems when we have the confluence of sufficient accumulated soil water and a sowing opportunity in the right window. Whilst these conditions are unlikely to occur every year, they are not infrequent across many environments in the northern grain region.

While considering many of the agronomic considerations outlined above, it is important to also consider the sowing and harvesting equipment available to you. Accurate seed depth control will achieve better and more consistent establishment in canola, and hence sowing machinery that provides this is advantageous. Similarly, accessing a windrower for canola is often challenging and whilst direct heading is possible, it does impose greater risk of harvest losses and requires more attention to timing of harvest to mitigate risk.

References/Further Reading

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