Improving profitability using double break crop sequences

Contents

Key Messages

- Double break crop sequences can be more profitable than current canola-cereal sequences
- Early sowing can be a significant driver of profitability for chickpea, especially mid-April sowing
- Weed populations increased in the chickpea phase but did not cause issues in the following cereal crop

Background

Break crops are widely acknowledged as being necessary to manage the biological constraints that reduce cereal crop production. While break crops have traditionally been used as a single crop in rotation, the use of two break crops in sequence has been shown to greatly increase cereal crop production and profitability, particularly as shifts in disease presence, and increases herbicide resistance in weeds has reduced the effectiveness of a single break crop.
One of the constraints in the use of a single or double break crop sequence is that the Gross Margin of the most commonly used break crops are generally less than growing a cereal crop. Growers need to balance the short-term decrease in economic return from growing a break crop with the longer-term benefits of decreased production costs and increased productivity of cereal crops for many years following. As a result, break crops are used sparingly by growers in crop rotations with the aim of maintaining the most profitable sequence of crops while maintaining reasonable control of weeds and diseases.
The most desired traits of a break crop are to be highly effective in controlling weeds and disease while also being highly profitable. Current highly effective break crop options of canola and lupin are rated as moderate to low profitability (respectively) by growers, while pasture phases or fallow period generally result in a low or negative Gross Margin.

The integration of high value legumes such as chickpea or lentil have been successful in medium to low rainfall environments of Eastern Australia to improve crop rotation profitability while maintaining effective weed control. Recent studies in WA found that profitable grain yields of both chickpea and lentil are achievable in the medium rainfall zone of the WA Wheatbelt. The impact of earlier sowing of these pulses has also been demonstrated to significantly increase in the profitability of these high value legumes. The downside of high value legumes is that potentially these break crop options have less developed (and therefore less effective) weed management packages for the WA environment.

The objective of this trial was to demonstrate the production and economic benefits of growing canola followed by a high value legume can lead to an effective and profitable double break crop sequence. Additionally, the contribution of an early versus a traditional time of sowing to increase the profitability of these crops was evaluated for the Western Australian Wheatbelt region.

Methodology

General project methodology

Six sites were established across medium and low rainfall zone of the WA wheatbelt covering the main soil types and regions where high value legumes can be grown, with a considered reliable rainfall pattern for legume production. Each site was managed by a local grower group, responsible for co-ordinating the activities of the site with the host farmer, data collection, and communication of outcomes of the project in their region. These groups included: the Liebe group, Corrigin Farm Improvement Group (CFIG) and Facey group; led by the West Midlands Group (WMG).
Each site was set up in a demonstration style (no replication) within paddocks that grew canola in 2019 or 2020, or fallow in 2020, forming the first year of the double break crop sequence. Each demonstration plot fit in with the host growers' current practices and were either 200m long by the width of the harvester, or 100m long by the width of the sprayer. All sites were sown, sprayed, and harvested with grower scale equipment.

The second-year crop sequences at each site included a range of high value legumes, sown either early or late depending on the soil type and species suitability, compared to host farmer practice of growing two cereal crops following canola. There were two times of sowing (TOS) for the high value legume, early (mid-April) and late (mid-late May), with the crop sown either dry or into moisture where available. The control treatment (cereal crop) was sown on the date determined by the farmer that maximised grain yield for the region (current grower practice). A comparison treatment of a second alternative break crop option available to the host grower was also included at some sites.
The third crop in the double break crop sequence was a cereal crop sown across the whole site to determine the effect on crop growth and grain yield.

Data collection

Soil nutrient, moisture tests were collected at the beginning of the season to a depth of 50cm to assess the nutrient requirements and presence of any soil constraints (eg. Acidity, nutrient toxicity). Predicta B soil pathogen tests (0-10cm) were carried out at the start of the second and third years of the double break crop sequence to monitor soil pathogen levels. Weed counts were completed at early tillering (GS.30 for cereals) by counting the total number of weeds in a 0.1m^2 quadrant at multiple locations across each plot.
The inputs for each season were collected from each trial site host for the year and used to develop a Gross Margin for each crop sequence. Input prices were based on long-term average price/unit and the same prices were used across all sites. The Cumulative Gross Margin was calculated by adding the Gross Margin (Income minus expenses) for each crop in sequence over the three-year period.

Table 1. Summary of the years and locations for the eight sites in this study. The Cuballing and Latham sites were discontinued after the first year due to poor crop growth, while the Dandaragan site was sown to a third break crop in 2022.

Site	2019	2020	2021	2022
Cuballing	Canola	Discontinued		

Latham	Canola	Discontinued		
Moora	Canola	Double Break	Cereal	
Wadderin	Canola	Double Break	Cereal	
Wickepin		Canola	Double Break	Cereal
Dandaragan		Canola	Double Break	Discontinued
Dalwallinu		Fallow	Double Break	Cereal
Narembeen		Fallow	Double Break	Cereal

Table 2. Soil pH at each site to a depth of 50 centimetres at the start of this study. Note: Dalwallinu site subsoil was tested in *10-20cm and **20-30cm layers.

Site	0-10 cm	10-30 cm	30-50 cm
Moora	6.6	4.4	5.3
Latham	6.0	5.5	5.4
Cuballing	4.9	5.5	5.8
Wadderin	5.5	7.1	7.7
Dalwallinu	8.7	8.7*	8.9**
Dandaragan	4.9	4.6	5.0
Narembeen	6.6	9.2	7.9
Wickepin	5.3	5.8	7.6

Table 3. Sowing date for each double-break legume treatment at each site. NA=treatment not applied at this site.

Site	Cereal	Early Sown	Late Sown	Alternate Crop
Moora	5 June	14 May	5 June	NA
Latham	7 April	7 April	28 May	28 May
Cuballing	20 May	20 May	15 June	NA
Narembeen	31 May	1 June	22 June	1 June
Dalwallinu	13 May	17 April	7 June	7 June
Wadderin	1 June	1 June	22 June	1 June
Dandaragan	5 May	10 May	26 July	NA
Wickepin	18 May	24 April	18 May	NA

Results

Crop growth and grain yield

Figure 1. Comparison of early sown (left) versus late sown (right) chickpea at Wickepin on the 17th of August 2021. The alternate plot can be seen in each photo for reference as well as tree in left of both pictures. Photo: Amy Bowden (Facey Group).

Table 4. Summary of Grain yield of each crop in the Double-Break crop sequence at each site. Shading denotes crop type: yellow=canola, orange=fallow, green=legume, blue=cereal crop.

Site	Break Crop	Time of Sowing	2019	2020	2021	2022
Cuballing	Canola	Standard	1.8			
	Lentil	Early		0.0		
		Late		0.0		
	Wheat	Early		2.4		
Latham	Canola	Standard	0.9			
	Chickpea	Early		0.0		
		Late		0.0		
	Lentil	Late		0.0		
	Wheat	Early		0.0		
Moora	Canola		1.4			
	Barley	Standard		2.9		
	Chickpea	Early		1.5		
		Late		1.5		
	Oats	Early			3.8	
		Late			4.3	
		Standard			3.5	
Wadderin	Canola		0.8			
	Albus Lupin	Alternate		0.4	3.9	
	Chickpea	Early		0.6	4.0	
		Late		0.2	3.9	
	Wheat	Standard		1.1	3.1	
Dandaragan	Canola	Standard		2.1		
	Chickpea	Early			1.0	
		Late			2.4	
	Wheat	Early			4.5	
Narembeen	Canola	Standard		Fallow	2.0	3.6

	Chickpea	Early		2.2	5.1
		Late		2.2	3.9
		Wheat		3.6	2.7
Dalwallinu	Chickpea	Early	Fallow	1.8	3
		Late		1.1	4.5
	Field pea	Alternate		0.7	4.9
	Wheat	Standard		4.4	4.1
Wickepin	Canola	Standard	0.9		
	Chickpea	Early		3.4	6.4
		Late		3.1	5.6
	Wheat	Standard		5.3	4.9

Weed populations and soil pathogens

There was a trend that total weed population in the third-year cereal or second-year legume was higher after the double break crop sequence compared to standard practice of growing two cereal crops following canola or fallow (Figure 2). Total weed population refers to the total number of all weeds present at GS.30 for cereals and flowering stage of legumes, inclusive of all grasses and broadleaf weeds. The use of canola or fallow as the first crop in the double break sequence appeared effective at lowering weed numbers as relatively low weed populations were observed for the cereal crop sequences. Weed control in the cereal crop (year 3) appears effective in ensuring that the invasive plants do not get out of control as total weed population was around 50 plants/m^2 for double break crop sequences regardless of whether it was in the second-year legume or third-year cereal crop. The type of agronomy package available for each break crop appear to impact on weed populations they increased significantly following Albus Lupin at the Wadderin site (Albus lupin has few registered herbicide options). In contrast, the Narembeen and Latham sites highlight that effective weed control is achievable and comparable to cereal crop production.

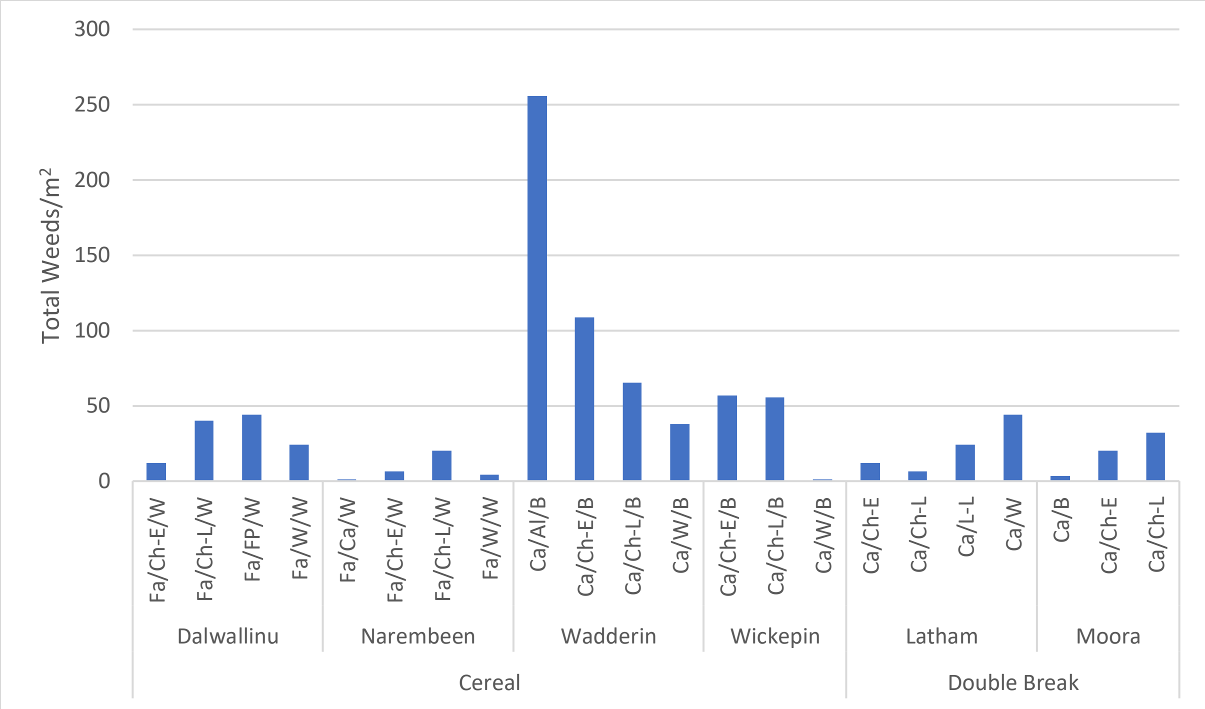

Figure 2. Total number of weeds present in each treatment at the end of July for each site after the application of all herbicides for the growing season. Sites denoted by 'Cereal' had weed counts taken in the cereal crop (i.e. third crop) in the crop rotation, while 'Double Break' sites had weed counts taken in the Double Break (i.e. second crop) year. Ca=Canola, Ch-L=Chickpea-Late sown, Ch-E=Chickpea-Early sown, L-L=Lentil-Late sown, AL=Albus Lupin, FP=Fieldpea, Fa=Fallow, W=Wheat, B=Barley, O=Oats

The impact of double break crop sequences on the four main soil pathogens in WA was unclear in this study. The level of soil pathogen varied between sites and years (Figure 3), with the major soil pathogens being P.neglectus and R. solani AG8. Within each site, there was evidence that each crop sequence had a greater impact on changing the relative proportions of soil pathogens rather than an overall reduction in pathogen levels. The structure of this study limited the collection of soil pathogen data prior to the double break (i.e. in the canola or fallow year) implementation, as such, the full impact of the double break cannot be presented.

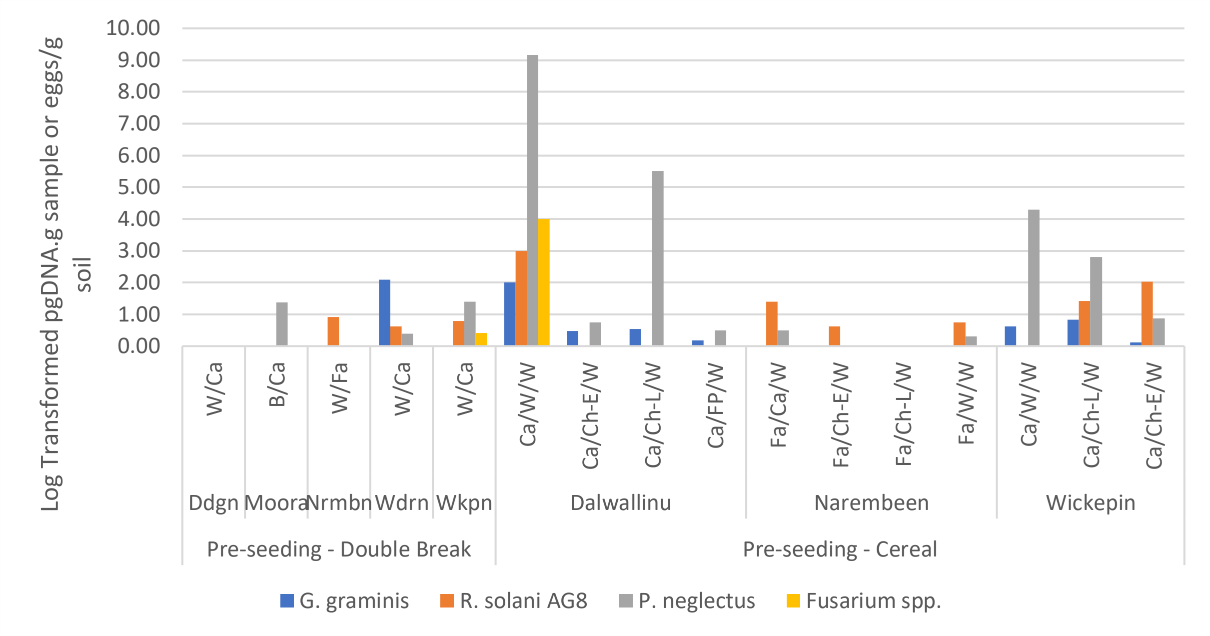

Figure 3. Profile of the four most common soil pathogens at sites either at the commencement of the project (start of the double break) or in the cereal phase (3rd year of rotation). Site abbreviations: Ddgn=Dandaragan, Nrmbn=Narembeen, Wkpn=Wickepin. Rotation abbreviations: Ca=Canola, Ch-L=Chickpea-Late sown, Ch-E=Chickpea-Early sown, FP=Fieldpea, Fa=Fallow, W=Wheat.

Economic Analysis

The partial budget for adopting a double break crop sequence was evaluated in Table 5 to determine the net economic benefit of changing from a canola-cereal-cereal to a canola-high value legume-cereal crop sequence. A partial budget considers the extra income and extra costs of a change in practice along with the income lost and costs saved from the existing farming practice. Over the three-year crop sequence, a double break crop rotation was more profitable and averaged $321/ha across all five sites. When this change in practice is applied to an area of 300ha and allowing for the purchase of extra capital items (grain handling equipment), the change in farming practice had a return on investment of 214%, having returned $2.14 for every $1 invested. The breakeven point for this change in practice was 0.5 years.

Table 5. Partial budget for the adoption of a double break crop sequence (Change in practice) versus current crop sequences (Existing practice).

	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL
Extra Income						
Canola Crop	$582					
Chickpea grain yield		$1,326				
3rd year cereal grain yield			$1,303			
Extra Costs						
Chemical	$69	$67	$54			
Fertiliser	$90	$37	$96			
Fungicide	$0	$37	$14			
Machinery	$151	$131	$132			
Seed	$24	$83	$30			
Gross Margin	**$248**	**$971**	**$976**	**$0**	**$0**	**$2,195**

(Change in practice)						
Income lost						
Canola Crop	$582					
Cereal Yield		$1,123				
Cereal on Cereal Yield			$1,151			
Costs Saved						
Chemical	$69	$62	$54			
Fertiliser	$90	$77	$96			
Fungicide	$0	$13	$14			
Machinery	$151	$141	$132			
Seed	$24	$27	$30			
Gross Margin (Existing Practice)	**$248**	**$803**	**$823**	**$0**	**$0**	**$1,874**
Net Difference in Gross Margin	**$0**	**$168**	**$153**	**$0**	**$0**	**$321**
Capital Investment						
Area invested in (ha) and Total return		300	300			$96,225
New grain handling equipment (total cost)		$45,000				$45,000
RETURN ON INVESTMENT (Percentage Return)						**214%**
RETURN ON INVESTMENT (Return:Investment)						**2.1 : 1**
BREAK EVEN (Years)						**0.5**

Cumulative Gross Margin of Double-Break crop sequences

There was large variation in the Cumulative Gross Margin of the double-break crop sequence of Canola (or Fallow) followed by a legume and a cereal crop (Figure 4) which was partly reflective of the range of annual rainfall and grain yield potential for each site. Within each site, a strong trend was that the inclusion of a double-break crop led to a similar or greater cumulative Gross Margin at all sites except for Dalwallinu. Within the double-break legume phase, the early time of sowing tended to give an increase in grain yield (Table 4) for chickpea, a significant driver of the increase in Gross Margin.

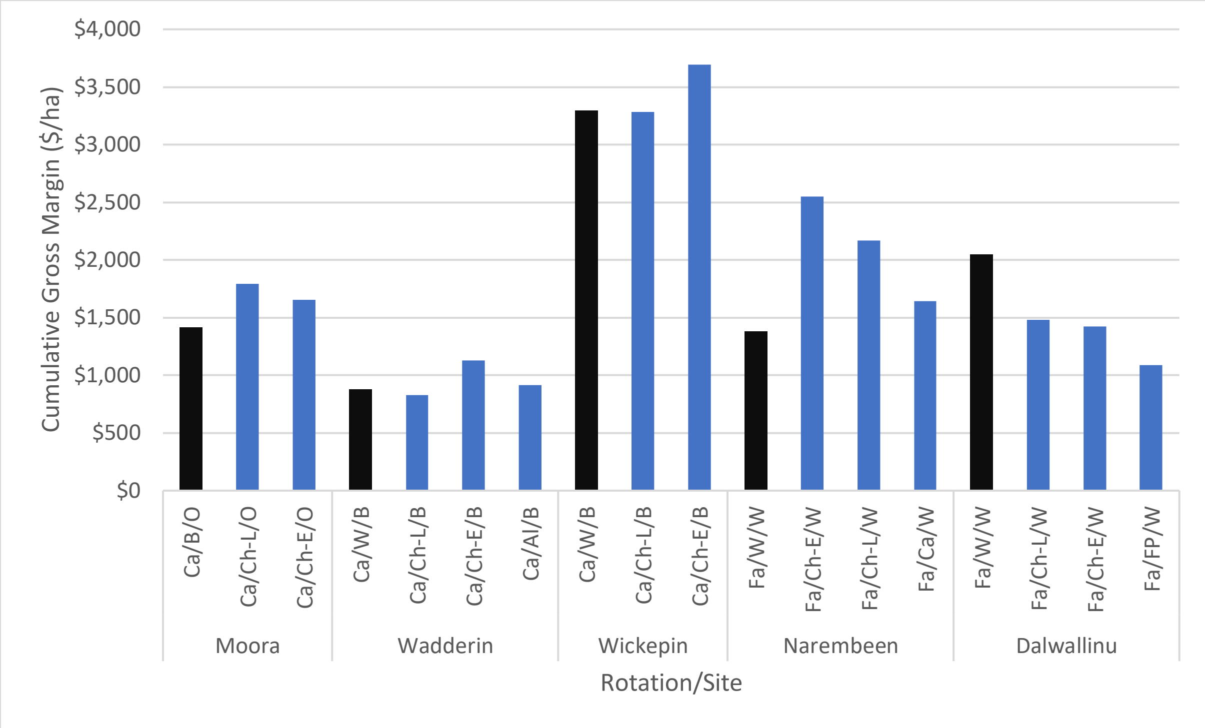

Figure 4. Cumulative Gross Margin over three years for each double-break crop rotation at each site compared to current practice (dark bars) in this study. Sites presented contained 3 years of data to include the first and second break crop, followed by cereal. Ca=Canola, Ch-L=Chickpea-Late sown, Ch-E=Chickpea-Early sown, L-L=Lentil-Late sown, AL=Albus Lupin, FP=Fieldpea, Fa=Fallow, W=Wheat, B=Barley, O=Oats

At sites that were discontinued following poor crop growth in the double-break year, the result for two-year Cumulative Gross Margin was variable (Figure 6). The use of a double-break legume such as lentil or chickpea led to a negative Gross Margin for the crop (Table 4), impacting on the Cumulative Gross Margin compared to growing wheat after a single break. The exception to this was the Latham site, where a severe hailstorm rendered all treatments un-harvestable, and no yield result could be obtained. However, visual observations during the growing season indicated that wheat following canola would have yielded significantly higher than chickpea (early or late sown) in the absence of storm damage.

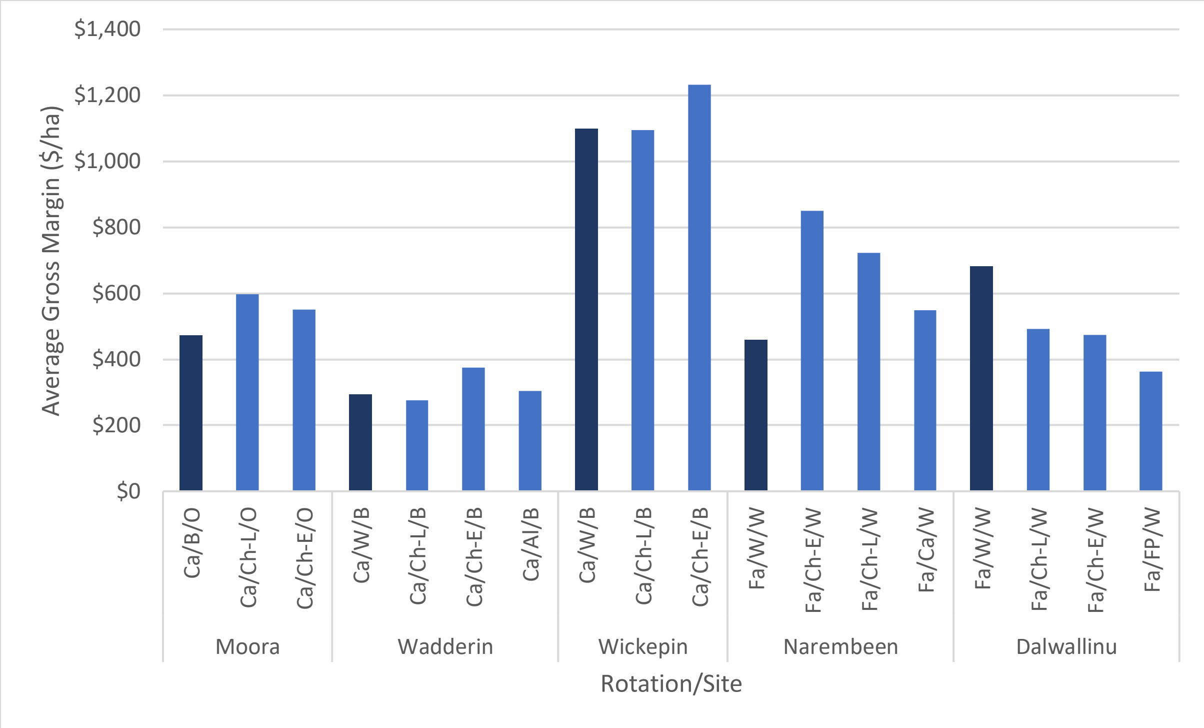

Figure 5. Average Gross Margin over three years for each double-break crop rotation compared to district practice (denoted by dark bar) at each site in this study. Sites presented contained 3 years of data to include the first and second break crop, followed by cereal. Ca=Canola, Ch-L=Chickpea-Late sown, Ch-E=Chickpea-Early sown, L-L=Lentil-Late sown, AL=Albus Lupin, FP=Fieldpea, Fa=Fallow, W=Wheat, B=Barley, O=Oats

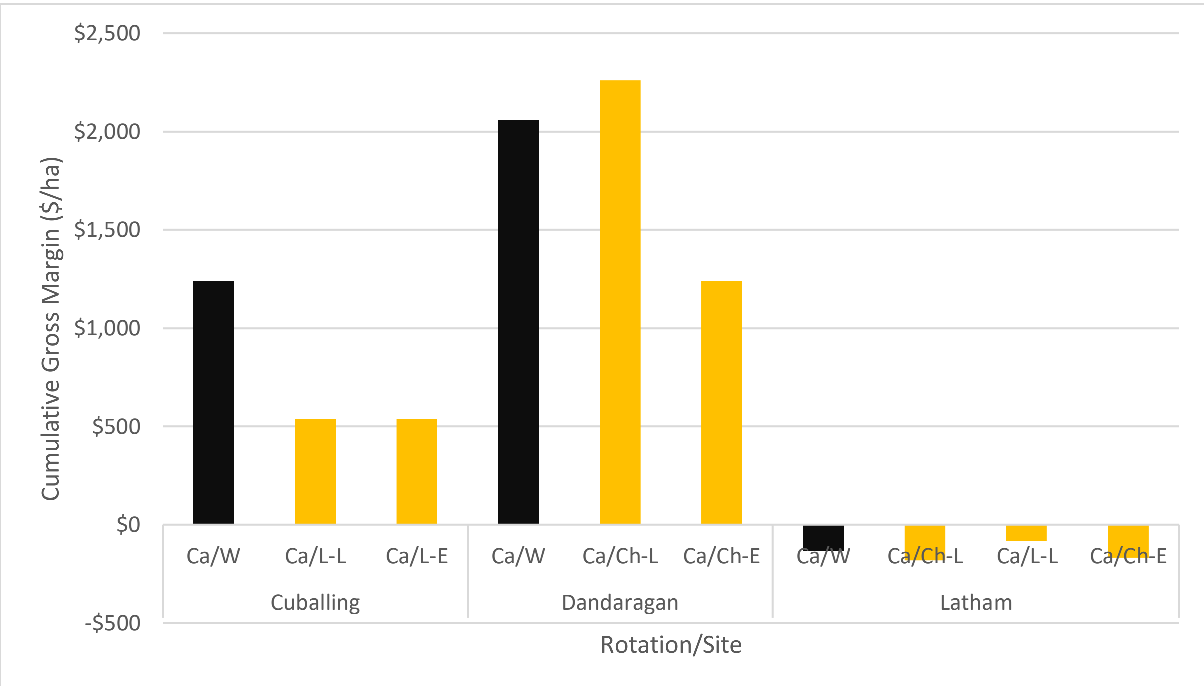

Figure 6. Cumulative Gross Margin for two years at sites where the break-crop failed, and the site was abandoned. District practice is denoted by the dark bar for each site

A trend was observed that the Gross Margin of cereal crops improved in the third phase of the crop sequence following a double break crop sequence (Figure 6). There was no consistent trend in the effect that time of sowing for chickpea had on subsequent cereal grain yield, however, the Gross

Margin (Figure 6) and grain yield (Table 4) were increased by the preceding legume crop when the legume grain yield was low, independent of the time of sowing. This is exemplified by wheat following field pea and chickpea (late sown) at Dalwallinu where these crops yielded 0.7 and 1.1 t/ha respectively but were the highest yielding crop sequences.

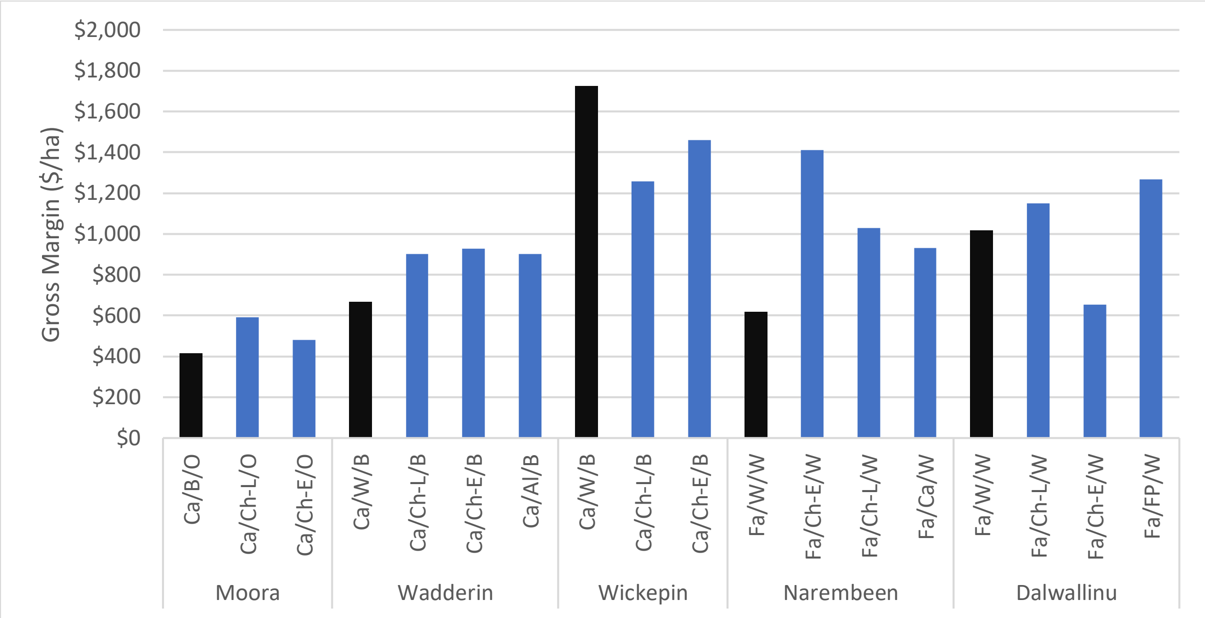

Figure 7. Gross Margin of cereal crops following a double-break for all sites that completed the 3-year crop sequence. Dark bars denote current practice for each site. Sequence abbreviations: Ca=Canola, Ch-L=Chickpea-Late sown, Ch-E=Chickpea-Early sown, L-L=Lentil-Late sown, AL=Albus Lupin, FP=Field pea, Fa=Fallow, W=Wheat, B=Barley, O=Oats

Discussion

Profitability of a double break

This study has shown that across the Wheatbelt of WA, a double break crop sequence can be more profitable than a single break given that a high value legume (chickpea) can be successfully grown. This was shown across a range of soil types and rainfall zones in this study, with a key outcome being that chickpeas were successfully grown in soil types and regions that were not considered to be suitable. While the positive benefits of growing a cereal crop following a single year of break crop have been widely researched, this study has highlighted that a well-managed three-year crop sequence is the driver of profit, rather than just a large increase in grain yield of the subsequent cereal crop. The two main drivers of profitability of the evaluated double break crop sequences were the Gross Margin of chickpea and the increase in grain yield of the cereal following chickpea. Within this, profitable chickpea production was based on the use of early seeding to maximise biomass production and grain yield for soil types that are not traditionally used for growing chickpea. A limitation of this study is that sites were discontinued where high value legumes could not be successfully grown, hence, the subsequent impact on the production and profitability of the cereal crop was not determined.

Impact of early seeding

The early seeding of a high value legume in Mid-April rather than Mid-May was an effective practice to increase grain yield across the Wheatbelt of WA. The practical application of early seeding across the Wheatbelt meant that a wide range of seeding dates were achieved, relative to the amount of soil moisture that was available at seeding in each year. Where seasonal conditions were below average and crop establishment was sub-optimal, large financial losses were sustained by growing a high value legume, which was not able to be compensated by the following cereal crop. However, where the season was below average and good crop establishment was achieved, it was possible to still grow a profitable legume crop. This contributed to a three-year double break crop sequence that was equal or better than growing canola followed by two cereal crops (current farmer practice). In each comparison, grain yield of an early sown legume was similar or greater than that of late sowing. This indicates little downside risk to early seeding of chickpea in WA, however, there is little evidence of chickpea sown earlier than Mid-April in WA to understand how early chickpea can be sown. This provides an opportunity for future research as there is much interest in crop options that maximise profitability from early season rainfall. Grain yield may have been overestimated in this project as treatments was measured using hand harvest techniques to measure the maximum amount of grain produced, without the impact of harvest losses. To reduce the risk of growing chickpea further, growers will need to have the confidence to manage harvest losses which can account for 0-55% of total grain yield (Seymour, 2021). Reducing the potential for harvest grain losses will have significant benefits for the profitability of a double break crop sequence that includes high value legumes.

In this study, situations arose where early sowing did not increase the grain yield of the high value legume. At the Dalwallinu site on a heavy red clay soil (typically suited to growing chickpea), mid-April sowing led to excessive early growth of chickpea, with the total height of the crop being close to 1 metre tall at maturity. This excessive growth in a high rainfall year led to increased vegetative growth compared to the mid-May sowing and did not increase grain yield, although did increase the requirement for fungicide. At the Dandaragan site, early seeding did not lead to higher grain yield as transient waterlogging occurred from heavy rainfall after sowing chickpea in May (early sowing timing), while the grain yield of lentil at the Cuballing site (which was discontinued after the legume phase) was reduced due to high soil acidity. It is recommended that early sowing of chickpeas is used predominantly on soils that have historically been considered unsuitable for chickpea, where early growth seems to be important driver of yield.

The need for due diligence in selecting where to grow lentil (and chickpea) revolves around adequate soil testing to determine current soil acidity levels, and the longer-term deployment of soil amelioration strategies (for example: liming, deep ripping, mouldboard ploughing) successfully addressing these constraints. These paddock traits appear a strong indicator that alternate legumes can be successfully grown on these soil types.

Suitability of chickpea in WA

The potential for chickpea to be a profitable break crop appears to be underestimated in WA with the current agronomy packages and genetic material available. A large driver of this profitability is early sowing of chickpea (mid-April) to allow greater growth of the chickpea during the season. This is in contrast to best practice chickpea production in the Eastern States of Australia, where early sowing leads to excessive vegetative growth and increased risk of disease infection, especially Ascochyta blight. While heavier soil types are traditionally favoured for growing chickpea, successful chickpea crops have been achieved in WA on sandy soil types that are cropped and soil amelioration strategies have addressed soil constraints. This has been supported by previous studies of chickpea production in the West Midlands region (on a sandy soil, atypical of where chickpea would be normally grown), which highlight the consistent advantage in biomass and grain yield production for chickpea through early sowing.

These sandy soils have typically had soil constraints that have reduced the growth and grain yield of chickpea, such as soil acidity (surface and sub-soil), compaction, and soil water repellence. The successful adoption of soil amelioration strategies for these soils to overcome these physical and biochemical constraints means that chickpea can now be successfully grown in these soils. Further research is required to determine the extent of area that will now support the growth of chickpea in WA outside of the traditional soil types. While the grain yield advantage in these atypical soils has been highlighted in previous studies, the mechanism of how this occurs is not clear., appearance suggests it is related to greater biomass growth achieved through a longer growing season and the relationship between legume biomass, nitrogen fixation, and grain yield.

Weed and disease control

The level of weed and disease control from implementing a double break crop rotation was not clearly highlighted in this study, despite being a significant factor for its use. This study had a greater focus on the use of early seeding on the profitability of a double break crop sequence and relied on previous studies where strong conclusions have demonstrated the application of the double break approach for grain growers in WA. The structure of the study, utilising existing canola paddocks as the first break crop sequence meant that an initial measurement of root disease in the paddock prior to the implementation of a double break crop sequence could not be fully quantified. The data collected in this study indicates that weed populations are likely to increase in the legume phase of the double break sequence but does not cause a weed 'blowout' in the subsequent cereal crop. While managing the trial sites, we encountered a barrier to successful weed control due to the limited knowledge among agronomic advisors on effectively growing high-value legumes, particularly in applying effective herbicide packages with newly available chemical options. This was evident with growing Albus lupin at one site, where lack of herbicide options (likely in part to lack of local herbicide knowledge) meant that weeds increased significantly compared to other crop types. Limited knowledge of effective herbicide packages impacted on the success of growing chickpea (and lentil) as generic herbicide packages had to be used in lieu of tested packages that could effectively control weeds in the legume crops. Further research and information will be needed to support capacity building and drive the successful growth of high value legume production in WA, irrespective of the crop sequence deployed by farmers.

There was a trend that the profile of soil pathogens at each site changed as a result of deploying a double break crop sequence. This contrasts with the expectation of a total reduction in soil pathogens and highlights that differing crops host different soil pathogens. Success in a double break crop sequence would mean ensuring that the profile of soil pathogens is favourable for the growth of the successive crop(s). In WA, this signifies a reduction in cereal diseases such as rhizoctonia, crown rot, and P. neglectus. However, this study indirectly highlights how responsive the profile of soil pathogens is to each crop, and the likelihood that the profile will change with each successive crop. From this, it can be postulated that long-term success with crop rotations to reduce soil pathogens will be dependent on growing a diverse range of crop types in succession so that the current pathogen profile does not have a negative effect on the growth of the next crop. The reality in WA is that the dominance of cereal crops being grown means that the soil will return to a dominance of pathogens that have a negative impact on cereal crop production in the medium term.

Other factors influencing profitability

A significant factor for the profitability of chickpea and lentil in a double break crop sequence is the value of grain produced, and indirectly, the marketing options available for growers at harvest time. The most common strategy for improving the profitability of chickpea in Eastern Australia is to utilise on-farm storage and market the grain independently to the harvest process. This approach is not used to any large extent in WA due to the highly effective co-operative-based grain handling system which handles a majority of the state's grain crop. While this works for the main commodities (wheat, barley, canola, lupin), it currently does not handle significant volumes of chickpea and so this is a limiting factor for farmers. The calculation of Gross Margins for chickpea in this study was based on a 5-year average price of $700 per tonne, however, can vary between $400 and $1700 per tonne which can significantly impact on profitability of the crop. Profitable growth of high value legumes in WA is likely to require a similar need to store and market the grain to maximise the high value nature of these legumes.

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