Companion cropping to utilise rainfall for profit

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Key points

- Four companion mixes (field pea/canola, faba bean/canola, faba bean/wheat and barley/canola) were sown at different ratios at Rutherglen during 2019.
- Six out of eight companion mixes evaluated had a small, but positive, yield advantage over the monoculture treatments.
- Hot, dry conditions during September–October and frost at early flowering affected the yield of canola more than other crops.

Introduction

Companion cropping involves planting and growing two (or more) species of crop in the same paddock at the same time. Companion cropping has the potential to increase the use of total available solar radiation and water per unit of land, offers an opportunity to intensify and diversify grain production, as well as increase yields and profits. In Australia, companion cropping is not widely practiced due to additional labour requirements and the added complexity of management (e.g. harvesting and handling of mixed species).

Aim

To determine if two crop species sown together (companion cropping) could provide an opportunity to intensify and diversify grain production and increase yield and profit.

Method

Four dual-species mixtures (field pea/canola, faba bean/wheat, faba bean/canola and barley/canola) were sown to compare the performance of cereals, legumes and oilseeds when grown as companion crops.

The dual-species mixtures were sown at different species ratio targets of 25:75 per cent, 75:25 per cent and each species was also grown as a monoculture.

On 4 June 2019, a field trial was sown at Rutherglen (Figure 1). Cultivar selection was based on crops with a similar phenology and, except for field pea, herbicide tolerance including imidazoline tolerance (CL) or triazine and imidazoline tolerance (CT). Cultivars were obtained commercially, with seed treated to protect against pests and disease (Table 1).

Seed was sown on 15cm row spacings and plot size was 4.8 x 20m, giving a total plot area of 96m^2. There were four replicates of each treatment.

The pea/canola plots were sprayed with 40g/ha Raptor® herbicide on 5 August, 2019, with the pea/canola and faba bean/canola plots sprayed with 500ml/ha Clethodim 240 and 75ml/ha Verdict on 12 August, 2019. The faba bean/canola, faba bean/wheat and barley/canola

FIGURE 1 Experimental layout at Rutherglen, showing the blocked design of the companion cropping experiment on the right

TABLE 1 Crops, cultivars and herbicide treatments for the companion cropping experiment at Rutherglen, 2019

Sowing fertiliser:	100kg/ha of MAP	
Pre-sowing herbicides:	Terbyne® (0.86kg/ha), trifluralin (1.5L/ha), Nail® (55mL/ha), and glyphosate (1.4L/ha)	
In-crop insecticides:	Veritas, Aviator X	
Crop	**Cultivar**	**Herbicide tolerance**
Barley	Spartacus CL	Imidazolinone
Canola	Hyola® 580 CT	Triazine and imidazolinone
Faba bean	PBA Bendoc	Imidazolinone
Field pea	PBA Butler	Nil
Wheat	Sheriff CL	Imidazolinone

plots were sprayed with 600ml/ha Intercept (Intervix) on 23 August. The main weeds being targeted at the site were wireweed (*Polygonum aviculare*), shepherd's purse (*Capsella bursa-pastoris*) and ryegrass (*Lolium rigidum*). Ryegrass in the barley/canola treatments was effectively suppressed by crop competition, so was not problematic. The herbicide weed control strategies were successful in all but the faba bean/wheat treatment, as Clethodium was not able to be applied to this treatment combination.

Plant establishment was recorded as plants per square metre, from random areas within the plots seven weeks after sowing, with establishment rates generally lower than the target populations. Flowering biomass was measured on 1 October 2019. Both species in each dual-species mixture were harvested together with a header, with grain separated post-harvest using a small-scale seed grader.

Rainfall at Rutherglen during 2019 was below average (Table 2). However timely, above-average rainfall during May, combined with good rainfall totals during June and July, helped to maintain yield potential above what would be expected given the dry spring conditions. Regular frosts during September and October coincided with key flowering and early grain filling periods for most crops, although the later time of sowing for this trial reduced its exposure to most of the severe frosts.

Results

Assessing the growth of companion crops is more complex than assessing monocultures, with several approaches available. The most commonly used approach is the land equivalent ratio (LER), which describes the additional land needed to grow the same quantity of both species if they were grown as monocultures, rather than as companion crops. The LER calculation is as follows;

TABLE 2 Rainfall at Rutherglen during 2019 compared with the long-term average

Month	Rainfall (mm)	Long-term average rainfall (mm)
January	10.0	37
February	36.4	39
March	24.6	39
April	0.8	42
May	85.0	50
June	45.0	56
July	41.4	63
August	20.6	60
September	19.8	54
October	8.8	57
November	41.0	46
December	16 .0	45
2019 total	**349.4**	**588**
2019 GSR (April – October)	**221.4**	**382**

$$LER = (Y1_c \div Y1_m) + (Y2_c \div Y2_m)$$

Where $Y1_c$ or $Y2_c$ = yield of crop 1 or 2 as a companion crop

$Y1_m$ or $Y2_m$ = Yield of crop 1 or 2 as a monoculture

The LER values for this trial were calculated using biomass at flowering and grain yield at harvest. An LER value of 1.0 means the productivity of the companion crop mix is equal to the monoculture components. An LER value greater than 1.0 means the companion crop is more productive than the monoculture components and is referred to as over-yielding.

i. Barley/canola companions

Total biomass at flowering (LER) was 7 per cent lower in both companion treatments compared with their monoculture biomass yield (Table 3, Figure 2).

Canola biomass at flowering indicated a higher yield potential than was achieved at harvest, likely due to the impact of frost at the start of canola flowering as well as hot and dry conditions during late October.

Total grain yield (LER) was 4–5 per cent higher in the barley/canola companion crop mix compared with their monoculture yields. For both the 25:75 and 75:25 barley/canola companion crop ratios, the canola yield was lower on an area basis compared with its monoculture, however the barley yielded well, leading to a high yield overall (Table 3, Figure 3).

TABLE 3 Barley/canola companion treatment results for flowering biomass, grain yield and land equivalent ratios (LER), Rutherglen, 2019

Planting ratio	Monoculture	75:25		25:75		Monoculture
Species mix	Barley (100%)	Barley (75%)	Canola (25%)	Barley (25%)	Canola (75%)	Canola (100%)
Flowering biomass (t DM/ha)	7.9	6.1	0.9	2.8	3.1	5.4
Flowering (LER*)	-	**0.93**		**0.93**		-
Grain yield (t/ha)	5.8	4.5	0.2	2.0	0.4	0.7
Grain (LER*)	-	**1.04**		**1.05**		-

* LER is a measure of crop yield when grown as a companion compared with that same crop grown as a monoculture.

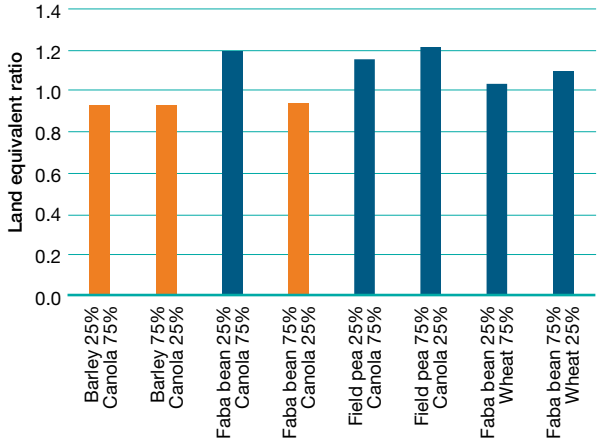

FIGURE 2 Land equivalent ratio (LER) of biomass at flowering for the four companion crop combinations at Rutherglen, 2019
Standard error of difference is 0.013.

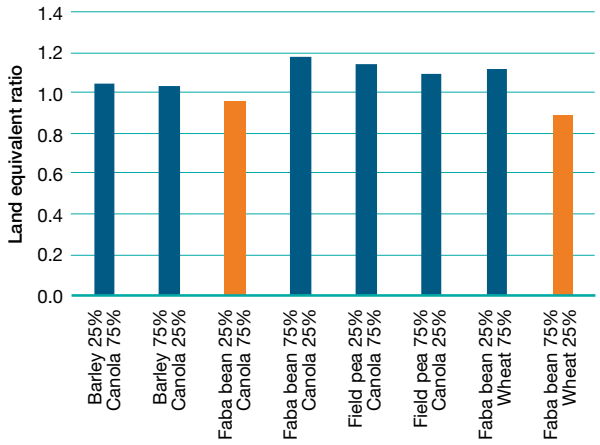

FIGURE 3 Land equivalent ratio (LER) of harvest biomass for the four companion crop combinations at Rutherglen, 2019
Standard error of difference is 0.019.

ii. Faba bean/canola companions

Total biomass at flowering (LER) was 15–21 per cent higher in both companion treatments compared with their monoculture (Table 4, Figure 2). Canola biomass at flowering indicated a higher yield potential than was achieved at harvest due to the impacts of frost at the start of flowering and hot and dry conditions during late October.

Total grain yield (LER) was -4 per cent for the faba bean:canola ratio of 25:75 per cent and +18 per cent for the faba bean:canola ratio of 75:25 per cent in crops grown as companions (Table 4, Figure 3).

iii. Field pea/canola companions

Canola and field pea biomass results at flowering indicated a higher yield potential than was achieved at harvest, with canola flowering impacted by frost and pod set by hot and dry conditions during late October (Table 5, Figure 2).

Total grain yield (LER) was 9–14 per cent higher in crops grown as a companion. In each of the companion crops, the field pea yield was lower on an area basis compared with its monoculture, however the extra yield achieved in the canola companion lead to a high yield overall (Table 5, Figure 3).

iv. Faba bean/wheat companions

Total biomass at flowering (LER) was 4–10% higher in both companion treatments compared to their monoculture (Table 6, Figure 2).

TABLE 4 Faba bean/canola companion treatment results for flowering biomass, yield and land equivalent ratios (LER), Rutherglen, 2019

Planting ratio	Monoculture	75:25		25:75		Monoculture
Species mix	Faba bean (100%)	Faba bean (75%)	Canola (25%)	Faba bean (25%)	Canola (75%)	Canola (100%)
Flowering biomass (t DM/ha)	4.1	2.4	2.9	1.0	4.8	5.2
Flowering (LER*)		**0.94**		**1.19**		
Grain yield (t/ha)	1.8	0.6	0.6	0.2	0.6	0.7
Grain (LER*)		**1.18**		**0.96**		

* LER is a measure of crop yield when grown as a companion compared with that same crop grown as a monoculture.

TABLE 5 Field pea/canola companion treatment results for flowering biomass, yield and land equivalent ratios (LER), Rutherglen, 2019

Planting ratio	Monoculture	75:25		25:75		Monoculture
Species mix	Field pea (100%)	Field pea (75%)	Canola (25%)	Field pea (25%)	Canola (75%)	Canola (100%)
Flowering biomass (t DM/ha)	3.9	3.0	2.2	0.8	4.3	5.9
Flowering (LER*)		**1.21**		**1.15**		
Grain yield (t/ha)	1.0	0.6	0.4	0.2	0.8	0.9
Grain (LER*)		**1.09**		**1.14**		

* LER is a measure of crop yield when grown as a companion compared with that same crop grown as a monoculture.

TABLE 6 Faba bean and wheat companion treatment results for flowering DM, yield and land equivalent ratios (LER), Rutherglen, 2019

Planting ratio	Monoculture	75:25		25:75		Monoculture
Species mix	Faba bean (100 %)	Faba bean (75%)	Wheat (25%)	Faba bean (25%)	Wheat (75%)	Wheat (100%)
Flowering biomass (t DM/ha)	4.2	2.9	2.5	1.2	5.8	7.2
Flowering (LER)		**1.04**		**1.10**		
Grain yield (t/ha)	1.4	0.4	2.6	0.1	4.1	4.2
Grain (LER*)		**0.89**		**1.12**		

* LER is a measure of crop yield when grown as a companion compared to that same crop grown as a monoculture.

Total grain yield (LER) was -11 per cent for the faba bean:wheat ratio of 75:25 per cent and +12 per cent for the faba bean:wheat ratio of 75:25 per cent in crops grown as a companion (Figure 3).

Observations and comments

This research demonstrates that companion cropping has the potential to increase yield in the cropping regions of southern Australia. Further work is being undertaken to determine the economic profitability and risk of companion cropping in a whole-farm context.

There are also different herbicide options available for use in these companion systems, which may provide alternative management options for grain growers.

This research is part of a project that had field experiments sown at core experimental sites at Rutherglen, Hamilton and Horsham during 2019. During 2020, additional satellite sites were sown in north-east Victoria at Burramine South and Caniambo.

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