Winter intercropping shows advantages in northeast Victoria

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Abstract

Intercropping has the potential to enhance water, nutrient and solar radiation efficiency, offers an opportunity to intensify and diversify grain production, and increase yields and profits. In Australia, intercropping is not widely adopted due to additional labour requirements and management complexity including herbicide choice and harvesting challenges. Field experiments were established in 2019 and 2020 at Rutherglen in northeast Victoria to compare performance of 2 species combinations of either cereals (wheat, barley), legumes (faba beans) or oilseeds (canola). In 2019, six out of eight mixtures evaluated had a small, but positive yield advantage over the monocultures. Whereas in 2020, all intercropping mixture evaluated demonstrated positive responses and additional profits. Of the eight mixtures evaluated, over the two years of the experiment, the greatest overyielding intercrops were faba bean/wheat and pea/canola. To get a positive economic return with our price and cost assumptions, the intercrop Land Equivalent Ratio (LER) needed to be greater than 1.1. This research indicates that intercropping has the potential to increase yield, value and profitability in cropping regions of northeast Victoria.

Keywords

companion cropping, diversification, land equivalent ratio, peaola

Introduction

Intercropping, the practice of planting and growing sowing two (or more) crop species together in the same paddock, 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, and increase yields and profits (Keating and Carberry 1993; Morris and Garrity 1993a; Morris and Garrity 1993b). In Australia, intercropping is not widely adopted due to additional labour requirements and additional management complexity (e.g. harvesting and handling of mixed species). However, in other developed countries, like Canada, there is evidence of farmers adopting the practice (Smith 2014). A review identified potential benefits of intercropping in dryland systems in Australia (Fletcher et al. 2016).

To achieve broader farmer adoption of intercropping and the associated yield benefits, further research is required to support early farmer adoption and to provide greater farmer confidence in these systems (Fletcher et al. 2016). This study aimed to determine if intercropping of two crop species when sown together provide an opportunity to intensify and diversify grain production and increase yields.

Methods

The site was located at Rutherglen (S36.108, E146.520) with experiments conducted in 2019 and 2020. The site was in a paddock that was in oats in 2018 and was a long-term lucerne pasture prior to that. Four two-species mixtures comprising mix ratio targets of 25%:75%, 75%:25% and 100% monocultures (field pea/canola, faba bean/wheat, faba bean/canola and barley/canola) were tested to compare performance of cereals with legumes and oilseeds when grown together. The sowing dates were 4/6/2019 and 7/5/2020. In 2019 annual rainfall was 349 mm annual and growing season (April to October) rainfall was 221 mm, and in 2020, annual rainfall 600 mm and growing season rainfall was 403 mm.

Cultivar selection was based on crops with a similar phenology and, except for field pea, herbicide tolerance including imidazoline tolerant (CL) or triazine and imidazoline tolerant (CT). Cultivars were obtained from commercial sources with seed treated to protect from pests and disease (Table 1). Row spacing was 15 cm and plot size was 4.8 by 20 m long giving a total plot area of 96 m^2. There were four replicates.

Table 1. Crops, varieties, and seed treatments for the companion cropping experiment at Rutherglen in 2019 and 2020.

Sowing fertiliser:	100 kg/ha of MAP
Pre-sowing herbicides:	Terbyne, Trifluralin, Nail, and Glyphosate
In-crop Insecticides:	Veritas, Aviator X

Crop	*Cultivar*	*Herbicide Tolerance*
Barley	Spartacus CL	Imidazolinone
Canola	Hyola® 580 CT	Triazine & Imidazolinone
Faba Bean	PBA Bendoc	Imidazolinone
Field Pea	PBA Butler	Nil
Wheat	Sheriff CL	Imidazolinone

Measurements, calculations and analyses

Plant establishment was recorded from random areas within the plots seven weeks after sowing. In 2019 plant establishment numbers were generally fewer than the target populations, especially in the canola due to the late sowing date. In 2020 target plant establishment was achieved. Both crops were harvested together, with grain separated post-harvest.

Land equivalent ratio (LER) values were calculated to give an indication of intercrop land productivity relative to the monoculture treatments. The LER is the sum of the relative responses of each species compared to their respective monoculture yields. It is expressed as:

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

Where $Y1_c$ or $Y2_c$ = Yield of crop 1 or 2 as an intercrop component, where $Y1_m$ or $Y2_m$ = Yield of crop 1 or 2 as a monoculture. The LER values were calculated using biomass and grain yield (t/ha). A LER value greater than 1.0 means the intercrop is more productive in terms of land usage than the monoculture components and is sometimes referred to as 'over-yielding' or 'land-sparing'; conversely a LER less than 1.0 shows monoculture advantage.

Net Gross Margins (Net GM) were also calculated to consider the mix ratios, the absolute yield of the monoculture species, the sale price of each species in the mix, and the difference in the costs and benefits of growing two crops as an intercrop rather than a monoculture. The NetGM is expressed as:

$Net\ GM = GM_c – GM_m$

$GM_c = [(Y1_c*P1 + Y2_c*P2) – C3]$

$GM_m = [Z1_c*(Y1_m*P1 – C1) + Z2_c*(Y2_m*P2 – C2)]$

Where $Y1_c$ or $Y2_c$ = Yield of crop 1 or 2 as a companion; $Y1_m$ or $Y2_m$ = Yield of crop 1 or 2 as a monoculture; $Z1_c$ and $Z2_c$ = proportional sown area of crops 1 and 2 in the intercrop; P1 and P2 are the five-year average of prices for crops 1 and 2; C1, C2 and C3 are the variable costs of production for crop 1, crop 2 and intercrop plots respectively; GM_c = Gross Margin from intercropping, GM_m = Gross Margin from monoculture with same enterprise mix as in the mixture. The five-year average (2016 – 2020) prices per tonne of barley, canola, faba beans, field pea and wheat are \$301, \$569, \$553, \$486 and \$302 respectively. The on-farm variable costs of producing a hectare of monoculture barley, canola, faba beans, field pea and wheat are \$388, \$545, \$419, \$371 and \$406 respectively. The cost of separating grains for the mixture after harvest is taken as \$24/t (per comm.).

Analysis of variance (ANOVA) was used to determine the significance of LER differences between monoculture and intercrop treatments by an unrestricted randomised complete block design, using the block structure rep/plots, with 95% confidence intervals (Genstat 2016).

Results

In 2019, measurement of biomass at flowering indicated excellent yield potential, however seasonal conditions impacted on final yields, with canola flowering impacted by frost. Canola pod set was also impacted by hot and dry conditions in late October. Six out of the eight intercrop treatments over yielded in 2019 (Table 2), however none were significantly different to the monocultures. With the best results from faba bean 75% canola 25%, followed by the pea 25% canola 75%.

Table 2. Intercrop treatment results for grain yield (t/ha) and land equivalent ratios (LER), Rutherglen 2019 and 2020

	2019 Grain yield (t/ha)		2019 Grain LER	2020 Grain yield (t/ha)		2020 Grain LER
Barley 100%	5.8			8.6		
Barley 75% Canola 25%	4.5	0.2	1.04	7.6	0.8	1.12
Barley 25% Canola 75%	2.3	0.5	1.10	3.4	2.5	1.14
Canola 100%		0.7			3.4	
Faba bean 100%	1.8			5.7		
Faba bean 75% Canola 25%	0.6	0.7	1.14	4.6	1.1	1.09
Faba bean 25% Canola 75%	0.2	0.7	0.93	3.4	2.4	1.21
Canola 100%		0.8			3.8	
Field pea 100%	1.0			5.8		
Field pea 75% Canola 25%	0.6	0.3	1.01	3.4	2.4	1.18
Field pea 25% Canola 75%	0.2	0.8	1.16	1.7	3.1	1.08
Canola 100%		0.9			4.2	
Faba bean 100%	1.4			5.7		
Faba bean 75% Wheat 25%	0.4	2.6	0.89	5.9	1.4	1.22
Faba bean 25% Wheat 75%	0.1	4.1	1.12	2.4	6.1	1.20
Wheat 100%		4.2			7.9	
residual standard error			0.28			0.097

The 2020 seasonal conditions resulted in excellent grain yields for all crops. In 2020 all the intercrop combinations over-yielded (Table 2), however only three combinations were significantly different to the monoculture. The greatest overyielding intercrop was faba bean 75% wheat 25%, with an over yield of 22%, closely followed by the faba bean 25% canola 75% at 21%, and the faba bean 25% wheat 75% at 20%. The benefits of intercropping were higher in the more favourable 2020 season.

Net GM results were strongly correlated with the LER in 2020 (Figure 1) and indicate that when the LER was greater than about 1.1 there is the potential to achieve positive returns from intercropping. There are different herbicide options available for use in these companion systems, which may provide alternative management options for grain growers.

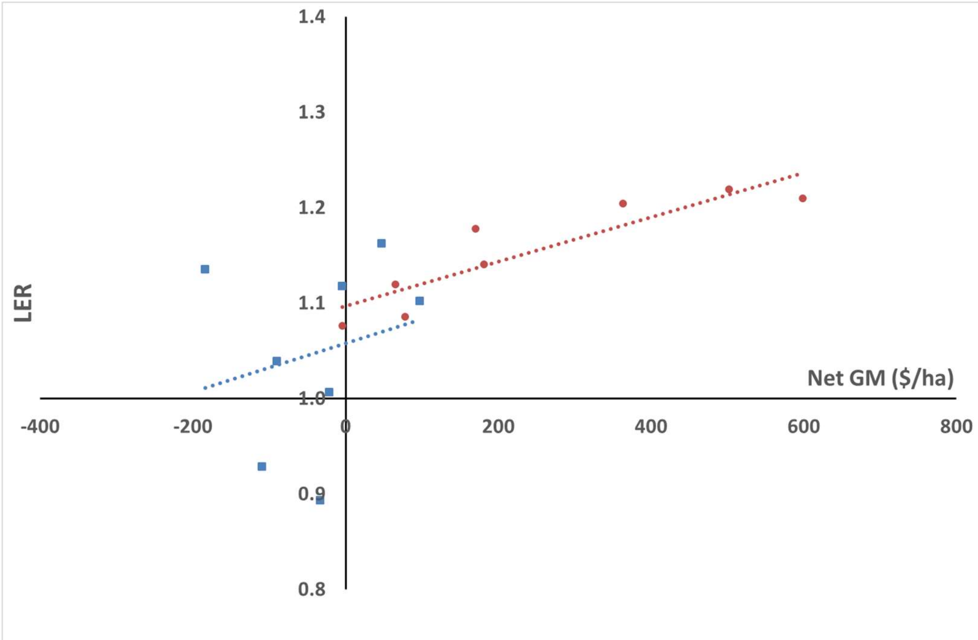

Figure 1. Relationship between land equivalent ratios (LER) and Net GM ($/Ha) for 2019 (■, R^2=0.0524) and 2020 (●, R^2=0.8096) at Rutherglen.

Conclusion

This research demonstrates that intercropping has the potential to increase yield in the cropping regions of northeast Victoria. Results demonstrate that growing a pulse with canola as an intercrop leads to positive benefits in terms of yield and additional dollar returns. The ideal seasonal conditions of 2020, combined with optimum sowing time, demonstrated that certain intercropping combinations led to productivity benefits.

Acknowledgements

This project was supported by Agriculture Victoria and the Grains Research and Development Corporation through the Victorian Grains Innovation Partnership. We also thank the growers and industry members of our reference panel who provided insight in the selection and management of the crop species used across our region for experimentation. Technical assistance was provided by Peter Harris, Tim Whitehead, Terry McLean and Jarrod Curran.

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