Old solutions to new problems: Intercropping reduces chocolate spot severity in faba bean

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Abstract
Chocolate spot (*Botrytis cinerea* and *B. fabae*) is a major disease of faba bean. Given the right conditions, it can reduce yields by 30 to 50%. Intercropping, growing multiple crop species together simultaneously is seen as a way to assist in such disease management. We investigated the extent of chocolate spot disease in various mixtures containing faba bean with canola or wheat in a new intercropping research project in southern Victoria. Field observations during 2020 found significant reductions ($P<0.05$) in chocolate spot severity when faba bean was intercropped with canola or wheat at 25, 50 and 75% of monoculture densities. There was no significant effect of the initial sowing density on faba bean grain yield. Intercropped treatments also had additional yield from the canola or wheat companion crop. Intercropping is therefore an option where monocultures fail due to difficulties breeding disease resistance, increased resistance to fungicides (carbendazim and procymidone) and the potential prohibition of fungicides due to human toxicity.

Keywords
Botrytis spp., companion cropping, diversity, disease

Introduction

Intercropping, growing multiple crop species together is as old as farming itself. A famous example is the role of the Three Sisters in American Indigenous culture, where corn, bean and squash have been grown together in a mutually beneficial relationship for 5000 years. In Australia, there has been an increased interest by grain growers in intercropping (Fletcher et al 2016). Perceived advantages over monocropping include increased productivity, improved water use and improved diversity reducing the severity of pests and diseases, and subsequent chemical use.

In 2019 an intercropping research project commenced in Victoria to evaluate winter intercropping systems to determine the potential to increase profit and systems diversity through crop mixtures. Three core field experimental sites were established in 2019 at Horsham, Hamilton and Rutherglen. In 2020, six additional satellite sites were established across Victoria. As only low levels of disease were detected at the other sites, only the Hamilton site was assessed for disease.

In 2020, there was a high incidence of crop diseases in the Hamilton trial, due to wet conditions and difficulties in trafficking the paddock to apply fungicides. Field observations during the growing season detected high levels chocolate spot *(Botrytis cinerea* and *B. fabae*) in faba bean, moderate to low levels of blackspot (*Didymella pinodes* syn. *Mycosphaerella pinodes*) in field pea and scald (*Rhynchosporium commune* (formerly *R. secalis*) in barley.

These are major crop diseases, and given suitable conditions, chocolate spot can reduce grain yields by 50%, blackspot can reduce yields in field peas by 60% and scald in barley by 40% (Davidson et al 2007; Fanning 2018). Infected seed from severely affected plants may serve as a source of primary inoculum while stains or blemishes will lower their market value.

Intercropping has been shown to reduced foliar diseases in intercrops (Fernández-Aparicio et al 2011; Boudreau 2013). Therefore, it was decided to assess monocrops and intercrops for disease. This paper reports on the effect of different species mixtures on disease development at Hamilton in southern Victoria.

Methods

Intercropping field trials were established at Hamilton in the Victorian high rainfall zone in 2020. Intercrop combinations were faba bean/canola; barley/canola; faba bean/wheat; and field pea/canola. Mixtures were sown at 25, 50, 75% of monoculture sowing rates, and included a skip row 50:50 treatment (e.g. 1 row canola/ 2 rows faba bean/2 rows canola/1 row faba bean).

The trial was sown on 18 May 2020 as a complete randomised block with four replicates. Plots were 5.25 x 20 m on raised beds. Monoculture sowing rates were faba bean cv. PBA Bendoc @ 325 kg/ha, canola cv. Hyola580 CT @ 3.6 kg/ha, wheat cv. Sheriff CL plus @ 75 kg/ha, barley cv. Spartacus CL @ 80 kg/ha, and field pea cv. Butler @ 110 kg/ha.

No artificial inoculum was applied as crop diseases were established by natural infection disseminated by wind. Disease assessments were measured as the percentage leaf area affected on 22 October 2020. Diseases assessed were chocolate spot in faba bean, in blackspot in field pea and scald in barley.

Fungicides applied during the growing season were: Veritas (tebuconazole 200 g/L + azoxystrobin 120 g/L @ 750 ml/ha) on 31 July 2020, Veritas (tebuconazole 200 g/L + azoxystrobin 120 g/L @ 750ml/ha) plus Mancozeb (750 g/kg @ 2 kg/ha) on 26 October 2020 and 9 November 2020.

Final biomass and grain yield were determined by hand harvesting four 50 cm internal rows per plot, between the 7 and 22 December 2020. Data was analysed using analysis of variance (ANOVA), Fisher's protected least significant difference test and linear regression in GenStat (18th Edition).

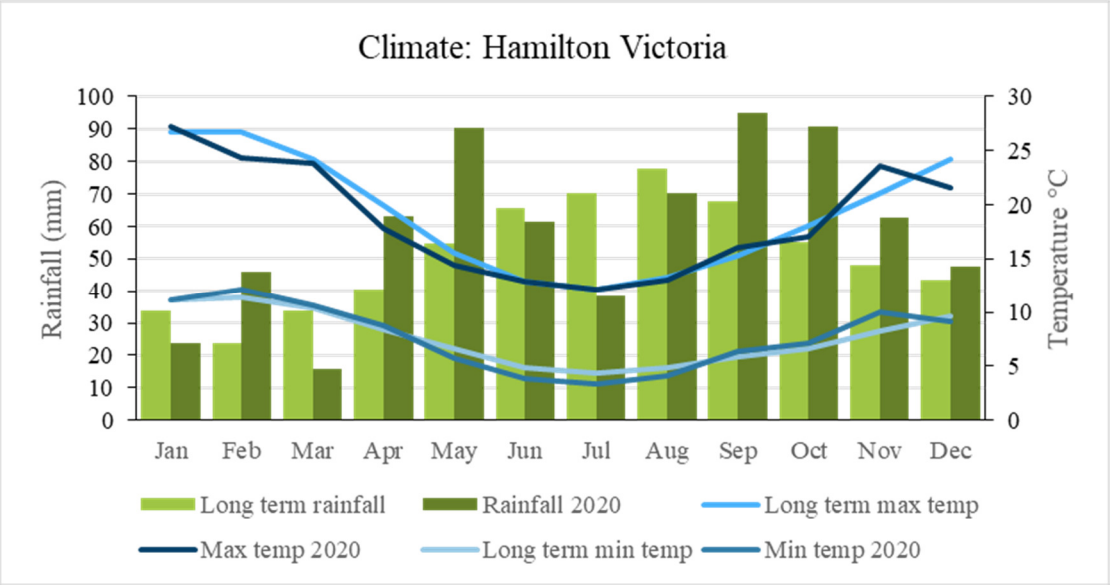

Figure 1. Comparison of rainfall, maximum and minimum temperature during 2020, compared to the long term average (30 years), for Hamilton Victoria (BOM 2021)

Rainfall was higher than average during 2020, and 2020 and was considered a decile 8 or 9 year (BOM 2020). Meteorological data for Hamilton were obtained from the Bureau of Meteorology (BOM 2021) Figure 1.

Results

The trial was assessed for crop diseases on 22 October 2020. Disease assessments of faba bean intercropped with canola indicate significant ($P<0.05$) reductions in the severity (percentage leaf area) of chocolate spot. Faba bean grown as a monoculture had the highest severity (88.8%) while the faba bean 25% canola 75% mix had the lowest (27.5%). Increasing the proportion of canola in the faba bean/canola sowing mix significantly ($P<0.05$) reduced chocolate spot (Table 1). There was no significant relationship between the sowing density of faba bean or canola on faba bean grain yield in this trial.

Table 1. Effect of intercrop (canola: cv. Hyola580 CT) on the severity (percentage leaf area affected) of chocolate spot (*Botrytis cinerea* and *B. fabae*) and grain yield of faba bean cv. PBA Bendoc CL in an intercropping trial at Hamilton, Victoria, 2020.

Crop mix	Severity (%)*	Yield (t/ha)*
Faba bean 100% : canola 0 (monoculture)	88.8a	3.9a
Faba bean 75% : canola 25%	53.8b	3.7a
Faba bean 50% : canola 50%	40.0b	3.0a
Faba bean 50% : canola 50% (skip row)	46.4b	3.5a
Faba bean 25% : canola 75%	27.5b	4.1a
Mean	51.2	3.6
LSD *P<0.05*	36.2	ns

*Values followed by the same letter do not significantly differ according to Fisher's Protected Least Significant Difference (LSD), ns = not significant.

Disease assessments of faba bean intercropped with wheat found significant (*P<0.05*) reductions in the severity (percentage leaf area) of chocolate spot. Faba bean grown as a monoculture had the highest severity (86.3%) of chocolate spot while the faba bean 25% wheat 75% mix had the lowest (26.3%). Increasing the proportion of wheat in the faba bean/wheat sowing mix significantly (*P<0.05*) reduced chocolate spot (Table 2). There was no relationship between chocolate spot severity or the sowing density of wheat on faba bean grain yield in this trial.

Table 2. Effect of intercrop (wheat: cv. Sheriff CL plus) on the severity (percentage leaf area affected) of chocolate spot (*Botrytis cinerea* and *B. fabae*) and grain yield of faba bean cv. PBA Bendoc CL in an intercropping trial at Hamilton, Victoria, 2020.

Crop mix	Severity (%)*	Yield (t/ha)*
Faba bean 100% : wheat 0 (monoculture)	86.3c	2.4a
Faba bean 75% : wheat 25%	57.0b	3.2a
Faba bean 50% : wheat 50%	48.8ab	3.1a
Faba bean 50% : wheat 50% (skip row)	55.0b	3.1a
Faba bean 25% : wheat 75%	26.3a	2.9a
Mean	54.6	2.9
LSD *P<0.05*	28.1	ns

*Values followed by the same letter do not significantly differ according to Fisher's Protected Least Significant Difference (LSD), ns = not significant.

Blackspot in field peas and scald in barley were also detected in the trial. While blackspot severity (50%) and scald (85%) were high in some monoculture plots, overall disease severity was low with blackspot in the field pea/canola mix 8.0% and scald in the barley/canola mix 7.5%.

Discussion

In this trial the severity of chocolate spot was significantly reduced when faba bean was intercropped with canola or wheat. This concurs with other research (Fernández-Aparicio et al 2011; Boudreau 2013) who also reported a reduction in disease with intercropping. The mechanism is probably related to the intercrop providing a physical barrier to *Botrytis* spores and thorough changes to the microclimate (temperature, moisture and humidity) in the canopy that could also contribute to reduction in disease severity. While intercropping reduced disease severity there was no effect of disease or sowing density of the companion crop on faba bean grain yield. Yield of the companion crop was additional to that of the faba bean. Using the 50:50 treatment as an example, this additional yield was 2.5 t/ha of canola for the 50:50 faba/canola treatment and 2.6 t/ha of wheat for the 50:50 faba/wheat treatment (detailed data not reported here). In the absence of a companion crop, reduced disease severity would normally translate into increased grain yield, as other researchers have found chocolate spot can reduce grain yield by 50% in monoculture (Davidson et al 2007; Fanning 2018).

Environmental conditions can have a major impact of crop diseases. Chocolate spot requires high leaf moisture or humidity (>70%) within the crop canopy and has optimal temperatures of between 15 to 28°C (Davidson et al 2007). In September and October 2020, Hamilton rainfall was 40% above average and with temperatures of between 16 to 23°C (Figure 1) coupled with high plant densities (47 plants/m^2), conditions were conductive to chocolate spot development during 2020. However, there are factors that may explain the consistent yields.

While rainfall was above average during May, dry conditions prevailed during winter. This would have delayed the advancement of chocolate spot and its impact on grain yield. Above average rainfall in spring would have favoured disease development (Figure 1). Fungicides applied on 31 July 2020 and 26 October 2020 would have protected faba bean flowers from disease, and this may explain why chocolate spot did not reduce grain yield in this trial.

The grain harvest was undertaken by hand harvesting internal rows in each plot on raised beds, while visual diseases assessments were conducted on the whole plot and there may have been a discrepancy between the harvest area and disease assessment. A single assessment on the non-green area may have also overestimated disease severity. As suggested by Whelan (1997), host-based measurements (e.g. green leaf area) may provide a better estimate of the pathogens effect on growth and yield than percent disease severity.

Conclusion

Intercropping faba bean with wheat or canola significantly (*P=0.05*) reduced chocolate spot severity in this trial, but did not affect grain yield. As the faba bean monoculture yield was not limited by disease or the sowing density of the companion crop, the yield of the companion was considered additional. Intercropping may play a role in an integrated approach for managing crop diseases reducing chemical use. Future research will concentrate on exploring the relationship between disease severity and crop yield in specifically designed intercropping disease trials. The opportunity also exists to reduce fungicide applications, investigate the potential use of remote sensing (RGB-imaging, spectral sensors, thermal sensors, fluorescence imaging, NIR) to improve visual assessments.

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