Effect of soil-borne Ascochyta blight fungi on the grain yield of Field peas

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Abstract

An experimental site was established at Tarranyurk (sandy loam soil, pH 7.8 in H_2O), in the northern Wimmera region of Victoria, to monitor changes in the populations of soil-borne ascochyta blight fungi following different cropping sequences. From 1990-1993, field peas (P) and barley (B) were sown at the site in eight different cropping sequences (PPPP, PPPB, PPBP, PPBB, PBPP, PBPB, PBBP and PBBB) in order to generate different populations of soil-borne ascochyta blight fungi. By June 1994, there were large differences between plots in the number of ascochyta blight fungi per gram of soil. The most probable number of fungal propagules ranged from 676 in plots sown to barley for three successive years to 8449 in plots sown to field peas every year. The grain yields of field peas in 1994 showed there was a strong correlation (R^2 = 0.91) between the level of soil-borne ascochyta blight fungi and decline in yield. To minimise crop losses there should be a period of at least 3 years between successive pea crops.

Key words

Ascochyta blight, field pea, disease control, crop rotation.

Introduction

Ascochyta blight caused by *Mycosphaerella pinodes* (Berk. & Blox.) Vestergr. and *Phoma medicaginis* var. *pinodella* (Jones) Boerema, is the most important disease of field peas in southern Australia. Studies by Davidson and Ramsey (3) showed that the decline in field pea yields reported by Peck and McDonald (5) was often associated with increased levels of ascochyta blight in pea crops. The importance of wind-borne ascospores released from pea stubble in establishing the disease in new crops is well-documented (1), however the importance of soil-borne inoculum under Australian conditions is unclear. Both pathogens can survive in soil as chlamydospores for several years (3), which may also be important in perennation of the disease.

These studies were undertaken to determine the effect of different cropping sequences on the survival of ascochyta blight fungi in soil and to establish the effect of different levels of soil-borne inoculum on the grain yield of field peas.

Results of these studies will provide pea growers with information on the effectiveness of crop rotation in reducing the level of soil-borne ascochyta blight fungi and establish guidelines for the minimum interval required between successive pea crops.

Materials and methods

Field trial

An experimental site was established at Tarranyurk (sandy loam soil, pH 7.8 in H_2O), in the northern Wimmera region of Victoria, to monitor changes in the populations of soil-borne ascochyta blight fungi following different cropping sequences. The site had previously been cropped to field peas in 1987, wheat in 1988 and barley in 1989. From 1990-1993, field peas (P) and barley (B) were sown at the site in eight different cropping sequences (PPPP, PPPB, PPBP, PPBB, PBPP, PBPB, PBBP and PBBB) in order to generate different populations of soil-borne ascochyta blight fungi prior to sowing field peas in 1994. The trial was set up as a split plot design with 2 replicates of each cropping sequence in the final year.

Individual plots were 20 m x 6 rows and were direct drilled with a 6-row cone seeder. Field pea cv Dundale was sown at 100 kg/ha and Barley cv Schooner at 75 kg/ha with 60 kg/ha double superphosphate plus zinc. In 1990, 1991, 1992, 1993 and 1994 plots were sown on 13 June, 29 May, 15 June and 16 June, respectively. From 1990 to 1994 plots were harvested on 9 December, 23 December, 10 December and 5 December, respectively. Crops were grown according to local farmer practice.

Estimating number of soil-borne ascochyta blight fungi

Each year, just prior to sowing and harvest, soil samples (ten 5-cm diameter x 10-cm deep soil cores) were taken from individual plots. Soil cores from each plot were combined before the most probable number (MPN) of propagules of ascochyta blight fungi per gram of soil was determined by plating soil-water suspensions (soil to water dilutions of 1:10, 1:50, 1:250, 1:1250, 1:6250) onto a selective agar medium as described by Sweetingham (6). The MPN of propagules per gram of soil was then calculated using the Genstat maximum likelihood program of Lawes Agricultural Trust (Rothamsted Experimental Station), based on the Newton-Raphson algorithm outlined by Cochran (2).

Calculations

The relationship between seasonal rainfall and potential grain yield was based on information presented by French (4). Potential yield (kg/ha) = [Growing season rainfall + stored water (mm) –130] x 15.

Water use efficiency (kg/ha per mm rainfall) = Grain yield (kg/ha)/[Growing season rainfall (mm) – 130]

Data analysis

Data were analysed with the aid of Genstat 5 (Rothamsted Experimental Station).

Results And Discussion

All plots had high levels of soil-borne ascochyta blight fungi after being sown to field peas in 1990. In the following years, the MPN of ascochyta blight fungi in soil taken from plots just prior to harvest had almost always increased in pea plots and decreased in plots sown to barley (Table 1). The level of soil-borne ascochyta blight fungi appeared to fluctuate between harvest and sowing depending on rainfall. The disease level in the pea plots also varied a lot from year to year depending on seasonal conditions.

Table 1. Effect of different cropping sequences, from 1990 to 1994, on the most probable number of ascochyta blight fungi in soil (1) just prior to sowing and (2) just prior to harvest:

(1) MPN of fungi in soil just before sowing.

Cropping sequence[A] 90,91,92,93,94	1990	1991	1992	1993	1994
P-P-P-P-P	14,379	19,376	23,493	25,373	8,449
P-P-P-B-P				25,373	3,019
P-P-B-P-P			23,493	20,006	5,113
P-P-B-B-P				20,006	2,726

P-B-P-P-P		19,376	8,004	59,433	5,704
P-B-P-B-P				59,433	3,459
P-B-B-P-P			8,004	16,674	3,912
P-B-B-B-P				16,674	676

(2) MPN of fungi in soil just before harvest.

Cropping sequence[A] 90,91,92,93,94	1990	1991	1992	1993	1994
P-P-P-P-P	25,961	41,186	16,779	18,545	12,157
P-P-P-B-P				10,747	6,478
P-P-B-P-P			7,389	23,797	10,505
P-P-B-B-P				4,492	1,211
P-B-P-P-P		10,747	7,209	7,265	7,430
P-B-P-B-P				7,888	4,693
P-B-B-P-P			1,144	11,496	2,974
P-B-B-B-P				1,708	661

[A] P = Field pea cv Dundale (shaded); B = Barley cv Schooner (unshaded)

By June 1994, just prior to sowing field peas, there were large differences between plots in the MPN of ascochyta blight fungi per gram of soil (Table 2). The MPN of fungal propagules ranged from 676 in plots sown to barley for three successive years to 8449 in plots sown to field peas every year. The grain yields of field peas in 1994 showed there was a strong correlation (R^2 = 0.91) between the level of soil-borne ascochyta blight fungi and decline in yield. A comparison of plot yields with their theoretical potential yield (0.822 t/ha) indicated that:

Yield loss (%) = $78.48(\log_{10}\text{MPN}) - 221.4$ (Fig.1).

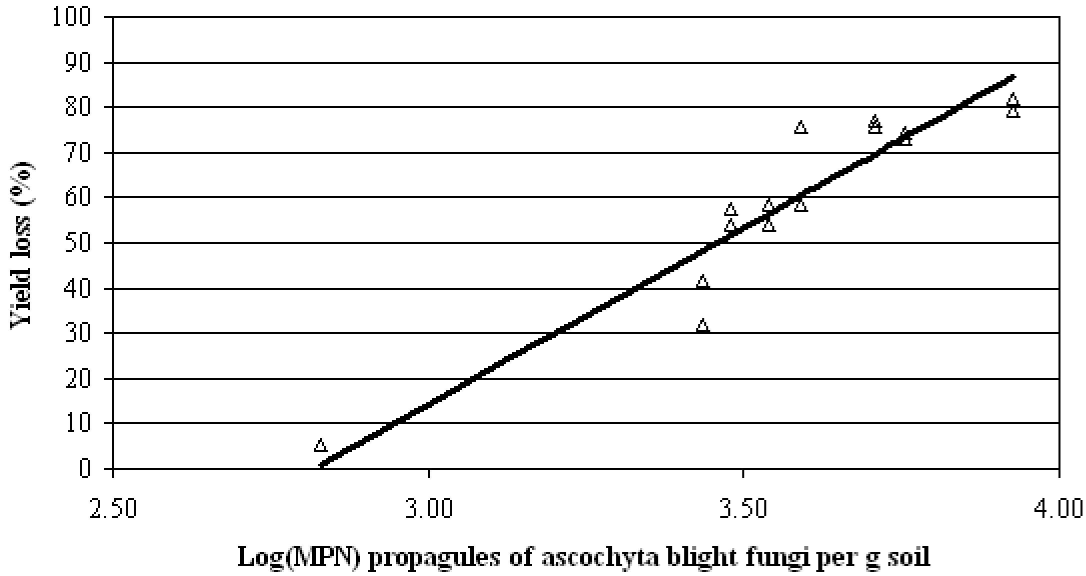

Figure 1. Relationship between the level of soil-borne ascochyta blight fungi and yield loss in field peas cv Dundale grown at Tarranyurk in 1994.

Grain yields following a three-year break were close to the predicted potential yield. However, grain yields following a two-year break, a one-year break or no break, were 18%, 56% and 81% respectively below their theoretical yield potential.

The water use efficiency for peas improved following break crops. For plots with no break (PPPP), a one year break (PPPB), a two year break (PPBB) or a three year break (PBBB), the water use efficiencies, based on growing season rainfall (April to October), were 3-6, 6-7, 9-11 and 14-16 kg/ha/mm rainfall, respectively.

Table 2. Effect of different cropping sequences from 1990 to 1993 on the level of ascochyta blight fungi in soil (just prior to sowing) and the grain yield of field peas cv Dundale grown in 1994

Cropping sequence[A] (1990 – 1993)	Soil-borne ascochyta (MPN propagules/g soil)	Grain yield (t/ha)	Yield loss[B] (%)	Water use efficiency (kg/ha per mm rainfall)
P-P-P-P	8,449	0.16	81	3.1
P-P-P-B	3,019	0.37	55	7.1
P-P-B-P	5,113	0.20	76	3.8
P-P-B-B	2,726	0.67	18	12.8
P-B-P-P	5,704	0.22	73	4.2

P-B-P-B	3,459	0.36	56	6.9
P-B-B-P	3,912	0.27	63	5.2
P-B-B-B	676	0.81	1	15.6

[A] P = Field pea cv Dundale; B = Barley cv Schooner.
[B] Compared to their theoretical potential grain yields (0.822 t/ha).

These results show that high levels of soil-borne ascochyta blight fungi can seriously reduce the grain yield of field peas. The magnitude of the losses is likely to vary from season to season depending on growing season rainfall. The April to October rainfall in 1994 of 132 mm was less than half the average rainfall for this period. Crop losses caused by the disease may have been higher if there had been more rain during the growing season.

Conclusion

Results of the studies showed that ascochyta blight fungi are able to survive in soil for at least three years in the absence of host plants. Barley was an effective break crop and significantly reduced the level of ascochyta blight fungi in soil. A single barley crop reduced the population by 47% while a three-year break resulted in a 94% reduction in propagule number. To prevent significant crop losses there should be a period of at least 3 years between successive pea crops.

Acknowledgments

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