Effects of Mixed Cropping of Faba Bean and Field Pea on Disease Development and Yield

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Abstract

Effects of mixed cropping of faba bean and field pea on disease development and yield was studied for three years at Holetta. Faba bean (cv. CS 20 DK) as a principal crop was mixed to field pea (cv. Mohanderfer) at a ratio of 42:0, 34:16, 31:21, 28:27, 20:41 and 0:81 per m^2 plant population. Serious diseases were chocolate spot (*Botrytis fabae* Sard) on faba bean and Ascochyta blight (*Mycosphaerella pinodes* Berk and Block) on field pea with no cross infection. All major diseases of both component crops were recorded. There was noticeable influence of mixed cropping on disease development and yield. Final chocolate spot score of three years decreased from 66.5 to 55.8% as the proportion of faba bean decreased from 100 to 33% in the mixture. Similarly, Ascochyta blight score dropped from 93 to 70% as the field pea proportion decreased from 100 to 32%. The pattern of chocolate spot progress differs from that of Ascochyta blight and apparent infection rate (r) was generally higher for chocolate spot than for Ascochyta blight in the mixed crops. However, in pure crops, Ascochyta blight of field pea developed faster (r = 0.112 unit per day) than chocolate spot (r = 0.084 unit per day) of faba bean. Seed yields of mixed crops were significantly higher than that of pure crops being 4.6q/ha of faba bean and 5.6q/ha field pea. Mixed crops produced mean seed yields of 9.5q/ha (ranging from 8.3 to 10.7q/ha). Land Equivalent Ratio (LER) exceeded one for all the mixed crops. Productivity of mixed cropping of the two species was superior over their pure cultures.

Introduction

Faba bean and field pea are important food legumes grown in the highlands of Ethiopia (Hailu *et al.* 1994). In many places of the country, these species are grown in mixed cropping for weed suppression and physical support of field pea by faba bean, although the mixing proportion are not known (Amare 1994, 1996; IAR 1996a; 1996b).

There are obvious advantages of mixed cropping which include, utilization of natural resources viz. space, light, and moisture and suppression of pest problems viz. disease, insect, and weeds (Amare 1996; Beets 1982; Trenbath 1976). In many instances, especially air-borne diseases are suppressed by growing a mixture of wo species (Beets, 1982). The principle is that spores leaving the parent infections are distributed over two host components, where some of these spores land on non-host species which select against incoming inocula (Beets 1982; Trenbath 1976; Zadoks & Schein 1979), thus serving as a buffer crop. On the other hand, mixed cropping can also enhance some diseases so that the practice becomes disadvantageous (Willey 1979).

The effect of mixed cropping may be so small that ordinary disease assessment cannot reveal its magnitude. Even so, the advantage can be of great use when effectively utilized in planning an integrated disease management program that depends on proper understanding of its effects on cropping system.

Amare (1994, 1996) studied the yielding ability of different mixing proportions of faba bean and field pea in mixed cropping systems and found that there was a clear yield advantage of mixed cropping of these species. In addition he recorded that chocolate spot was significantly reduced when the faba bean proportion was reduced in the mixture. Another study (IAR unpublished) on the same subject did not show any difference in disease scores of the different mixture levels, although there was a yield advantage like that of Amare's (1996).

There are several important diseases of faba bean and field pea that are found in both mixed and pure stands of these species (IAR 1996a, 1996b). The major ones include chocolate spot caused by *Botrytis fabae* Sard. and rust caused by *Uromyces vicia-fabae* (Pres.) Schre of faba bean and Ascochyta blight caused by *Mycosphaerella pinodes* Berk. & Block and powdery mildew caused by *Erysiphe polygoni* DC of field pea (Habtu & Dereje 1986, Dereje & Tesfaye 1994). None of these pathogens can naturally infect the other host species, being very specific to their respective hosts under natural conditions. The development of these diseases on their respective hosts either in pure or mixed stands was not yet understood. Therefore, an experiment was conducted to study the effects of mixed cropping of faba bean and field pea on disease development and yield. The experiment was conducted for three years (1993, 1994 and 1996 cropping seasons) at the Holetta Agricultural Research Center (HARC).

Materials and Methods

Four mixture levels and the two pure stands were tested. Faba bean cultivar, CS 20 DK, as principal crop was mixed to field pea cultivar, Mohanderfer, in different proportions at seeding. The mixing proportions included a faba bean to field pea ratios of 42:0, 34:16, 31:21, 28:27, 20:41, and 0:81 plants per m^2 in which the first and the last are pure stands of faba bean and field pea, respectively. These six treatments were arranged in a Randomized Complete Block Design with two replications having a net plot size of 10m x 13.5m. Three dense rows of cultivated oats were planted around each plot in order to reduce inter-plot interference.

Seeds and fertilizer were broadcasted in plots. In the pure stands the seed rate of faba bean was 200 kg/ha while that of field pea was 150 kg/ha. The various mixed crops were obtained by seeding of 100, 80, 75, 67, 50, and 0% of the seed rate of faba bean. The rest were field pea using its seed rate. Fertilization of plots was made by Di-ammonium-phosphate (DAP) containing 18kg N and 46kg P_2O_5 per hectare, a recommended rate for Nitosols at Holetta (Amare and Adamu 1994).

Diseases were scored at weekly intervals during the whole growing period. Derived disease parameters, were (i) the Apparent Infection Rate (r) calculated according to Zadoks & Schein (1979) and (ii) the Area Under the Disease Progress Curve (AUDPC) calculated according to Pandey *et al.* (1989) for the most conspicuous disease of faba bean (chocolate spot) and field pea (Ascochyta blight). Chocolate spot is caused by *Botrytis fabae* and infects only faba bean while Ascochyta blight caused by *Mycosphaerella pinodes* infects only field pea. Five plants of each species in a plot were labelled and followed throughout the season. Percent leaf area covered by a disease was scored using disease diagrams developed for these diseases (Dereje 1993, Hanounik 1986). Crop parameters were assessed at harvest. Measured seed yield was adjusted using stand count as a covariant in covariance analysis. Original data and derived parameters were subjected to statistical analysis considering recommendations made by Mead (1986) and Trenbath (1976) using MSTAT-C computer package (MSTU 1988). In addition, the Land Equivalent Ratio (Trenbth 1976, Willey 1979) was used to evaluate the productivity of each treatment.

Results and Discussion

Disease Development

Almost all major diseases of both faba bean and field pea were observed in the experimental plots every year at varying terminal severity (Table 1) and no mixed cropping treatment excluded any particular disease. Chocolate spot of faba bean

and Ascochyta blight of field pea were the two dominant diseases in the experimental plots. In 1993, chocolate spot disease caused by *Bortytis fabae* Sard. and foot rot disease caused by *Fusarium avenaceum* (Cord. ex Fr) Sacc. were very severe on faba bean. In subsequent years (1994 and 1996) foot rot infection, a disease of high rainfall seasons, was as low as in other fields at HARC.

Chocolate spot and Ascochyta blight developed better on the respective pure stands and extreme mixtures than in most mixed stands. The pattern of progress of chocolate spot on faba bean differed from that of Ascochyta blight on field pea both in pure and mixed stands (Fig.1). Generally, chocolate spot had an early start and gradually approached a maximum (convex curves) whereas Ascochyta blight started slowly and gradually gained speed (concave curves).

These patterns of disease progress suggest the time, when, to apply control measures against any one of these diseases in pure stands or mixed cropping and thus has practical implications. Faba bean was at flowering stage in August while field pea in mid-September. Final scores of chocolate spot infection at the end of September, when senescence of leaves began on both crops, decreased from 66.5 to 55.8% as proportion of faba bean increased from 33 to 100% in the mixed cropping (Table 2). Amare (1996) also found that chocolate spot severity was significantly reduced when the field pea proportion increased in the mixture, which is in agreement with this finding.

Ascochyta blight of field pea caused by *Mycosphaerella pinodes* was the only severe disease observed on field pea in all the three seasons (Table 1). Mixed cropping influenced Ascochyta blight as it did for chocolate spot. Blight severity was significantly lower in mixed crops than pure stands of field pea, final severity dropping from 93 to 70% as field pea proportion, in the mixed cropping, decreased from 100 to 32% (Table 2).

Area under the chocolate spot progress curve was highest for the pure faba bean crop and significantly different from 2:1 and 1:1 treatments. Similarly, area under the Ascochyta blight progress curve was highest in the pure crop of field pea and significantly different from the mixed crops (Table 2). AUDP, calculated from six disease scores spread over the whole growing period, considers increase of a disease throughout the whole growing season. It is a multiple point parameter, hence, shows the amount of disease pressure developed on a treatment over the whole season. It was the highest in plots with highest severity and lower in the mixtures.

The apparent infection rate (r) was generally higher for chocolate spot of faba bean than for Ascochyta blight on field pea in the mixed cropping treatments (Table 2). However, in pure crops, Ascochyta blight developed faster ($r = 0.112$ unit per day) than chocolate spot ($r = 0.084$ unit per day) indicating the potential of *Mycosphaerella pinodes* infection to cause serious epidemics, because apparent infection rate is a sensitive parameter useful to measure small effects (Zadoks & Schein 1979).

Generally, chocolate spot and Ascochyta blight development was slower in mixed crops than in pure crops of faba bean and field pea, respectively, although the differences were small. This result partly explains why disease severity is usually lower in farmers' field planted with mixed crops than those in research sites where pure stands are grown.

Yield Parameters

Although mean seed yield was lowest in 1993, the trend was the same for all the three years. Seed yields of mixed crops were significantly higher than of pure crops of either faba bean or field pea (Table 3). Pure crops of faba bean and field pea yielded 4.6 and 5.6 q/ha, respectively, which were comparatively lower than mixed crops which had a mean seed yield of 9.45 q/ha (ranging from 8.3 to 10.7 q/ha). The results clearly show the superior productivity of mixed crops of these species under Ethiopian conditions. Note that the yield of faba bean is generally very low at HARC due to low soil reactions (Amare and Dereje, unpublished data).

The present study confirms that of Amare (1994, 1996). An obvious yield advantages was obtained by all mixtures in comparison with the pure

cultures. This was partly due to reduced disease pressure. The advantage provided by faba bean as a physical support for field pea with its spreading growth habit has not been quantified. This advantage to field pea contributes to the superiority of mixed crops.

Land equivalent Ratio (LER), which shows the total area needed in pure crops to produce the same yield as on a unit of land area with mixed crops was higher than unity for all mixtures (Table 3). Amare (1994) found a LER of 1.31 for 3:1 and 1.10 for 1:1 ratio of faba bean to field pea. In the present study, the corresponding values were 1.73 and 1.47, respectively. Although these values were lesser than previously reported, the trend of productivity was the same with the present study. According to Amare (1996), mixed cropping affected faba bean more than field pea. In the present study the yield fraction of field pea was also higher than faba bean in the mixture crops confirming his finding.

Table 1. Diseases and the causal pathogens recorded and identified on faba bean and field pea and their severity in percentage in 1993, 1994 and 1996 at Holetta.

Crop/Disease	Pathogen	Final severity (%)*		
		1993	1994	1996
Faba bean				
Chocolate spot	*Botrytis fabae*	68	61	57
Foot rot	*Fusarium avenaceum*	60	4	4
Blight	*Ascochyta fabae*	1	2	1
Rust	*Uromyces vicia-fabae*	5	3	4
Black spot	*Alternaria tenuis*	Tr	Tr	Tr
Zonate leaf spot	*Cercospora zonata*	Tr	Tr	Tr
Field pea				
Ascochyta blight	*Mycosphaerella pinodes*	65	64	84
Pod/stem spot	*Ascochyta pisi*	Tr	Tr	Tr
Blotch	*Septoria pisi*	5	7	5
Stem lesion	*Phoma medicaginis*	8	8	8
Powdery mildew	*Erysiphe polygoni*	0	3	2
Root rot	*Fusarium avenaceum*	7	4	0

*= Severity less than a unit is given with **Tr** and is mean of two replications of terminal severities.

Table 2. Means of apparent infection rate (r) in percent per day, final disease score in percent, and area under the disease progress curve (AUDPC) in percent by days for chocolate spot of faba bean and Ascochyta blight of field pea. Means were calculated over all data from the 1993, 1994 and 1996 cropping seasons.

Ratio*	Chocolate spot (*Botrytis fabae*)			Ascochyta blight (*Mycosphaerella pinodes*)		
B:P	R	Final score	AUDPC	r	Final Score	AUDPC
42:0	0.084	66.5a	1547a	--	--	--
34:16	0.083	64.1a	1509a	0.055	70.0c	896c
31:21	0.089	63.9a	1527a	0.063	80.0bc	991c
28:27	0.090	61.3a	1368b	0.070	87.5ab	1024bc
20:41	0.071	55.8b	1288b	0.078	87.5ab	1129b
0:81	--	--	--	0.112	92.5a	1286a

Plant population per m^2; B is faba bean and P is field pea.
Mean values followed by the same letters (in columns) do not differ significantly at 5 % level of [DRMT])

Table 3. Mean seed yield and Land Equivalent Ratio (LER) of various mixed crops and pure stands of faba bean and field pea. Entries are means over two replications.

Ratio*	Seed yield (q/ha)				Land Equivalent Ratio			
B:P	1993	1994	1996	Mean	1993	1994	1996	Mean
42:0	4.0b	2.6d	5.9b	4.6b	1.0	1.0	1.0	1.00
34:16	8.1a	11.7a	12.3a	10.7a	1.6	1.9	1.6	1.70
31:21	7.4a	12.3a	8.7ab	9.5a	1.7	1.8	1.7	1.73
28:27	5.5ab	12.6a	10.8a	9.3a	1.5	1.7	1.4	1.53
20:41	5.7ab	8.6b	10.5a	8.3a	1.3	1.2	1.9	1.47
0:81	4.3b	6.3c	6.3b	5.6b	1.0	1.0	1.0	1.00

Plant population per m^2; B is faba bean and P is field pea.
Mean values followed by the same letter within a column are not significantly different from each other at P< 0.05 (DMRT)

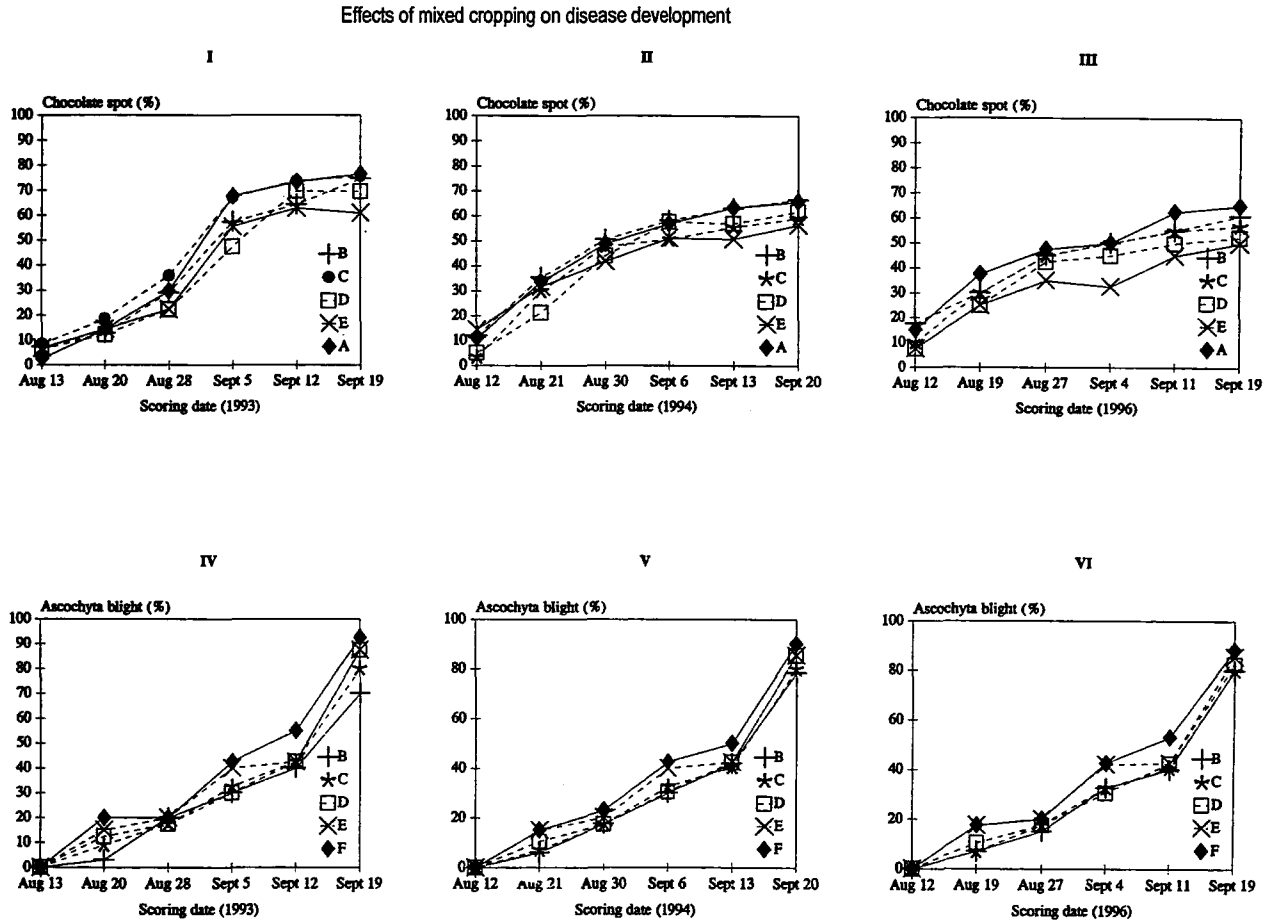

Figure 1. Progress of chocolate spot and Ascochyta blight in mixed crops of faba bean and field pea at the Ratio of A = 42:0 (pure stand of faba bean), B = 34:16, C = 31:21, D = 28:27, E = 20:41, and F = 0:81 (pure stand of field pea) during the 1993 (I and IV), 1994 (II and V), and 1996 (III and VI) cropping seasons.

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