Effect of Barley-Legume Intercrop on Disease Frequency in an Organic Farming System

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Abstract

The effect of barley-legume intercrop in an organic farming system on disease incidence was investigated. The legumes were lupin, faba bean and pea. Diseases were detected on pea and barley. On pea, only ascochyta blight (*Ascochyta pisi*) was observed. When either pea variety was intercropped with barley, the level of ascochyta blight was reduced. Net blotch (*Pyrenophora teres*), brown rust (*Puccinia recondita*) and powdery mildew (*Blumeria graminis* f. sp. *hordei*) (in order of incidence) were monitored on barley between flag leaf emergence and heading. The levels of all three diseases were reduced in every intercrop treatment compared to the barley monocrop. However, this reduction was only statistically significant in the pea treatments for net blotch.

Keywords: barley; lupin; faba bean; pea; legume; monocrop; intercrop; organic farming system; ascochyta blight; net blotch; brown rust; powdery mildew

INTRODUCTION

In Danish (and European) organic farming, there is an urgent requirement for increased production of protein and cereal crops to meet the increasing demand for feeding monogastric animals (pigs and poultry) (NORHOLT 1997; AVELINE 1999). Grain legumes and cereals can complement one another in animal feeds, legumes providing high levels of protein and cereals supplying carbohydrate. Intercropping (which is defined as growing two or more crops together on the same area of ground) allows the simultaneous cultivation of grain legumes and cereals, and when ripe can be harvested together and fed directly to animals as a mixture. Intercropping is most commonly practised without high inputs of agrochemicals and synthetic fertilisers and therefore fits well with the principles of organic farming. Indeed, since legumes use atmospheric N_2 and non-leguminous species use available soil nitrogen, the reduced competition for N may be the key to their success in organic systems. Furthermore intercrops have been reported to have reduced growth of weeds and reduced incidence of pests and diseases (OFORI & STERN 1987; BOUDREAU & MUNDT 1992). In this study we investigate the influence of intercropping barley with pea (both semi-leafless and full leafed), faba bean or lupin on disease levels in two locations in Denmark.

MATERIALS AND METHODS

Sites and soil

The experiments were carried out in 2001 at experimental fields on two different locations in Denmark; location I in the east part and location II in the south-

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west. The soil at location I was a sandy loam with 8% clay, 32% silt, 48% fine sand and 13% coarse sand with a pH($CaCl_2$) of 6.8. Location II was a sandy soil at with 4% clay, 4% silt, 17% fine sand and 73% coarse sand with a pH($CaCl_2$) of 5.5,

Species, cultivars and experimental set-up

Field pea (*Pisum sativum* L.) (cv. Agadir, a semi-leafless cultivar with tendrils and cv. Bohartyr, with normal leaves), faba bean (*Vicia faba* var. *minor* L.) (cv. Columbo) and narrow-leafed lupin (*Lupinus angustifolius* L.) (cv. Prima) were grown as monocrops and in a two species mixture (intercrop) with spring barley (*Hordeum vulgare* L.) (cv. Lysiba and cv. Otira).

The experiment plots (15.4 m^2 and 36 m^2 at location I and II, respectively) were laid out in a complete randomised block design with 16 treatments of intercrops and monocrops in four replicates. The intercrop design was based on the replacement principle, with mixed grain legume and barley grain sown in the same rows 12.8 cm apart in 50%:50% ratios. Target plant densities in monocrops were 300, 120, 90 and 40 for sole crops of barley, lupin, pea and faba bean, respectively. The target plant density for one of the species in the intercrops was half of the monocrop target plant densities.

Management practices

Seeds were sown mixed in the rows in the same depth in late spring 2001 at both locations. The crops were grown organically and without any fertiliser application. A false seedbed was established prior to sowing at both locations. No other weed management was practised at location I, whereas mechanical weeding was performed at location II.

Disease assessment

Plants were monitored for disease during plant development. In location I net blotch (*Pyrenophora teres*) and brown rust (*Puccinia hordei*) were observed on both barley varieties. Since their incidence was higher on cv. Otira than on cv. Lysiba, cv. Otira was assessed in detail. Powdery mildew (*Blumeria graminis* f.sp. *hordei*) was only observed on cv. Lysiba. The uppermost three leaves (flag leaf and the two leaves below it) of 10 random tillers were scored either for net blotch lesion number (> 0.5 cm), percentage brown rust severity or powdery mildew pustule number. Ascochyta blight (*Ascochyta pisi*) was scored on the upper three leaves on both pea cultivars (Bohartyr or Agadir).

Statistical analysis

The data approximated either to normal or non-normal frequency distributions. For multiple comparisons parametric ANOVA followed by the Tukey's test was conducted on normal data. When the data approximated to non-normal frequency distributions the nonparametric Friedman's test was carried out.

RESULTS

Overall a very low incidence of disease was observed. The full list of diseases detected is presented in Table 1. In both location I and II net blotch was reduced on barley whenever it was intercropped with grain legumes (Figures 1A,B). This reduction was statistically significant (Friedman's test; $F = 17.14$; $P < 0.01$) in location I when barley was intercropped with the pea cv. Bohartyr. Brown rust was the next most serious disease observed on barley. While there was no significant difference in rust severity between barley in monocrop or in intercrop (Figure 2), its incidence was slightly lower in the intercrop (Figure 2). Powdery mildew was observed on barley cv. Lysiba at very low levels (Figure 3) and similar trends were seen here as in rust and net blotch i.e. mildew severity was reduced (though not significantly) whenever barley was intercropped with grain legumes (Figure 3).

Table 1. List of diseases monitored on barley and grain legumes at locations I and II

Location	Barley	Lupin	Faba bean	Pea
I	Net blotch Brown rust *Powdery mildew*	none	none	Ascochyta blight
II	Net blotch	none	none	none

On pea, a low incidence of ascochyta blight was observed on both cultivars. When either pea (Bohartyr or Agadir) cultivar was intercropped with barley (Otira or Lysiba), the level of ascochyta blight was reduced (Figure 4). This was significant in the cv. Bohartyr and Otira intercrop (ANOVA; $F = 5.71$; $P < 0.05$).

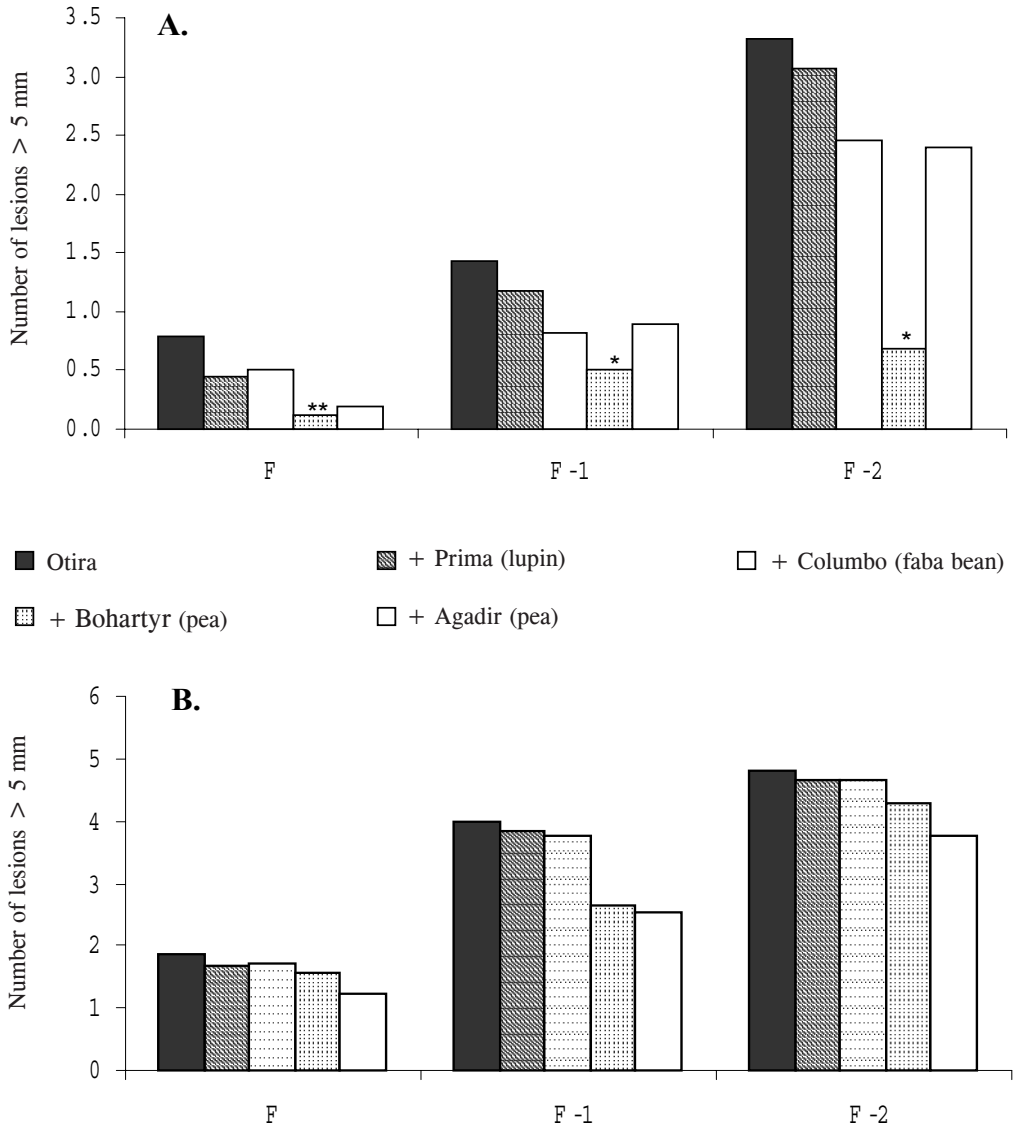

Figure 1. Disease severity (number of lesions) of net blotch on the ag leaf (F), first leaf below (F-1) and second leaf below (F-2) ag leaf of barley cv Otira grown as a monocrop or in an intercrop with grain legumes in location I (A) and in location II (B). *, ** indicate significant differences between barley monocrop and intercrop at $P = 0.05, 0.01$, respectively after Friedman's test

DISCUSSION

Intercropping has been reported to render protection against disease to the component crops (BOUDREAU & MUNDT 1992; FININSA 1996). However results can vary in different locations and using different crop varieties (BOUDREAU 1993; BOUDREAU & MUNDT 1992; BULSON *et al*. 1997). Thus we designed experiments in an organic farming system using barley and grain legumes that were on the Danish organic recommended variety list in 2001 at two different sites in Denmark to investigate if intercropping these varieties would reduce disease levels. Thus our results are of immediate practical interest to Danish organic farmers.

Our results indicated that barley grain legume intercropping has a negative impact in disease incidence. This was regardless of the location (net blotch was reduced both in location I and II), the disease or the crop (reduction was observed in all diseases monitored on barley and pea). While these reductions were

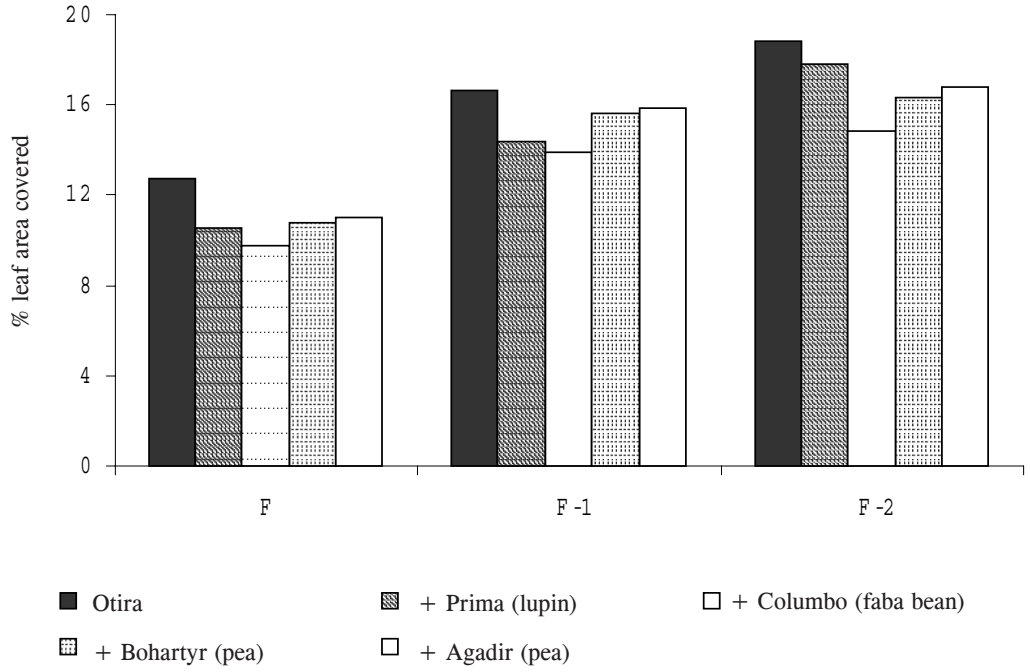

Figure 2. Disease severity (% leaf area covered) of brown rust on the ag leaf (F), first leaf below (F-1) and second leaf below (F-2) ag leaf of barley cv. Otira grown as a monocrop or in an intercrop with grain legumes in location I

statistically significant only in some cases, the trend was the same for every disease observed.

The reduction in disease levels in the intercrop compared to the monocrop could be due to differences in spatial arrangement of the different crops or to the changes in the microenvironment within the crop. Differences in spatial arrangements of the crops could affect disease dispersal, as has been demonstrated for

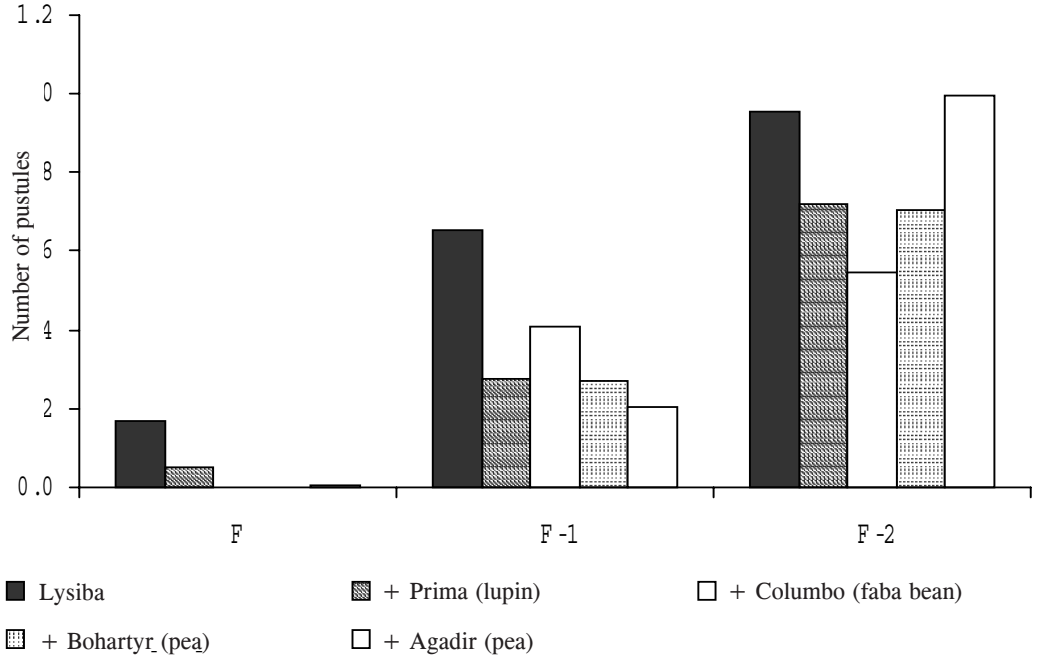

Figure 3. Disease severity (number of pustules) of powdery mildew on the ag leaf (F), first leaf below (F-1) and second leaf below (F-2) ag leaf of barley cv. Lysiba grown as a monocrop or in an intercrop with grain legumes in location I

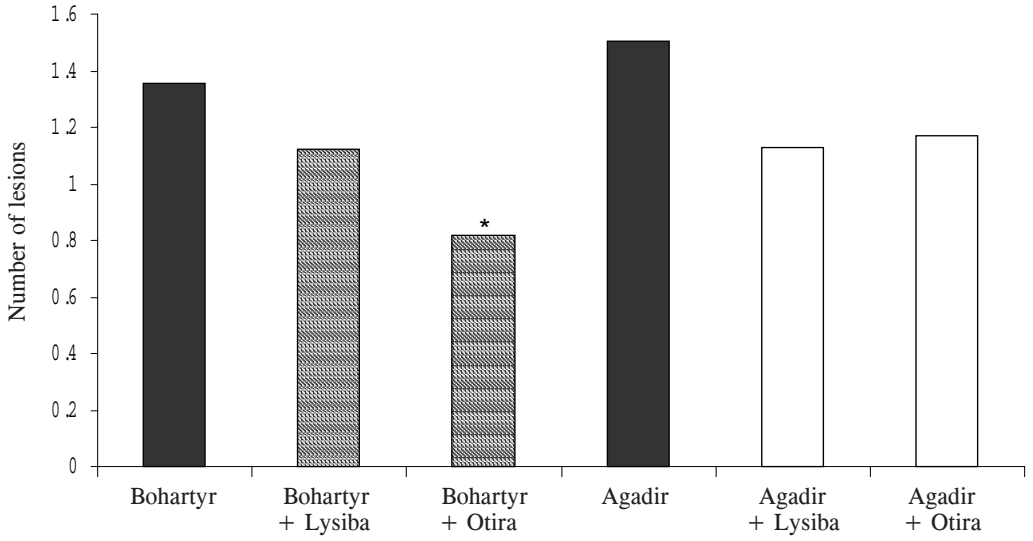

Figure 4. Disease severity (number of lesions) of ascochyta blight on the uppermost three leaves of pea cvs. Bohartyr and Agadir grown as monocrops or in intercrops with barley in location I. * indicates significant difference between pea monocrop and intercrop at $P = 0.05$ with Tukey's test after analysis of variance ANOVA 3

Septoria tritici in a wheat clover intercrop by BANNON and COOKE (1998). Changes in the microenvironment within the crop e.g. BOUDREAU (1992) demonstrated that intercropping generally reduces temperature and wind velocity but increases relative humidity, could alter disease development. The mechanism of interaction between pathogen, host, non-host and microenvironment that determine disease levels in an intercrop have not been investigated in the present work, but provide interesting future research

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