Effect of Mixed Cropping of *Pisum sativum* L. on *Acyrthosiphon pisum* (Harris) Infestation and Ascochyta Blight Infection in Ethiopia

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Abstract

The effect of mixed cropping field pea (*Pisum sativum*) with faba bean (*Vicia faba*), wheat (*Triticum aestivum*) and Ethiopian mustard (*Brassica carinata*) on the incidence of ascochyta blight and the population dynamics of pea aphid and its natural enemies was studied during the 2000 and 2001 growing seasons. The experiment was conducted at three locations, in a randomized complete block design involving seven treatments, each replicated four times. Data were collected on ascochyta blight severity, population densities of *Acyrthosiphon pisum* and its natural enemies, number of pods/plant, 100 seed weight and grain yield. Field pea intercropped with mustard had less disease severity and aphid infestation compared to field pea planted in a monoculture. The pooled results for locations and seasons showed that the field pea plus Ethiopian mustard intercropping was superior to pea pure stand in terms of grain yield, land equivalent ratio and economic return.

Key words: *Acyrthosiphon pisum*, ascochyta blight, mixed cropping, field pea, Ethiopia

Introduction

The cultivation of more than one crop in a field, commonly referred to as mixed cropping or intercropping, is a popular cultural practice in most subsistence farming systems. The system is practiced in many parts of the world (Reddy 1990), although it varies from one location to another depending on the dominant crops. The reasons for practicing intercropping include: risk aversion through crop diversification, compensation for total crop failure in the event of natural disasters such as droughts and pest outbreaks, and production of a variety of crops required by farmers. In addition, research findings have shown that intercropping also has other merits. These include: reduction in pest population density of one or more of the crops included in the cropping mixture (Andow 1991, Alghali 1993), reduction in the severity of some diseases (Kikoka et al. 1989, Nigussie and Reddy 1996, Teferi 1997, Dereje 1999) and increased total yields.

Intercropping has been reported to promote natural biological control in certain crop combinations (Altieri and Liebman 1986). Intercropping may also result in a reduction in the amount of pesticide needed for the effective management of pests (Alghali 1993), thereby reducing both production costs and the negative effects of pesticides on the environment. In general, the system ensures greater yield stability over seasons, higher yield per unit area of land, better use of resources and maintenance of soil fertility.

A mixture of cereals with grain legumes has been the most preferred combination by small-scale farmers in the tropics. In Uganda, cowpea and sorghum are commonly grown in mixture. In the savanna regions of West Africa, farmers normally grow cowpea in mixture with either sorghum, millet or groundnut, or sometimes all three crops together (Norman et al. 1982). Agriculture in Ethiopia is largely of a subsistence nature and most farmers practice mixed cropping. A survey carried out at various locations indicated that farmers grow field pea in mixture with faba bean (Beyene et al. 1994). Chickpea and lentil are also mixed-cropped with sorghum and maize (Million and Beniwal 1988).

However, most studies on cowpea intercropping on pest populations have used sorghum or maize as cereal combination crops (Bottenberg et al. 1998). Several reports have shown that some intercropping patterns reduce the incidence of infestation by pests (Risch et al. 1983, Weiss et al. 1994, Alghali 1993, Olufemi et al. 2001). However, there are other reports which have indicated that intercropping only has a limited effect on pest populations. Bottenberg et al. (1998) reported that mixed cropping only had a limited potential as a means of controlling cowpea pests. Certain reports have also indicated that some intercropping patterns may actually lead to higher incidence of crop damage by insect pests (Dissemond and Hindorf 989) and diseases (Dissemond and Hindorf 1989, Kikoka et al. 1989, Allen 1990). In view of these conflicting findings, the merits of a given intercropping system should be based on the pest and disease situation at a target locality.

In Ethiopia, there was no information available regarding the effect of intercropping on pea aphid infestation in field pea. Therefore, the aim of the present study was to assess the potential of a legume:legume:non-legume intercropping system as a cultural pest management strategy against pea aphid and ascochyta blight in Ethiopia. The focus of the investigation was an evaluation of the influence of a single field pea cultivar mixed with faba bean, Ethiopian mustard and wheat in comparison to field pea cultivated in a monoculture system.

Materials and Methods

Field experiments were carried out at Holetta ($38^0$31'E $09^0$03'N, 2400 masl), Denbi ($38^0$59'E $8^0$46'N, 1900 masl) and Kulumsa ($39^0$11'E $8^0$03'N, 2200 masl) during winter in 2000 and 2001. Tillage at all locations was conventional with moldboard plowing followed by disk harrowing. Weeds were controlled by hand weeding, and pesticides were not applied.

Pure stands of field pea, faba bean, wheat and Ethiopian mustard (*Brassica carinata* Braun.), respectively, were established at a seeding rate of 150, 200, 150 and 15 kg ha^{-1}. There were three mixed stands: field pea + faba bean (112.5:50 kg ha^{-1}), field pea + wheat (112.5:37.5 kg ha^{-1}) and field pea + Ethiopian mustard (112.5:3.75 kg ha^{-1}). The individual plots size of was 20 m^2 (4 x 5) m and all crops were established by broadcasting at the same time. The crops were sown between mid-June at Holetta and late June at Denbi and Kulumsa. The planting dates coincided with the practice of local farmers in the respective study area. The experimental plots were fertilized with Diammonium phosphate (DAP) at a rate of 100 kg ha^{-1} (containing 18 kg N and 46 kg P_2O_5) at sowing. Field pea variety Mohanderfer was used at Kulumsa and Denbi and Tegegnech at Holetta. The selection of field pea variety was based on the suitability to the respective environmental conditions. For Ethiopian mustard and wheat, varieties Yellow Dodolla and Galema, respectively, were used. Two faba bean varieties were also used: CS-20DK at Holetta and NC-58 at Denbi and Kulumsa. The experiment was designed as a randomized complete block with four replications at each location for two seasons.

After the first appearance of *A. pisum* in field pea plots (early August), data on aphid populations were recorded on 10 randomly selected plants in each plot throughout the season. Whole plants were examined during the first few weeks of the season, but as plants grew larger only the terminal 20–30 cm of the stem tips were inspected. Parasitised aphids were also noted on the same 10 plants. Intensive scrutiny for predators (mainly coccinellids and syrphids) was conducted and individuals counted on a plot basis. Each plot was rated for blight severity using a 0 to 5 scale (Roger et al. 1999). Disease ratings commenced when the blight symptoms appeared, and each plot was rated seven times during the season at weekly intervals. Measurements of plant stands at emergence and at harvest, pods per plant, and seed weight were made. Land use efficiency for pure and mixed stands was calculated using the Land Equivalent Ratio (LER) (Willy 1979), which is determined thus:

$$LER = \sum (Xi / Yi)$$

Where, Xi is the yield of the crop I in the intercropping setup and Yi is the yield of crop I in the pure stand setup. Values for the area under the disease progress curve (AUDPC)

$$\text{AUDPC} = \sum_{i=1}^{n} \left[\frac{(Y_{i+n1} + Y_1)}{2} \right] [X_{i+1} - X_1]$$

for each treatment were calculated using the formula of Shaner and Finney (1977):

in which, Yi = ascochyta blight severity (per unit) at the ith observation, Xi = time (days) at the ith observation, and n = total number of observations.

An analysis of variance (ANOVA) was conducted using MSTAT-C (1990). Data from individual sites were analyzed separately. Yield components and grain yields of wheat, faba bean, mustard and peas were analyzed. Differences between treatments were compared using the least significance difference (LSD, P = 0.05) if F-test showed significant effects. Net monitory returns were calculated by deducting the variable cost for seed from gross returns, based on the fact that other variables such as fertilizer, labor, and land preparation were similar for all the treatments.

Results

The analysis of variance for the two years indicated that field pea/mustard mixed crops were consistent in sustaining significantly lower incidence of ascochyta blight infection than the field pea monocrops in Holetta and Denbi on most of the sampling dates (figures 1 and 2). The mixture also showed the lowest incidence of infection at Kulumsa during September (Figure 3). These observations suggest that the presence of mustard in the mixture served to reduce the severity of ascochyta blight in field pea. The ascochyta blight progress curve, pooled over seasons, was also lowest for field pea/mustard mixtures and significantly different from the other intercrop treatments at Holetta and Denbi, but not at Kulumsa (Table 1). However, the level of disease on all treatments was highest at Denbi, followed by Kulumsa, while the least was at Holetta.

A. pisum populations were about 2–3 times higher at Denbi and Kulumsa than at Holetta. *A. pisum* was more numerous at Denbi and Kulumsa and peaked during September 15–20, i.e., at flowering which is an important period with regard to damage levels and grain yield (Table 2). Over the two years and at all three locations, the incidence and size of aphid colonies were highest in field pea monoculture compared to the three mixtures (Table 2). At Holetta, average aphid densities per plant on field pea monoculture were significantly higher ($P<0.05$) than those of mixed croppings. At Denbi, there were significantly more aphids per plant in pure field pea plots (17.2) than in mixtures with wheat (14.1) and mustard (9.7).

Table 1. Ascochyta blight score and area under the disease progress curve (AUDPC) in field peas as influenced by crop type.

Treatment	Holetta				Denbi				Kulumsa			
	Mean score		AUDPC		Mean score		AUDPC		Mean score		AUDPC	
	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001
FP[1]	2.0a	2.2a	477.7a	527a	2.7a	2.8a	2138a	2249a	2.8a	2.6b	1083a	1365b
FP/FB[2]	1.8a	2.0a	468.1a	512a	2.7a	2.6a	1238a	1986a	2.9a	2.4b	1510a	1429b
FP/W[3]	1.8a	1.9a	475.1a	486a	2.5a	2.6a	1956a	2010a	2.9a	2.8a	1575a	1767a
FP/M[4]	1.5b	1.2b	366.2b	351b	2.2b	2.1b	1032b	990b	2.5a	2.5b	1080a	1103b
CV (%)	4.6	6.9	5.1	11.2	5.0	7.2	10.1	15.1	10.9	11.5	15.5	12.2

[1] Fp Fp = field pea, [2] Fb = faba bean, [3] W = wheat, [4] M = mustard
MeaCColumns within rows followed by the same letter are not significantly different at P=0.05.

Table 2. Effect of intercropping on pea aphid population density (aphid/plant) on field pea at the three experimental sites in Ethiopia during 2000 and 2001.

Sampling date	Intercropping pattern			
	Fp[1]	Fp+Fb[2]	Fp+W[3]	Fp+M[4]
Holetta				
21/8	5.4	4.6	4.5	4.3
28/8	6.2	5.0	3.6	4.1
05/9	6.0	5.2	5.6	4.6
13/9	5.5	5.8	5.7	4.3
18/9	7.2	5.9	6.9	6.1
25/9	6.2	6.2	6.1	6.0
02/10	8.3	6.1	4.3	4.6
Mean	6.4a	5.5b	5.2b	4.8b
Denbi				
15/8	10.3	10.4	11.0	8.0
22/8	14.2ab	15.6a	8.9c	8.1c
29/8	27.8a	22.5ab	17.2c	16.7c
07/9	13.0b	15.0b	24.0a	12.0b
13/9	11.4a	8.7b	8.7b	6.0b
19/9	24.0a	22.0a	8.0b	8.2b
26.9	20.0a	15.5ab	11.5b	9.0c
Mean	17.2a	15.7ab	14.1b	9.7c
Kulumsa				
23/8	7.5	8.3	5.6	9.6
30/8	5.7	7.2	7.0	7.3
06/9	10.0	8.9	9.4	4.6
12/9	14.6b	13.1b	19.6a	6.4c
20/9	19.8a	19.9.a	16.0b	8.8c
27/9	16.5a	14.8b	18.7a	9.7c
04/10	14.0ab	16.1a	16.9a	13.6ab
Mean	12.6a	12.6a	13.3a	8.6b

[1] Fp = field pea, [2]Fb = faba bean, [3] W = wheat and [4] M = mustard
Means within respective rows without same letters differ significantly at p<0.05.

Among the mixtures, field pea = mustard had significantly fewer aphids. The pea aphid densities were different between the locations, with lower values in the cool, high rainfall Holetta site, compared to the warm, mid-altitude sites at Denbi and Kulumsa, respectively.

The cropping systems had no impact on the degree of parasitization by *Aphidius* spp., (Brachonidae) in both years. However, the percentage of *A. pisum* parasitised by wasps varied between locations. There were more parasitised aphids in field pea/faba bean mixtures at Holetta (9.0%) and Denbi (8.7%) than monoculture field pea plots, while it was

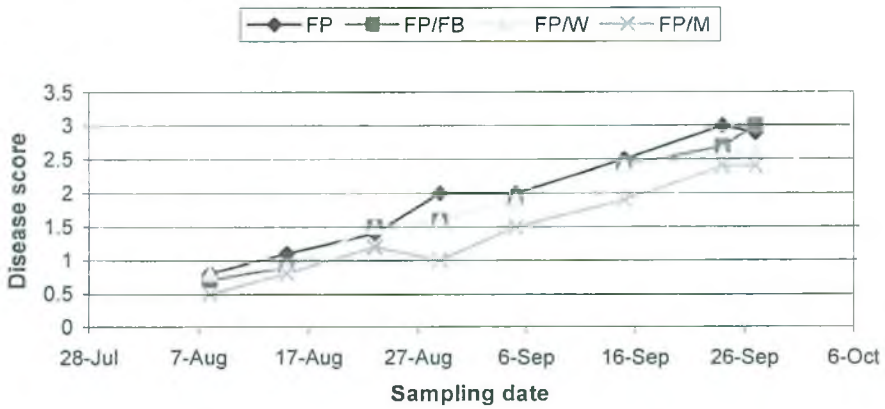

Figure 1. Incidence of ascochyta blight in pure field pea (FP) and under intercrop at Holetta, Ethiopia.

Fb= faba bean, W = wheat and M= mustard, Fp = field pea

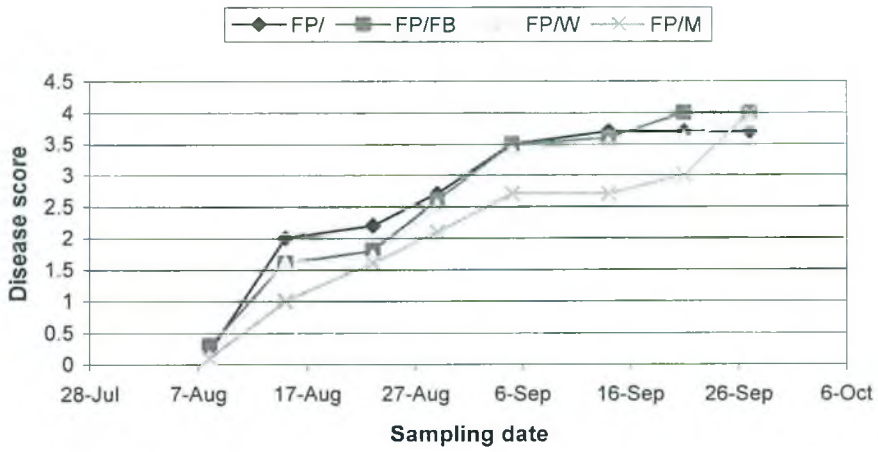

Figure 2. Incidence of ascochyta blight in pure field pea and under intercrop at Holetta, Ethiopia.

Key: FB = faba bean, W = wheat, M = mustard, FP = field pea

7.7% in field pea / mustard mixtures at Kulumsa in 2001. In 2001, it was 10.2%, 12.5% and 16.2%, respectively. The population of predators was too low to be assessed.

The effect of mixed cropping on the yield components of field pea was inconsistent across sites and years. The number of pods per plant and 100-seed weight of field pea at harvest was not affected by the different treatments at Holetta and Kulumsa (Table 3). However, at Denbi, field pea/mustard mixtures gave significantly fewer pods per plant compared with other treatments, which resulted in lower grain yield at this site. At Kulumsa, none of the yield components were affected by mixed cropping in both years.

Table 3. Effect of different mixed cropping combinations on pods/plant and 100-seed weight of field pea (Fp), at Holetta, Denbi and Kulumsa, Ethiopia during 2000and 2001

Treatment	Pods/plant			100-seed weight		
	2000	2001	Mean	2000	2001	Mean
			Holetta			
Fp	10.2a	10.0a	10.1a	20.0a	21.0a	20.0
Fp+Fb	10.3a	10.8a	10.5a	21.5a	20.6a	21.0
Fp+w	11.7a	10.2a	10.9a	22.0a	21.4a	21.7
Fp+m	7.4a	8.5a	7.9a	21.5a	21.1a	21.3
CV(%)	16.73	12.0	15.55	7.92	7.92	9.20
Denbi						
Fp	9.0a	10.0a	9.5a	15.0a	14.8a	14.9
Fp+Fb	8.0ab	9.1ab	8.8ab	14.7a	14.6a	14.6
Fp+w	7.6b	8.7ab	8.1ab	14.0a	13.9a	14.0
Fp+m	6.0c	6.5c	6.2c	14.2a	14.1a	14.1
CV(%)	8.57	9.22	10.1	14.4	12.6	13.5
Kulumsa						
Fp	13.5a	11.6a	12.5a	15.0a	14.7a	14.8a
Fp+Fb	13.4a	12.2a	12.8a	13.7a	14.0a	13.8a
Fp+w	11.7a	11.8a	11.7a	15.2a	15.3a	15.2a
Fp+m	13.1a	12.7a	12.9a	15.2a	14.8a	15.0a
CV(%)	21.0	19.57	22.51	8.70	9.62	10.21

[1] Fp = field pea, [2]Fb = faba bean, [3] W = wheat and [4] M = mustard
Means within column, without letters in common, differ significantly at p<0.05.

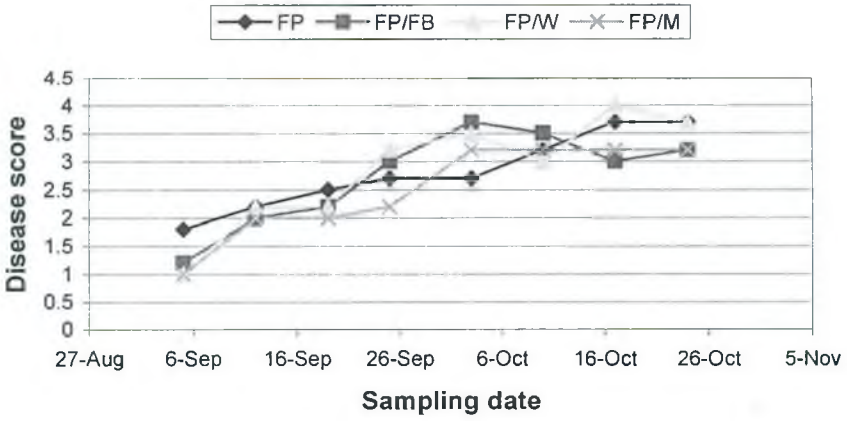

Figure 3. Incidence of ascochyta blight in pure field pea and under intercrop at Holetta, Ethiopia.

Key: FB = faba bean, W = wheat, M = mustard, FP = field pea

Significant treatment effects were observed for field pea grain yield at all the locations and seasons (Table 4), in particular producing reduced yield when mixed with mustard. At all locations and in both seasons, the field pea suffered higher when mix cropped with mustard, as compared to faba bean and wheat.

The mean grain yield of field pea in pure stand was higher at Holetta (1640 kg ha^{-1} in 2000 and 1695 kg ha^{-1} in 2001) than Denbi (395 and 450 kg ha^{-1}) and Kulumsa (1231and 1312 kg ha^{-1}). Field pea grain yield at Denbi was lower than that of Holetta and Kulumsa due to a higher incidence of ascochyta blight and pea aphid damage. Among the intercrops, pea yield was higher in the field pea/wheat intercrop at Holetta and Kulumsa, while it was significantly higher than field pea/mustard mixtures at Holetta (Table 4) in both years.

Table 4. Effect of different intercropping combinations on grain yields (kg/ha) of field pea, faba bean, wheat and Ethiopian mustard at Holetta, Denbi and Kulumsa, Ethiopia during 2000 and 2001.

Treatment	Grain Yield (k/ha)							
	2000				2001			
	Fp	Fb	W	M	Fp	Fb	W	M
				Holetta				
Fp	1640a	-	-	-	1695a	-	-	-
Fb	-	1722a	-	-	-	1820a	-	-
W	-	-	2010a	-	-	-	2100a	-
M	-	-	-	3087a	-	-	-	3219
Fp+Fb	1236b	118b	-	-	1311b	1287b	-	-
Fp+W	1337b	-	411b	-	1410b	-	1400b	-
Fp+M	496c	-	-	2725a	569c	-	-	2652b
				Denbi				
Fp	395a	-	-	-	450a	-	-	-
Fb	-	3120a	-	-	-	2969a	-	-
W	-	-	3236a	-	-	-	3186a	-
M	-	-	-	3925a	-	-	-	4010a
Fp+Fb	211b	699b	-	-	324b	810b	-	-
Fp+W	160bc	-	751b	-	269c	-	929b	-
Fp+M	91c	-	-	3762a	225c	-	-	3942a
				Kulumsa				
Fp	1231a	-	-	-	1312a	-	-	-
Fb	-	5662a	-	-	-	4960a	-	-
W	-	-	2377a	-	-	-	3110a	-
M	-	-	-	3712a	-	-	-	3861a
Fp+Fb	930b	695b	-	-	1020b	820b	-	-
Fp+W	1126a b	-	306b	-	1119b	-	409b	-
Fp+M	917b	-	-	2162b	982b	-	-	2612b

[1] Fp= field pea, [2]Fb = faba bean, [3] W = wheat and [4] M = mustard

Means within column, without letters in common, differ significantly at $p<0.05$.

Mixed crops in 2000 produced mean seed yields of 2108 kg ha^{-1} (ranging from 1354 to 3221 kg ha^{-1}) at Holetta. The mean yield at Denbi was 1891 kg ha^{-1} (with a range of 911 to 3853 kg ha^{-1}) and 2046 kg ha^{-1} (1432 to 3081 kg ha^{-1}) at Kulumsa. In 2001, the yields were 2876, 2166 and 2321 kg ha^{-1} at Holetta, Denbi and Kulumsa, respectively.

The advantage gained from intercropping, compared with growing pure stands is often evaluated by calculating Land Equivalent Ratio (LER) (Willy 1979). If LER is higher than unity, then there is an advantage (increased biological efficiency) from intercropping compared to growing pure stands. LER values calculated from grain yields were above unity in the field pea/mustard intercrop at all locations and years, with wheat at Kulumsa. Field pea intercropped with mustard gave higher mean LER of 1.70 at Holetta 1.37 Kulumsa and 1.27, Denbi (Table 5).

The highest mean net benefit of 10451, 1349 and 10219 birr ha^{-1} was obtained when field pea was cropped mixed with mustard at Holetta, Denbi and Kulumsa, respectively (Table 5). Monoculture field pea at Denbi gave the lowest net benefit. Generally, the trend was that the higher the LER value, the better the net benefit (Table 5).

Table 5. Land Equivalent Ratio (LER) and net economic benefits of different intercropping patterns at Holetta, Denbi and Kulumsa, Ethiopia during 2000 and 2001.

	LER			Net benefit (birr ha^{-1})		
Treatment	2000	2001	Mean	2000	2001	Mean
Fp	1.0	1.0	1.0	3530	3648	3589
Fb	1.0	1.0	1.0	2728	2883	2805
W	1.0	1.0	1.0	3251	3396	3323
M	1.0	1.0	1.0	10750	11209	10979
Fp+Fb	0.83	0.79	0.81	2720	3389	3054
Fp+W	0.51	0.60	0.55	3563	4685	4124
Fp+M	1.72	1.69	1.70	10042	10860	10451
			Denbi			
Fp	1.0	1.0	1.0	417	475	446
Fb	1.0	1.0	1.0	5904	5618	5761
W	1.0	1.0	1.0	5457	5372	5414
M	1.0	1.0	1.0	13683	13979	13831
Fp+Fb	0.79	0.83	0.81	1329	1656	1492
Fp+W	0.54	0.66	0.60	1233	1621	1427
Fp+M	1.23	1.32	1.27	12966	14022	13494
			Kulumsa			
Fp	1.0	1.0	1.0	2507	2690	2598
Fb	1.0	1.0	1.0	10608	9297	9952
W	1.0	1.0	1.0	3912	5118	4515
M	1.0	1.0	1.0	12938	13457	13197
Fp+Fb	0.89	0.78	0.83	3109	3520	3314
Fp+W	1.18	1.22	1.20	2847	3033	2940
Fp+M	1.34	1.40	1.37	9431	11008	10219

Discussion

The incidence of ascochyta blight and aphid numbers were lower in intercropped than pure field pea. The study confirmed that increased crop diversity within field cultivation can result in fewer pests and diseases. The major benefit in the study was reflected in ascochyta blight. In mixtures of field pea with mustard, significantly lower ascochyta incidences were recorded at all the experimental sites except Kulumsa where a difference was noted towards the end of the season. The mechanism by which field pea/mustard intercropping reduced this blight was not investigated in the present study. However, it is speculated that the presence of mustard in field pea/mustard mixtures, acts as a barrier to blight spread through wind and rain splash. Another possible reason could be due to shading and other microclimatic effects under field pea/mustard intercropping which could cause a reduction in the infection and development efficiency of the pathogen (Pfleeger and Mundt 1998). Dereje (1999) also reported that ascochyta blight severity was disproportionately but significantly reduced in field pea/faba bean mixed crops. Similarly, Guar and Singh (1996) reported that chickpea intercropped with mustard had the lowest *Ascochyta rabiei* infection compared with barley, pea or lentil intercropping, but that yield was also greatly reduced. The mustard plants acted as support structures onto which the field pea twined, thereby reducing the direct contact of the pea plants with infected crop debris on the soil. Reducing the soil contact of the peas may also decrease the incidence of disease by providing a drier microclimate, which may improve the quality of the harvested pea seed (Weiss et al. 1994).

The finding is in agreement with reports that intercropping pulses with non-pulse crops reduces the incidence of aphids in legumes (Coderre et al. 1989, Ogenga-Latigo et al. 1992, Olufemi et al. 2001). While it is difficult to explain the manners in which

aphids responded to increased crop diversity, it is well known that plant quality differences among crops can affect aphid population development. In this regard, it is possible that differences in chemical or visual stimuli emanating from different crops could have played a role. Data from the mustard mixtures, however, suggest that physical differences were important, since the dispersion of a 'short' pea variety among tall and dense mustard plants restricted aphid settling through the protective barrier provided by mustard plants.

These findings differ from those reported by ICRISAT (1980) that *Rhopalosiphum maidis* (Aphididae) populations on sorghum were not different in sorghum monoculture and polycultures of sorghum and pigeon pea. On the contrary, Helenius (1991) showed that peak densities of cereal aphids were 30–85% higher in mixtures of oats/faba bean than in the pure stand of oats. He attributed the main mechanism contributing to this observation to be the concentration of alate colonies in fewer tillers per unit area within the mixtures. In the present study, total aphid density per plant was much lower in the mixtures than in the field pea monoculture, especially in field pea/mustard mixtures.

The results across three locations and two seasons consistently showed that mixed cropping is preferable to pure stands of field pea in terms of overall grain yield, economic advantage and LER. Field pea mixed with mustard resulted in lower yield compared with other mixtures. This might be attributed to increased competition for soil nutrients and water. Mustard growth was tall and dense, and resulted in shading, which in turn could possibly have contributed to reduced field pea yield in the mixture. However, the lower yield was compensated for by the yield of mustard when compared with other mixed crop arrangements. Mean LER values were 0.81 (Holetta), 0.60 (Denbi) and 0.83 (Kulumsa), respectively, which are less than unity. Amare (1994) reported an LER value of 1.31 for 3:1 ratio of field pea to faba bea at Holetta.

The incidence of certain natural enemies (coccinellids, syrphids) on field pea plants was not affected by mixed cropping. However, *Aphidius* spp. appeared to be attracted when field pea was mixed with faba bean at Holetta and Denbi. Helenius (1990) reported similar findings in that the population sizes of natural enemies of *Rhopalosiphum padi* (Aphididae) in oats/faba bean mixtures were not significantly affected by mixed cropping when compared to oats monocropping.

The lack of statistical significance for some of the parameters considered in the current study may be attributed to the characteristically irregular pattern of distribution of plant damage under natural aphid infestation. Such a phenomenon is known to cause high variability. Nevertheless, a general pattern was observed whereby the intercropping of field pea with mustard reduced pea aphid incidence and damage on field pea. In this respect, therefore, the field pea/mustard mixed cropping arrangement was the more effective combination. Besides, there was also an additional harvest of mustard gained from the mixed crop set-up. This is an important value-added factor, particularly if one takes into consideration that most Ethiopian farmers are small-scale and resource poor.

The potential of mixed cropping, especially as a component of an integrated pest management system in Ethiopia is promising and deserves to be investigated further. The current study presented some evidence that mixed cropping might provide some yield stability under adverse pest and disease conditions. Since this is largely a traditional practice, farmers can easily adopt unlike many new technologies. Certainly, mixed cropping has its drawbacks, the major one being that different plants have a wide maturity range. For example, mustard is phenologically late maturing; whereas, field

peas mature relatively early. Therefore, the identification of suitable varieties and the right proportion of seed rates for intercropping field pea with cereals and mustard should be a priority research area in order to reduce pest and disease incidence and increase productivity of the system.

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