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DEVELOPMENT OF SPRING CEREAL DISEASES IN PEA/SPRING CEREAL INTERCROPS

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Abstract

An important aspect in organic farming is plant health management. The study was aimed to examine the development of diseases in pea/spring cereal intercrops in the organic farming conditions. The experiment was carried out in 2007 at the Lithuanian Institute of Agriculture in Dotnuva on a loamy *Endocalcari-Ephypogleyic Cambisol*. Peas (*Pisum sativum* L.) and spring cereals: wheat (*Triticum aestivum* L.), barley (*Hordeum vulgare* L.), oats (*Avena sativa* L.), and triticale (x *Triticosecale* Wittm.) were sown as intercrops or mono crops for grain. Powdery mildew (*Blumeria graminis*), rust (*Puccinia* spp.), leaf blotch (*Pyrenophora avenae*), net blotch (*Pyrenophora teres*), tan spot (*Pyrenophora tritici-repentis*), septoria leaf blotch (*Septoria* spp.), and head blight (*Fusarium* spp.) were identified and assessed in the intercrops and mono crops. In many cases, the diseases developed intensively during grain formation stage. Cultivation of spring cereals in mixtures with peas did not have any exceptionally marked effect on the occurrence of diseases, since the trends of reduction of the severity of individual diseases were not always consistent. The grain yield of spring cereals was higher when they had been grown as mono crops compared with pea/cereal intercrops.

Key words: cereal diseases, peas, grain yield, organic farming.

Introduction

In organic farming, prevention of damage caused by pests and diseases relies primarily on management practices such as the crop rotation, choice of species and varieties, and cultivation techniques. In some cases, the use of plant protection products is necessary to avert the threat to a crop, but a product has to be registered for use at national level, moreover, there are not so many biological control agents.

Some crop combinations or cultivation of mixing species offer advantages in terms of reducing pest, disease and weed occurrences, providing greater biological and economic stability, however the great variability of responses to pests and diseases in multi-species systems requires a clearer understanding of the mechanisms involved in those biological interactions /Willey, 1979; Altieri, 1999; Hauggard-Nielsen et al., 2001; Malezieux et al., 2008/.

Intercropping of cereals and grain legumes is a neglected theme in agricultural science and practice in both conventional and organic. An important aspect of intercropping systems in their potential is to reduce the incidence of diseases. Plant diseases

continue to play a major limiting role in agricultural production. The control of plant diseases using classical pesticides raises serious concerns about food safety, environmental quality and pesticide resistance, which have dictated the need for alternative pest management techniques. The species diversity of more complex agroecosystems and thus the dispersion of individual host species may restrict the spread of plant pathogens. In an intercrop combination, there is a mixture of susceptible and resistant (non-host) plants, and thus greater distance from one host plant to another /Altieri, Liebman, 1986/.

Calculations made in Lithuania show that cereal productivity on an organic farm declines by 47% compared with that on a conventional farm /Zemeckis, Ribašauskienė, 2005/. The main condition to obtain high yield is adequate fertilisation. However, yield reduction can be caused not only by no nitrogen fertilisation but also by diseases and pests /Mäder et al., 2002/. While observing the rules of good plant protection practice, priority is always given to environmentally safe pest and disease control measures /Gaurilčikienė, Semaškienė, 2004/, that can also be applied on organic farms. Research on the biological products, characterised by antagonistic effect on pathogen, was done at he Lithuanian Institute of Agriculture, however their efficacy under field conditions was found to be low /Semaškienė, 2000; Semaškienė, Dabkevičius, 2000; Kadžiulienė et al., 2005/. Cultivation of disease resistant varieties is an important tool to prevent diseases on organic farms /Lotter, 2003; Leistrumaitė, 2006; Semaškienė et al., 2007/. In the research literature, cultivation of different plant species in a mixture is considered to be one of the main plant protection practices reducing disease damage /Czembor, Gasek, 1996; Bulson et al., 1997; Garrett, Mundt, 1999; Finckh et al., 2000/.

The study was aimed to examine the development of diseases in pea/spring cereal intercrops in the organic farming conditions.

Materials and Methods

The field experiment was carried out in 2007 at the Lithuanian Institute of Agriculture in Dotnuva (55˚ 24‘N) on a loamy *Endocalcari-Epihypogleyic Cambisol*. The soil pH varied between 7.5, humus content was 2.3%, available P 74–79 mg kg^{-1} and K 135–140 mg kg^{-1}. Wheat (*Triticum aestivum* L.), barley (*Hordeum vulgare* L.), oats (*Avena sativa* L.) or triticale (x *Triticosecale* Wittm.) were grown as sole crop and intercrops with a field pea cultivar (*Pisum sativum* L.). The experimental plots were laid out in a complete one – factor randomised block design in three replicates. The intercrop design was based on the proportional replacement principle, with mixed pea grain and spring cereals grain at the same depth in the same rows at relative frequencies of 50:50. Crops were cultivated according to organic management practices.

The development of leaf diseases was monitored in cereal crops by sampling 15 plants from trial plots. Random tillers were selected per plot and the top three leaves were scored for disease severity by using the 1, 5, 10, 25, 50 and 75% scale /EPPO Standards, 2004/. Growth stage was recorded when diseases severity was assessed /Meier, 1997/. Observations of disease severity were made approximately every 10–14 days on each plot starting at the stem elongation and continuing through the late milk stage. Fusarium head blight was assessed at doughy ripening (BBCH 85) /EPPO Standards, 2004/.

Results and Discussion

Leaf spotting diseases occurred in the crops of all cereal species grown in a mono crop as well as in mixtures with peas. The weather conditions in 2007 were conducive to the spread of diseases, since warm and wet weather prevailed. Already at booting stage, the first disease lesions were spotted on the leaves of spring cereals and in the second half of the summer up to 75% of the plants were affected by the disease (Table 1). Spring wheat and triticale were affected by tan spot (*Pyrenophora tritici-repentis*), spring barley by net blotch (*Pyrenophora teres*), oats by leaf blotch (*Pyrenophora avenae*). Septoria leaf blotch (*Septoria* spp.) in wheat and triticale started

Table 1. The severity of leaf spotting diseases in the crops of spring cereals grown in mono crops and in mixtures with peas, Dotnuva, 2007

	Disease severity %				
	06 08	06 19	06 29	07 13	07 27
	Tan spot				
Pea/wheat	0.39 c	1.47 bc	3.41 b	8.23 d	4.64 ab
Wheat	0.31 c	1.57 c	2.37 ab	5.57 bcd	5.18 b
Pea/triticale	0.01 a	0.96 a	2.44 ab	2.51 a	3.82 ab
Triticale	0.01 a	1.15 abc	2.55 ab	2.92 ab	3.87 ab
	Septoria leaf blotch				
Pea/wheat	0	0	0.26 ab	3.52 b	16.80 b
Wheat	0	0	2.54 b	2.63 ab	25.70 c
Pea/triticale	0	0	0.01 ab	0.90 ab	1.16 a
Triticale	0	0	0	0.49 ab	1.04 a
	Leaf blotch				
Pea/oat	0.48 b	1.97 a	3.17 a	4.14 a	17.80 a
Oats	0.46 a	2.33 b	3.87 b	7.90 b	23.10 b
	Net blotch				
Pea/barley	1.84 a	4.13 a	9.61 a	7.96 a	–
Barley	1.91 b	5.55 b	13.00 b	11.09 b	–

to occur after the cereal heading stage. This disease spread much more abundantly in spring wheat than in triticale. In spring wheat, where the disease severity was 14–25 times higher than in triticale, spring wheat that grew in mixture with peas was significantly less affected compared with spring wheat grown in a mono crop, whereas at low disease severity the effect of triticale growing in a mono crop or in a mixture with peas on septoria leaf blotch occurrence was not revealed. The occurrence of tan spot was higher in spring wheat than in triticale also, however the incidence and severity of this disease in triticale and wheat mono crops was similar to those in the crops grown in mixture with peas. Experiments done at LIA showed that at the severity of leaf spotting diseases above 5%, a significant yield reduction occurred in most cases compared with wheat at grain filling stage completely protected from diseases /Ronis et al., 2007/. In

our experiments, leaf spotting disease severity in spring wheat, grown in mono crop and intercrop, was higher than 5%, therefore yield decrease from leaf spotting disease in wheat was probable. However, the severity of leaf blotch in oats and net blotch in barley during the entire growing season was significantly higher in mono crops. In Denmark, it was also established that net blotch severity was statistically lower in pea/barley intercrop compared to barley mono crop /Kinane, Lyngkjęr, 2002/.

Powdery mildew (*Blumeria graminis*) started to spread in spring barley and triticale grown in mono crops and in mixtures with peas from the early growth stages (Table 2). The highest powdery mildew incidence was determined in spring barley. In barley grown in mono crop or mixture with peas the incidence of powdery mildew was similar. Other researches indicate that powdery mildew severity was reduced in barley whenever barley was intercropped with grain legumes, however the authors indicate, that infection level of powdery mildew was low and severity reduction was not significant /Kinane, Lyngkjęr, 2002/. In spring triticale the severity of powdery mildew was nearly twice as low as in spring barley. At milk maturity the severity of powdery mildew was lower in the treatments where spring wheat had been grown in mixture with peas, however, the difference was not statistically significant. In triticale the severity of powdery mildew was low during the entire growing season and no distinct differences in powdery mildew incidence and severity were revealed in mono crops or mixtures with peas. Powdery mildew did not occur in oats in 2007.

Table 2. The severity of powdery mildew and rust of spring cereals in mono crops and pea/cereal intercrops

Dotnuva, 2007

	Disease severity %				
	06 08	06 19	06 29	07 13	07 27
			Powdery mildew		
Pea/wheat	0.01 a	0.10 a	0.29 a	0.26 a	0
Wheat	0.00 a	0.13 ab	0.07 a	0.17 a	0
Pea/barley	2.13 d	4.95 e	10.40 d	10.89 d	–
Barley	1.84 d	4.34 cde	9.75 d	10.49 d	–
Pea/triticale	1.24 b	2.55 bcde	5.13 b	2.67 ab	0.04 a
Triticale	1.04 b	2.41 abc	5.54 b	4.16 b	0.20 b
			Rust		
Pea/wheat	0	0	0.01 a	0.84 a	12.30 a
Wheat	0	0.01 ab	0.02 a	1.20 a	33.00 bcd
Pea/barley	0	0	0.01 a	3.84 ab	42.13 cd
Barley	0	0	0.03 a	3.46 ab	29.23 b
Pea/oat	0	0	0.17 abc	4.41 abc	35.77 bcd
Oat	0	0	0.16 abc	9.69 cde	12.30 a
Pea/triticale	0	0.07 ab	1.03 c	8.57 bcde	13.33 a
Triticale	0	0.10 b	0.47 abc	10.40 e	42.13 d

In all cereal crops rust started to spread after heading: in barley – barely leaf rust (*Puccinia hordei*), in oats – crown rust (*Puccinia coronata*), and wheat and triticale – brown rust (*Puccinia recondita*). The incidence of rust in the crops of all cereal species was high in 2007. As was mentioned before, different cereal species were affected by rusts caused by different pathogenic fungi. In spring wheat and triticale the severity of brown rust was significantly lower in the treatments grown in mixture with peas compared with sole crops, whereas the severity of crown rust in oats and leaf rust in barley was lower in mono crops.

At the beginning of dough maturity, Fusarium head blight pressure on spring wheat was by up to 56% higher than in triticale (Figure 1). The incidence of Fusarium head blight in spring wheat and triticale did not differ significantly between the treatments of sole cereals or mixed with peas.

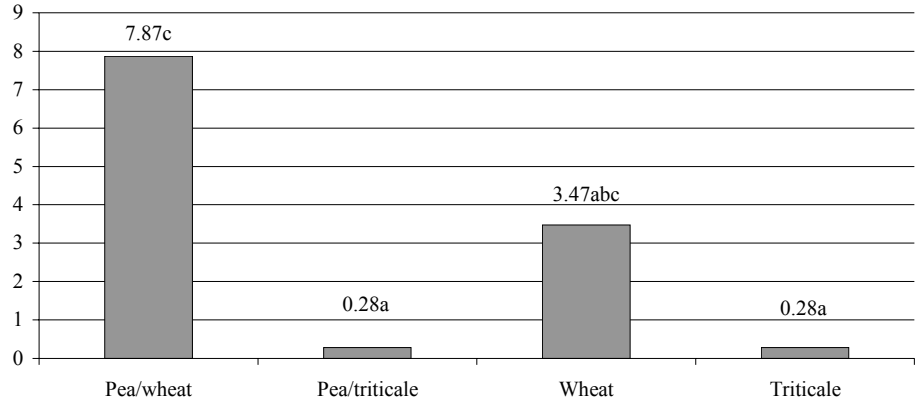

Figure 1. The incidence of Fusarium head blight in spring wheat and triticale at the beginning of wax maturity, 2007

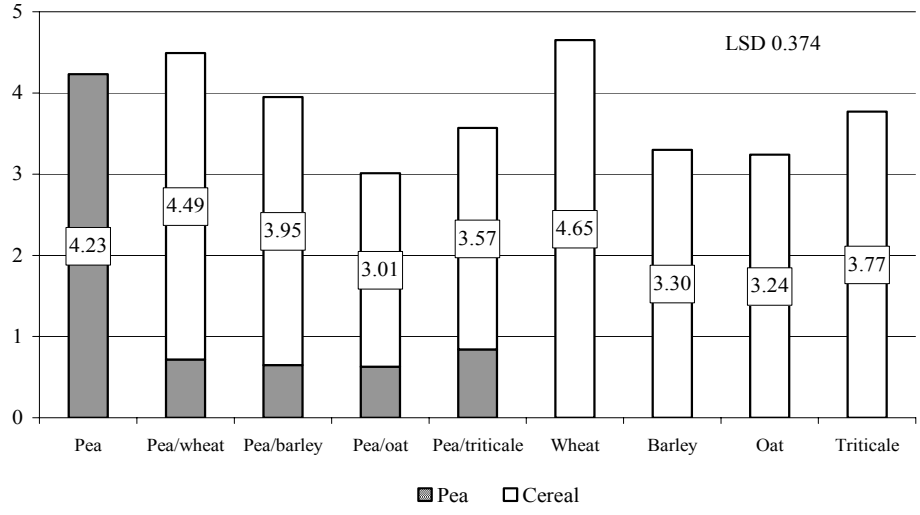

Figure 2. The yield of spring cereals grown in a mono crop and mixtures, 2007

The yields of spring cereals – triticale, wheat, oats grown in mono crops were either significantly higher or trends of increasing were observed compared with mixtures (Figure 2). Barley in mixture with peas produced a significantly higher grain yield compared with that produced by barley mono crop. Comparison of grain yield of mixtures revealed barley and pea mixture to be the highest yielding too. Pea and oats mixture produced significantly lower grain yield compared with the other mixtures.

Conclusions

1. Powdery mildew, rusts, blotches, Septoria leaf blotch, head blight spread in the crops of spring cereals grown as mono crops and in mixtures with peas in the organic crop rotation. In most cases, the diseases reached the highest severity during the grain filling stage. Cultivation of spring cereals in mixtures with peas did not have any exceptionally marked effect on the occurrence of diseases, since the trends of reduction of the severity of individual diseases were not always consistent.

2. The productivity of spring cereal mono crop or pea-cereal mixtures depended on the cereal species. The productivity of pea-spring barley and pea-spring wheat mixtures was significantly higher than that of the other mixtures and cereal mono crops, except spring wheat. Peas grown in a mono crop were also productive, however they yielded less than pea-spring wheat crop and were insignificantly more productive than pea-spring barley mixture. Protein concentration and amount were found to be higher in the grain of pea-cereal mixtures.

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