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THE PROBLEM OF ROOT AND STEM BASE HEALTH OF OAT (*AVENA SATIVA* L.) CULTIVATED IN MIXTURE WITH SPRING RYE (*SECALE CEREALE* L.)

*Grzegorz Lemańczyk**

University of Technology and Life Sciences, Department of Phytopathology and Molecular Mycology
Kordeckiego 20, 85-225 Bydgoszcz, Poland

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Abstract: Field experiments were carried out at Mochełek (17°51'E, 53°13'N). The health status of roots and stem bases of oat cultivated in pure stand and in mixture with spring rye was evaluated. A low intensity of root-rot was observed. Eyespot and *Fusarium* foot rot were observed on stem bases. Oat was infected with *Fusarium* spp. in higher degree when it was grown in mixture with spring rye. The pathogenic fungi occurring on oat roots were mostly represented by *Fusarium* spp., especially *F. solani* and *F. equiseti.* Stem bases showed the occurrence of *F. culmorum, F. equiseti* and *F. avenaceum*. Cultivation of oat in mixture did not affect the composition of fungal species occurring on roots and stem bases.

Key words: oat, mixture, spring rye, fungi, health status, diseases, roots, stem base

INTRODUCTION

Spring cereals grown in cereal mixtures are often less considerably infected by leaf pathogens than when grown in pure stand (Willey 1979; Garrett and Mundt 1999). The companion plants can also have a favourable effect on the health status of roots and stem bases (Vilich-Meller 1992). These days it is also recommended that a form of spring rye be grown especially on light soils, as a component of mixtures sown in spring. The current information available about spring rye is primarily concerned with genetic aspects and collection research (Galek 2003; Malyshev *et al.* 2001; Ma *et al.* 2004). However, there is no information on its effect on the health status of companion crops.

The aim of the present research was to verify whether spring rye as a mixture component modifies the composition of fungal communities and the health status of roots and stem bases in oat.

MATERIALS AND METHODS

The research was carried out from 2000–2002 at the Experiment Station at Mochełek (17°51'E, 53°13'N), on the experimental plots of the Department of Plant Production and Experimenting of the University of Technology and Life Sciences in Bydgoszcz, Poland. The experiments were set up in a randomized block design in 3 reps, on Haplic Luvisol, good rye complex. The research material was made up of naked oat, 'Akt' cultivar, grown in pure stand or in the mixture with 'Abago' spring rye.

Observations of the health status of roots and stem bases were performed at the shooting phase (GS 34–36; Zadoks *et al.* 1974) and milk stage (GS 75–77). The roots were evaluated using the 0–4° scale, and the infection of the stem base with *Fusarium* spp. and *Oculimacula* spp. – using the 0–3° scale. Each time the health status of 30 randomly sampled plants from each replication was analysed. The degrees of infection were converted into the disease index (DI) according to the Townsend and Heuberger formula (Wenzel 1948). Statistical analyses were performed with the Tukey's test.

The health status evaluation was supplemented with mycological analysis. The material for analysis of fungi which were infesting roots and the stem base were randomly sampled from organs demonstrating disease changes. The 5 mm fragments were cut out from the roots at the shooting phase, whereas from stems – at the milk stage. From each combination 100 pieces each were prepared. The material was disinfected for 20 seconds in 1% solution of $AgNO_3$ and then rinsed three times in sterile water and placed on the PDA medium with streptomycin and then onto Petri dishes.

RESULTS

During our observations we found relatively few disease symptoms which occurred on the roots and the stem bases in oat (Table 1). A greater infection was reported for the roots. The infection was especially visible in 2002

*Corresponding address:
Grzegorz.Lemanczyk@utp.edu.pl

Table 1. Root and stem base infestation of oat at two growth stages – disease index [%]

Sowing combination	Shooting phase				Milk stage			
	2000	2001	2002	mean	2000	2001	2002	mean
Root-rot								
Oat	5.67	1.40	12.23	6.43	7.67	6.00	15.00	9.56
Oat + spring rye	8.00	2.50	11.43	7.31	7.67	4.33	13.07	8.36
Mean	6.83	1.95	11.83	6.87	7.67	5.17	14.03	8.96
LSD (0.05)	ns	ns	ns	ns	ns	ns	ns	ns
Eyespot								
Oat	0.33	0.00	0.60	0.31	0.67	0.33	6.10	2.37
Oat + spring rye	0.00	0.00	0.83	0.28	1.07	1.67	8.87	3.87
Mean	0.17	0.00	0.72	0.29	0.87	1.00	7.48	3.12
LSD (0.05)	ns	ns	ns	ns	ns	ns	ns	ns
Fusarium foot rot								
Oat	1.00	0.00	0.27	0.42	3.33	2.00	0.53	1.96
Oat + spring rye	1.67	0.00	0.00	0.56	4.67	2.33	0.27	2.42
Mean	1.33	0.00	0.13	0.49	4.00	2.17	0.40	2.19
LSD (0.05)	ns	ns	ns	ns	ns	ns	ns	0.273

ns – not significant difference

Table 2. Share of fungi [%] isolated from roots of oat at the shooting phase

Fungus	Oat in pure stand				Oat + spring rye				Mean
	2000	2001	2002	mean	2000	2001	2002	mean	
Alternaria alternata	–	2.5	–	0.8	–	–	–	–	0.4
Arthrinium phaeospermum	–	–	–	–	–	1.9	–	0.6	0.3
Aspergillus niger	–	–	–	–	–	3.8	–	1.3	0.6
A. bolleyi	7.8	15.0	22.5	15.1	1.8	23.1	8.3	11.1	13.1
Chaetomium spp.	–	5.0	–	1.7	–	–	–	–	0.8
F. avenaceum	–	–	10.0	3.3	3.6	–	11.1	4.9	4.1
F. culmorum	15.7	2.5	–	6.1	13.4	3.8	–	5.7	5.9
F. equiseti	26.5	2.5	5.0	11.3	20.5	–	2.8	7.8	9.5
F. oxysporum	–	–	–	–	5.4	–	–	1.8	0.9
F. solani	20.6	15.0	10.0	15.2	17.0	9.6	5.6	10.7	13.0
Fusarium total	62.7	20.0	25.0	35.9	59.8	13.5	19.4	30.9	33.4
Gliocladium catenulatum	3.9	–	–	1.3	5.4	–	–	1.8	1.5
Gliomastix murorum	–	–	–	–	–	3.8	–	1.3	0.6
Gymnoascus reesii	–	2.5	–	0.8	–	3.8	–	1.3	1.1
Humicola grisea	–	–	–	–	–	3.8	–	1.3	0.6
Monocillium indicum	–	–	–	–	–	1.9	–	0.6	0.3
Mucor spp.	–	7.5	2.5	3.3	5.4	1.9	8.3	5.2	4.3
Paecilomyces lilacinus	5.9	–	–	2.0	–	–	13.9	4.6	3.3
Penicillium spp.	3.9	20.0	10.0	11.3	1.8	15.4	22.2	13.1	12.2
Periconia macrospinosa	9.8	–	7.5	5.8	16.1	5.8	2.8	8.2	7.0
Phoma spp.	5.9	–	7.5	4.5	8.0	–	5.6	4.5	4.5
Rhizoctonia solani	–	2.5	–	0.8	1.8	7.7	–	3.2	2.0
Rhizopus nigricans	–	–	–	–	–	1.9	–	0.6	0.3
Scopulariopsis brevicaulis	–	–	–	–	–	1.9	–	0.6	0.3
Stamphilium sp.	–	–	–	–	–	1.9	–	0.6	0.3
Trichoderma polysporum	–	10.0	–	3.3	–	3.8	–	1.3	2.3
Non-sporulating	–	15.0	25.0	13.3	–	3.8	19.4	7.8	10.5
Total number of isolates	102	40	40	182	112	52	36	200	382

(DI = 14.03%). The oat root infection was not affected by its cultivation in the mixture with the spring form of rye.

Neither did growing oat in the mixture with spring rye differentiate the infection of the stem base in oat with *Oculimacula* spp. (which was inconsiderable). More symptoms were observed at the milk stage, especially in 2002 (DI = 7.48%). The infection with *Fusarium* spp. was also low. Despite this, the application of spring rye in the mixture at the milk stage did not improve the health status of roots and stem bases in oat. Instead an even greater intensity of Fusarium foot rot was observed.

From infected oat roots the fungi considered most pathogenic were mostly isolated fungi of the *Fusarium* genus, especially *F. solani* and *F. equiseti* (Table 2). Many of

Table 3. Share of fungi (%) isolated from stem base of oat at the milk stage

Fungus	Oat in pure stand				Oat + spring rye				Mean
	2000	2001	2002	mean	2000	2001	2002	mean	
Alternaria alternata	–	–	–	–	4.7	–	–	1.6	0.8
Aspergillus niger	2.9	3.0	–	2.0	–	2.9	–	1.0	1.5
A. bolleyi	–	4.5	7.4	4.0	–	–	12.9	4.3	4.2
F. avenaceum	4.9	9.1	61.1	25.0	–	8.6	62.9	23.8	24.4
F. culmorum	44.1	43.9	9.3	32.4	34.1	65.7	8.1	36.0	34.2
F. equiseti	48.0	25.8	9.3	27.7	57.6	2.9	9.7	23.4	25.5
F. oxysporum	–	–	–	–	–	–	1.6	0.5	0.3
F. sporotrichioides	–	–	7.4	2.5	–	–	–	–	1.2
Fusarium total	97.1	78.8	87.0	87.6	91.8	77.1	82.3	83.7	85.7
Mucor spp.	–	6.1	–	2.0	–	14.3	–	4.8	3.4
Penicillium spp.	–	3.0	–	1.0	–	–	–	–	0.5
R. cerealis	–	3.0	–	1.0	–	–	1.6	0.5	0.8
Rhizopus nigricans	–	–	–	–	3.5	–	–	1.2	0.6
Torula sp.	–	1.5	–	0.5	–	–	–	–	0.3
Trichoderma koningii	–	–	1.9	0.6	–	–	3.2	1.1	0.8
Trichoderma viride	–	–	1.9	0.6	–	–	–	–	0.3
Non-sporulating	–	–	1.9	0.6	–	5.7	–	1.9	1,3
Total number of isolates	102	66	54	222	85	35	62	182	404

them were obtained in 2000. Besides, there were selected *Rhizoctonia solani* and *Aureobasidium bolleyi*. In the present research, from the infected stem base in oat *Fusarium* spp. was mainly isolated. From the *Fusarium* spp., *F. culmorum* and *F. equiseti* dominated in 2000 and 2001, and in 2002 *F. avenaceum* dominated (Table 3). No symptoms of sharp eyespot were observed from the stem base in oat but *Rhizoctonia cerealis* was isolated which is currently considered the main agent of that disease. Despite observing eyespot in oat, *Oculimacula* spp. was not isolated. Growing oat in mixture with spring rye did not have a clear effect on the composition of fungal communities isolated from infected roots and stem base.

DISCUSSION

Oat is considered to have little susceptibility to infection with pathogens causing root and foot rot diseases, which was confirmed in the present research, though stronger infection affected the roots. These findings coincide with the reports by Kurowski (2002) who claims that oat when compared with other cereals, still definitely showed the healthiest roots.

Kurowski and Adamiak (2007) claim that the stem base in oat is mostly identified with Fusarium foot rot, and additionally, sporadically, eyespot. In the present research those diseases occurred at a similar level. Garrett and Mundt (1999) while performing observations on spring barley also noted no effect of the companion crop on the occurrence of eyespot. It is claimed that mixed crops do not increase the soil resistance; limiting infection (Hiddink *et al.* 2005). Vilich-Meller (1992) has a slightly different opinion, claiming that growing barley and wheat in mixture can decrease infection with *Oculimacula* and *Fusarium* genera fungi. The effect of companion crops on the health status depends on their share in the mixed crops (Mundt *et al.* 1995). Michalski *et al.* (2000) found a significant decrease in barley infection with *Oculimacula* spp. where the share of oat in the mixture accounted for at least 50%. Mundt *et al.* (1995) claim that the harmfulness of *Oculimacula* spp. and *Fusarium* spp. is reduced by growing in mixtures when the diseases on leaves occur at lower intensity.

The application of spring rye as a component of the mixture with oat increased the intensity of Fusarium foot rot on oat. Even though the disease does not occur at high intensity in spring rye from its infected stem base were isolated *F. culmorum, F. equiseti* and *F. avenaceum* (Lemańczyk 2009), which to some extent could have also contributed to the increase in the infection of the oat grown with the spring rye observed in the present research. Even though Pięta and Kęsik (2008) claim that the application of spring rye as mulch stimulates growth and development of microorganisms, especially the antagonistic ones (*Bacillus* spp., *Pseudomonas* spp., *Gliocladium* spp., *Trichoderma* spp.), they note that it affects only the health status of successive crop.

From the infected oat roots, the fungi considered pathogenic were mostly isolated fungi representing *Fusarium* genus, especially *F. solani* and *F. equiseti* as well as *R. solani* and *A. bolleyi*. Kurowski (2002) and Kurowski and Adamiak (2007) consider *F. culmorum* to be the main agent of root-rot. Sturz and Bernier (1989) pointing to *F. culmorum* as one of the main oat pathogens, claim that *A. bolleyi* is also frequent. The species is, however, considered to be a background pathogen as it does not penetrate tissues deep, and as such it does not disturb their functioning.

Other authors (Kurowski 2002; Kurowski and Adamiak 2007) much more often isolated *F. culmorum* from the infected stem base of oat. In the present research *R. cerealis* was also isolated. The occurrence of sharp eyespot on oat was reported by Glynne (1950), pointing to the agent being *R. solani*. However, she noted that the disease on oat at greater intensity can occur only sporadically. Błażej and Błażej (2000) isolated much less *Fusarium* from the

stem base in oat and barley when growing those cereals in the mixture than in pure stand.

No fungi of the *Oculimacula* genus can be due to a high share of *Fusarium* spp., which are common in soil and show high competitiveness towards other pathogens and the capacity for coexistence on plants in the presence of other fungi. They often infest plants infected primarily by other pathogens (Kurowski 2002).

CONCLUSIONS

1. The use of spring rye as a mixture component increased infection by *Fusarium* spp. in the stem base of oat. The use of spring rye in the mixture did not affect infection with *Oculimacula* spp. and the health status of roots.
2. Growing oat in the mixture with spring rye did not have a considerable effect on the composition of fungal communities isolated from infected roots and the stem base.
3. From the infected roots of oat the most isolated were: *Fusarium* spp., especially *F. solani* and *F. equiseti*, and from the stem base: *F. culmorum, F. equiseti* and *F. avenaceum*.

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POLISH SUMMARY

PROBLEM ZDROWOTNOŚCI KORZENI I PODSTAWY ŹDŹBŁA OWSA (*AVENA SATIVA* L.) UPRAWIANEGO W MIESZANCE Z FORMĄ JARĄ ŻYTA (*SECALE CEREALE* L.)

Badania polowe prowadzono w Mochełku (17°51'E, 53°13'N). Oceniano zdrowotność korzeni i podstawy źdźbła owsa uprawianego w czystym siewie i w mieszance z żytem jarym. Obserwowano stosunkowo mało objawów zgnilizny korzeni owsa. Na podstawie źdźbła stwierdzono tylko objawy łamliwości źdźbła i fuzaryjnej zgorzeli podstawy źdźbła. Uprawa owsa w mieszance z żytem wpłynęła na wzrost porażenia przez *Fusarium* spp. Z porażonych korzeni owsa izolowano głównie *Fusarium* spp., zwłaszcza *F. solani* i *F. equiseti*, a z podstawy źdźbła *F. culmorum, F. equiseti* i *F. avenaceum*. Uprawa owsa w mieszankach nie wpłynęła na skład gatunkowy grzybów izolowanych z porażonych korzeni i podstawy źdźbła owsa.