Healthiness of Winter Wheat and Spring Barley Farmed under Different Systems

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Abstract

In 1997–2001 health of roots, stem bases and harvested grain of winter wheat and spring barley cultivated in organic and conventional farms in Poland was investigated. More isolates of *B. sorokiniana* were obtained from spring barley in the organic farm and *Fusarium* spp. in the conventional farm. Results of winter wheat health estimation were not clear. In the end of cropping season higher mean disease index for roots was observed in organic farm, and for stem bases the relation was opposite. The main casual agents were *Fusarium* spp. Their higher occurrence was observed on roots, stem bases and also on grain in the organic farm. Furthermore, organic farm conditions were favourable to *Trichoderma* spp. development and conventional one to *Penicillium* spp.

Keywords: wheat; barley; *Bipolaris sorokiniana*; *Fusarium* spp.; fungi; diseases

INTRODUCTION

Nowadays more and more attention is paid to natural environment protection and human and animal health. Consumers are becoming interested in the origin of food and methods used in the production. This lead many farmers to adopt organic farming methods and to produce organic food which may play a role in the prevention of allergies or cancers. However, some research results indicate that these products can be contaminated by pathogenic microorganisms such as fungi or contain harmful substances like mycotoxins (MARCKMANN 2000; TREWAVAS 2001). In approachable literature, except from few papers, there is not many detailed information about organic product mycological quality. The intention of this investigations is to show general trends in the development of saprophytic fungi and pathogens and the extent of their presence in winter wheat and spring barley in the organic and conventional farming systems.

MATERIALS AND METHODS

The studies were carried out on production fields in north-western Poland. The research variety was winter wheat cv. Roma and spring barley, cv. Damazy from 1997–2001. Sowing material and crops in the conventional system were chemically treated. Macroscopic evaluation of plant health status and mycological analyses were carried out at emergence and at the beginning of dough maturity stages. At emergence, four replicates of 50 plants were sampled randomly from each field and root and stem base infestation was evaluated. At dough maturity four replicates of 25 plants were sampled from each field.

At both crop stages, root and stem base infestation was evaluated on a 0–5 scale from 0 (healthy roots or stem bases) to 5 (roots with > 70% area damaged or stem bases rotted completely). The level of infestation was transformed to a disease index (DI) according to Townsend's and Heuberger's formula (WENZEL 1948). The obtained data were analysed statistically and a Tukey test used to compare means.

At both crop stages, during evaluation of infestation, plants with disease symptoms on roots and stem bases were mycologically analysed on PDA medium. In every year four harvested 100-grain samples from each farm were also subject to the same mycological analysis on PDA medium. Fungi from all samples were isolated according to methods commonly used in such mycological investigations.

RESULTS

Results of winter wheat health estimation were differentiated. In the end of cropping season higher mean level of DI for roots was observed in organic farm, however in the case of stem bases the relation was opposite (Table 1). The main casual agents were *Fusarium* spp. Generally their higher occurrence was observed on roots, stem bases and also on grain in the organic farm (Tables 2 and 3).

Health evaluation of spring barley showed that mean DI of roots and stem bases at emergence was higher in the organic farm compared to conventional one. At the dough maturity stage there were no differences between systems (Table 1). At both stages more isolates of *B. sorokiniana* were obtained in the organic farm and *Fusarium* spp. in the conventional one (Table 2). The adequate situation was observed on grain where *B. sorokiniana* was isolated in higher percent, however *Fusarium* spp. were a little bit less numerous in the conventional farm (Table 3).

There was observed that *Penicillium* spp. were isolated numerously from roots and stem bases of wheat and barley in the conventional farm. The opposite result was obtained for grain harvested in ecological system. *Trichoderma* spp. was generally more numerous in the organic farm. Other fungus species were isolated in all samples (Table 2).

DISCUSSION

Mycological analyses showed that one of the main causes of disease were *Fusarium* spp. and *B. sorokiniana*. They are considered as one of the most important cereal pathogens. It was noted by Wakuliński and Chełkowski (1993) and Parry *et al.* (1995).

Higher infection of stem bases and harvested grain of barley with *B. sorokiniana* in the organic system was confirmed by other observations made on organic and conventional farms by Baturo-Czajkowska *et al.* (1998) and higher number of *Fusarium* spp. in conventional system by Baturo (2002). In the case of winter wheat results of mycological analysis presented in this paper were different what is adequate to results of Baturo-Czajkowska *et al.* (1999). It can show that *Fusarium* development is limited in organic system in the case of barley only. The cause could be interactions between these fungi and *B. sorokiniana* which are not clearly found out (Bateman & Kwaśna 1999). Mentioned fungi could also be dangerous due to their abilities to produce mycotoxins (Chełkowski 1994; D'Mello *et al.* 1999). Trewavas (2001) claims that contamination by mycotoxigenic fungi and mycotoxins can be higher in organic products than in conventional ones. The results presented here confirm this hypothesis in the case of *Fusarium* spp.

Trichoderma spp. were frequent in the organic system where their higher occurrence could have caused a bit lower occurrence of *Fusarium* spp. isolates. *Trichoderma* spp. as well as *Gliocladium* spp. show antagonistic properties and they are considered as a human-friendly in the plant pathogen control (Łacicowa & Pięta 1996).

In the conventional farm *Penicillium* spp. were isolated more frequently than from the organic one. It can not be confirmed by Hansen *et al.* (2001) who observed in organic soil more spores of *Penicillium* spp. Fungi of this genus was reported by Tahsein & Amein (1988) as an antagonistic towards pathogens responsible for cereal stem base diseases.

Table 1. Mean disease index on roots and stem in organic (O) and conventional (C) farm during emergence (Em.) and dough maturity stage (D.m.)

Farm	Winter wheat 1998–2001				Spring barley 1997–2000			
	Roots		Stem bases		Roots		Stem bases	
	Em.	D.m.	Em.	D.m.	Em.	D.m.	Em.	D.m.
O	0.2 a	9.0 a	4.5 a	45.7 b	9.4 a	15.4 a	9.1 a	32.8 a
C	0.0 a	6.1 b	2.8 b	54.8 a	2.6 b	15.9 a	0.8 b	29.2 a

* values in the same column followed by different letters are significantly different

Table 2. Fungi isolated from roots and stem bases (%) – mean value from all years of the studies

Fungi	Winter wheat 1998–2001								Spring barley 1997–1999							
	Roots				Stem bases				Roots				Stem bases			
	e		d		e		d		e		d		e		d	
	O	C	O	C	O	C	O	C	O	C	O	C	O	C	O	C
Alternaria alternata (Fr.) Keissler	9.1	1.9	–	–	–	–	0.7	–	–	–	1.8	–	–	–	–	–
Aspergillus niger van Tieghem	9.1	–	1.1	0.8	1.3	2.5	2.1	5.1	–	–	–	3.8	–	–	1.8	1.0
Aureobasidium bolleyi (Sprague) von Arx	–	–	–	1.2	1.9	2.2	0.7	3.4	2.2	–	1.8	–	1.7	–	5.3	11.9
***Bipolaris sorokiniana* (Sacc. in Sorok.) Shoem.**	–	–	2.2	–	1.0	–	3.0	0.8	**52.2**	**17.1**	**15.6**	**6.7**	**54.3**	**36.4**	**56.6**	**49.5**
Colletotrichum spp.	–	–	–	–	–	–	–	–	–	–	–	–	0.9	–	–	–
Cylindrocarpon candidum (Link) Wollenweber	–	–	2.2	–	1.9	–	6.0	1.7	1.1	2.4	–	–	–	–	–	–
Epicoccum nigrum Link	–	1.9	–	2.5	2.1	–	–	–	–	–	1.8	1.9	–	–	–	–
***Fusarium* spp. ***	**36.3**	**5.8**	**30.4**	**34.6**	**27.3**	**11.0**	**30.6**	**26.3**	**16.4**	**34.2**	**39.4**	**51.9**	**5.2**	**63.7**	**6.3**	**24.8**
Gliocladium catenulatum Gilman et Abbott	–	–	–	–	1.0	–	2.2	0.8	–	–	1.8	–	0.9	–	–	–
Gliocladium roseum (Link) Thom	–	–	3.4	1.2	–	–	–	–	–	2.4	–	–	–	–	0.9	–
Mortierella vinacea Dixon–Steward	–	–	–	1.0	–	–	–	–	–	–	–	1.0	–	–	–	–
Mucor mucedo (Linne) Brefeld	–	3.8	–	1.2	3.8	2.1	–	–	–	2.4	2.8	3.8	–	–	1.8	2.0
Mucor spp.	–	–	6.5	2.5	2.0	1.7	5.2	–	3.3	2.4	4.6	4.8	1.7	–	–	–
Myrothecium verrucaria (Albert. & Schweinitz) Ditmar	–	–	–	0.8	–	–	–	–	–	–	1.8	–	–	–	–	–
Penicillium spp.	27.2	38.5	19.6	13.6	13.2	35.1	9.0	15.3	10.9	12.2	6.4	11.5	11.2	27.3	22.1	5.9
Periconia macrospinosa Lefebvre & A.G. Johnson	–	–	0.2	–	–	–	0.5	–	–	–	2.8	–	–	–	–	–
Phoma spp.	–	5.1	1.7	–	3.5	–	4.5	1.7	1.1	–	2.8	4.8	1.7	–	2.7	–
Pyrenochaeta decipiens Marchal	–	–	–	–	–	–	–	0.2	–	–	0.9	–	–	–	–	–
Rhizoctonia sp.	–	–	–	–	–	0.7	–	–	–	–	–	–	1.7	–	–	–
Rhizopus nigricans Ehrenberg	–	–	1.1	4.9	3.8	2.2	3.0	–	2.2	–	0.9	–	0.9	–	2.7	–
Spicaria violacea Abbott	–	–	–	0.2	–	–	–	0.7	–	–	–	1.9	–	–	–	–
Torula spp.	–	–	–	–	–	–	–	1.0	–	–	–	4.8	–	–	–	–
Trichoderma spp. **	9.1	1.9	6.5	6.2	3.8	8.8	8.9	2.4	8.7	29.2	13.8	1.9	15.6	–	3.6	–
Zygorrhynchus sp.	9.1	–	–	–	–	0.7	–	0.8	–	–	0.9	–	0.9	–	–	–
Non sporulating fungi	–	5.8	–	–	3.8	–	2.2	6.8	2.2	–	–	–	3.4	–	1.8	2.0

**Fusarium* spp.: *Fusarium avenaceum* (Corda ex Fr.) Sacc., *Fusarium culmorum* (W. Gams Sm.) Sacc., *Fusarium equiseti* (Corda) Sacc., *Fusarium graminearum* Schwabe, *Fusarium oxysporum* Schlecht., *Fusarium poae* (Peck.) Wollenweber, *Fusarium solani* (Mart.) Sacc.

***Trichoderma* spp.: *Trichoderma album* Preuss, *Trichoderma hamatum* (Bon.) Bain, *Trichoderma harzianum* Rifai, *Trichoderma koningi* Oudemans, *Trichoderma viride* Pers. ex S.F. Gray

Table 3. The percent of grain with fungi – mean value from all years of the studies

Fungi	Wheat 1998–2001		Barley 1997–2000	
	O	C	O	C
Acremoniella fusca Kunze	0.2	–	0.3	–
Acremonium spp.	0.5	0.9	0.8	0.8
Alternaria alternata (Fr.) Keissler	34.5	39.6	57.5	66.4
Aspergillus niger van Tieghem	0.9	0.4	1.0	–
Aureobasidium pullulans (de Bary) Arnaud	0.9	0.2	–	0.45
Bipolaris sorokiniana (Sacc. in Sorok) Shoem.	0.7	0.3	26.4	16.0
Botrytis cinerea Pers. ex Fr.	0.7	1.5	0.4	3.5
Cladosporium herbarum (Pers.) Link ex Gray	5.0	4.9	2.0	8.0
Drechslera teres (Sacc.) Shoem.	–	–	0.7	0.4
Drechslera triseptata (Drechs.)	–	0.2	–	–
Drechslera tritici-repentis (Died.) Shoem.	0.5	–	–	–
Epicoccum nigrum Link	38.7	42.1	34.0	44.40
Fusarium avenaceum (Corda ex Fr.) Sacc.	8.7	6.9	11.0	10.5
Fusarium culmorum (W.G. Smith) Sacc.	1.2	0.9	0.9	1.8
Fusarium equiseti (Corda) Sacc.	–	0.2	–	0.5
Fusarium graminearum Schwabe	0.4	–	0.5	–
Fusarium poae (Peck.) Wollenweber	15.6	11.9	13.2	9.4
Total *Fusarium* spp.	25.9	19.9	25.6	22.2
Gonatobotrys simplex Corda	0.2	1.6	0.3	4.0
Mucor spp.	1.1	2.4	0.5	0.7
Nigrospora sphaerica (Sacc.) Mason	–	0.2	–	0.3
Papularia sphaerosperma (Person) von Höhnel	0.7	0.4	1.5	–
Penicillium spp.	5.9	1.6	4.4	0.5
Rhizopus nigricans Ehrenberg	1.1	0.5	0.6	4.3
Trichoderma koningi Oudemans	0.2	–	–	0.2
Trichoderma viride Pers. ex S.F. Gray	0.1	–	0.3	–
Non sporulating fungi	5.1	3.0	4.4	4.8
Total number of isolates in all years of the studies	2 235	2 467	2 570	2 799

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