University of Warmia and Mazury, Olsztyn, Poland

# FUNGAL COMMUNITIES COLONIZING GRAIN OF HULLED AND NAKED OAT GROWN UNDER ORGANIC FARMING SYSTEM

T.P. Kurowski and U. Wysocka

## Abstract

The grain of hulled oat cv. 'Chwat' and naked oat cv. 'Polar', grown in 2004–2006 under organic farming system was investigated to determine the species composition and abundance of fungi colonizing these grains.

A total of 697 fungal colonies from hulled oat and 536 from naked oat were isolated. *Alternaria alternata* dominated among the isolated colonies (21.3% and 33.5% of all isolates from hulled and naked oat, respectively). Fungi of the genus *Fusarium* accounted for 56.5% and 36.9% of all isolates, respectively, with the most abundant species *F. poae* and *F. solani* (only in 2004). Fungal colonies of the genus *Fusarium* were isolated more frequently from non-disinfected grains.

**Key words:** fungi, grains, hulled oat, naked oat, organic farming system

## Introduction

Oat is a cereal crop considered a valuable component of the crop rotation. Oat reduces the incidence of foot rot diseases, particularly in farms where cereal grains are grown in large quantities, which is why it holds an important position in organic cropping systems (Wenda-Piesik et al. 2000, Kuś and Jończyk 2003). Apart from traditional hulled oat cultivars, also naked oat has been grown in Poland for over 10 years. Due to its health-promoting properties and wide use as an animal feed component, naked oat may, to a certain degree, constitute a viable alternative to currently grown cereal crops (Szumiło and Rachoń 2006).

The aim of this study was to determine the species composition and abundance of fungi colonizing grains of hulled and naked oat grown under organic farming system.

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## Materials and methods

Laboratory experiment was carried out during the years 2004-2006. The grain of hulled oat cv. 'Chwat' and naked oat cv. 'Polar' was obtained from a field experiment established in Bałcyny near Ostróda, where oat was grown under organic farming system. According to the method by Narkiewicz-Jodko (1986), 100 well-developed grains and 100 small grains or with disease symptoms were randomly selected from each cultivar. Within each sample of 100 grains, 50 grains were rinsed in sterile water, dried on sterile filter paper and placed on PDA medium, and the remaining 50 grains were surface-disinfected for 30 s in 50% ethyl alcohol and for another 30 s in a 0.1% solution of sodium hypochlorite, rinsed three times in sterile water, dried on sterile filter paper and placed on PDA medium. Incubation was conducted in an incubator at approximately 20°C, for five–seven days. The fungal colonies that developed were transferred to PDA slants, and the cultures were identified based on the relevant keys.

## Results

A total of 1233 fungal colonies were isolated from oat grain, including 697 from hulled oat and 536 from naked oat (Tables 1, 2). *Alternaria alternata* dominated among the isolated colonies. This species accounted for 21.3% and 33.5% of all isolates from hulled and naked oat, respectively. Among the isolated fungal communities, a large group was formed by members of the *Fusarium* genus. These fungi accounted for 56.5% and 36.9% of all isolates from hulled and naked oat, respectively. The most abundant species of the above genus were *Fusarium poae* (18.8% of all isolates from hulled oat and 18.4% from naked oat) and *F. solani*, but only in 2004 (12.2% and 11.3%, respectively). Fungal colonies of *Fusarium* spp. were isolated more frequently from non-disinfected grains, compared with the disinfected ones (54.1% and 42.0%, respectively).

Other pathogenic fungi that colonized the grain of both oat forms were *Bipolaris sorokiniana* (3.6% of all isolates from hulled oat and 3.0% from naked oat), *Microdochium nivale* (4.1% and 1.2%, respectively) and *Cylindrocarpon destructans* (0.9% from both oats). These species were isolated more frequently from disinfected grains.

As regards saprotrophic fungi, the species *Epicoccum purpurascens* was isolated from the grain of both oat forms (2.4% of all isolates from hulled oat and 6.3% from naked oat). *Rhizopus nigricans* occurred abundantly, but only in 2006. This species was significantly more abundant on non-disinfected grains, in comparison with the disinfected ones.

**Table 1**

Fungi isolated from kernels of hulled oat

| Species of fungus | 2004 | | | | 2005 | | | | 2006 | | | | Sum | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | small grains | | well-developed | | small grains | | well-developed | | small grains | | well-developed | | | |
| | d | nd | d | nd | d | nd | d | nd | d | nd | d | nd | | |
| *Acremonium strictum* | – | – | – | – | – | 3 | – | – | – | – | – | – | 3 | 0.4 |
| *Alternaria alternata* | 2 | – | 10 | – | 12 | 2 | 24 | 31 | 17 | 21 | 17 | 12 | 148 | 21.3 |
| *Arthrinium phaeospermum* | – | – | – | – | – | 2 | – | – | – | – | – | – | 2 | 0.3 |
| *Bipolaris sorokiniana* | 2 | – | 5 | – | – | – | – | – | 8 | – | 10 | – | 25 | 3.6 |
| *Cladosporium cladosporioides* | – | – | – | – | – | – | – | – | – | – | 2 | – | 2 | 0.3 |
| *Cylindrocarpon destructans* | 2 | 3 | 1 | – | – | – | – | – | – | – | – | – | 6 | 0.9 |
| *Epicoccum purpurascens* | – | – | – | – | 1 | 3 | 2 | – | 1 | 3 | 2 | 5 | 17 | 2.4 |
| *Fusarium avenaceum* | – | 6 | – | 8 | 14 | 34 | 1 | – | – | 1 | – | – | 64 | 9.2 |
| *Fusarium culmorum* | – | – | 1 | – | 2 | – | – | – | 2 | 7 | 4 | 3 | 19 | 2.7 |
| *Fusarium equiseti* | – | 16 | – | 13 | – | – | – | 3 | – | 3 | – | 1 | 36 | 5.2 |
| *Fusarium poae* | 8 | 10 | 7 | 18 | 13 | 7 | 29 | 12 | 12 | 7 | 8 | – | 131 | 18.8 |
| *Fusarium sambucinum* | – | – | – | – | – | – | – | – | – | 1 | 1 | – | 2 | 0.3 |
| *Fusarium solani* | 24 | 23 | 18 | 20 | – | – | – | – | – | – | – | – | 85 | 12.2 |
| *Fusarium sporotrichioides* | – | – | – | – | – | – | – | – | – | 3 | – | – | 3 | 0.4 |
| *Fusarium tricinctum* | – | – | – | – | 6 | – | 28 | 20 | – | – | – | – | 54 | 7.7 |
| *Microdochium nivale* | 13 | 1 | 14 | 1 | – | – | – | – | – | – | – | – | 29 | 4.1 |
| *Mortierella* spp. | – | 2 | – | 1 | – | – | – | – | – | – | – | – | 3 | 0.4 |
| *Nigrospora oryzae* | – | – | – | – | – | – | – | – | – | – | 3 | – | 3 | 0.4 |
| *Rhizopus nigricans* | – | – | – | – | – | – | – | – | 7 | 8 | – | 30 | 45 | 6.5 |
| Non sporulating fungi | – | – | – | – | – | – | – | – | 3 | 8 | 6 | 3 | 20 | 2.9 |
| Total | 51 | 61 | 56 | 61 | 48 | 51 | 84 | 66 | 50 | 62 | 53 | 54 | 697 | 100.0 |

d – disinfected seeds, nd – not disinfected seeds.

**Table 2**

Fungi isolated from kernels of naked oat

| Species of fungus | 2004 | | | | 2005 | | | | 2006 | | | | Sum | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | small grains | | well-developed | | small grains | | well-developed | | small grains | | well-developed | | | |
| | d | nd | d | nd | d | nd | d | nd | d | nd | d | nd | | |
| *Acremoniella atra* | – | – | – | – | – | – | – | – | 1 | – | – | – | 1 | 0.2 |
| *Alternaria alternata* | 29 | – | 30 | – | 2 | – | 11 | 26 | 29 | 6 | 26 | 21 | 180 | 33.5 |
| *Arthrinium phaeospermum* | – | – | – | – | – | – | – | – | 1 | – | 3 | – | 4 | 0.7 |
| *Bipolaris sorokiniana* | 3 | – | 2 | – | – | – | – | – | 1 | – | 10 | – | 16 | 3.0 |
| *Cylindrocarpon destructans* | 2 | – | 1 | 2 | – | – | – | – | – | – | – | – | 5 | 0.9 |
| *Emericellopsis minima* | – | – | – | – | – | – | – | – | 1 | – | – | – | 1 | 0.2 |
| *Epicoccum purpurascens* | – | 2 | – | 1 | 7 | 2 | 2 | 3 | 6 | 4 | 4 | 3 | 34 | 6.3 |
| *Fusarium avenaceum* | – | 3 | – | 3 | – | – | 1 | – | – | – | – | – | 7 | 1.3 |
| *Fusarium culmorum* | – | 1 | – | – | – | – | – | – | 1 | – | – | – | 2 | 0.4 |
| *Fusarium equiseti* | – | 8 | – | 8 | – | 2 | 8 | – | – | – | – | – | 26 | 4.9 |
| *Fusarium poae* | – | 10 | 2 | 15 | 23 | 24 | 9 | 1 | 6 | – | 9 | – | 99 | 18.4 |
| *Fusarium solani* | 6 | 24 | 12 | 19 | – | – | – | – | – | – | – | – | 61 | 11.3 |
| *Fusarium* spp. | – | – | – | – | – | – | – | – | – | – | 1 | – | 1 | 0.2 |
| *Fusarium tricinctum* | – | – | – | – | – | 1 | – | – | – | – | – | – | 1 | 0.2 |
| *Fusarium verticillioides* | – | – | – | – | – | – | – | 1 | – | – | – | – | 1 | 0.2 |
| *Microdochium nivale* | – | – | 3 | 3 | – | – | – | – | – | – | – | – | 6 | 1.2 |
| *Mortierella* spp. | – | 5 | – | 5 | – | – | – | – | – | – | – | – | 10 | 1.9 |
| *Penicillium* spp. | – | – | – | – | – | – | – | – | – | – | 2 | – | 2 | 0.4 |
| *Rhizopus nigricans* | – | – | – | – | – | – | – | – | 6 | 41 | 4 | 25 | 76 | 14.2 |
| *Trichoderma polysporum* | – | – | – | – | – | – | – | – | 1 | – | – | – | 1 | 0.2 |
| Yeast-like fungi | – | – | – | – | – | – | – | – | – | – | 1 | – | 1 | 0.2 |
| Non sporulating fungi | – | – | – | – | – | – | – | – | 1 | – | – | – | 1 | 0.2 |
| Total | 40 | 53 | 50 | 56 | 32 | 29 | 31 | 31 | 54 | 51 | 60 | 49 | 536 | 100.0 |

d – disinfected seeds, nd – not disinfected seeds.

## Discussion

Among a total of 1233 fungal colonies, 57% were isolated from hulled oat kernels, while 43% – from naked oat kernels. Błaszkowski and Piech (2002) also isolated considerably more colonies from hulled oat grain. The predominant species was *A. alternata*, which was much more frequently isolated from naked oat. According to many authors, this species dominates among isolates obtained from grain of all cereal crops (Pandey 1978, Burgieł and Pisulewska 2003, Horoszkiewicz-Janka and Michalski 2006, Kowalczyk and Maciorowski 2006). *Alternaria alternata* is a typical cosmopolitan species, considered by some authors (Chełkowski and Grabarkiewicz-Szczęsna 1991, Baturo 2002) potentially dangerous due to the production of toxins which inhibit elongation of radicles and germs, and seedling development. However, this hypothesis was not confirmed by Burgieł and Pisulewska (2003).

Members of the genus *Fusarium* dominated among pathogenic fungi. Similarly to the remaining pathogens (*B. sorokiniana, M. nivale* and *C. destructans*), they occurred more abundantly on hulled oat kernels. Michalski and Horoszkiewicz-Janka (2003) reported similar results at first, but their later findings were quite opposite (Horoszkiewicz-Janka and Michalski 2006). The present results suggest that naked oat kernels are effectively protected against pathogens only by husks, which is why they are colonized by fewer fungal spores during harvest than hulled oat kernels. *Fusarium poae* was the predominant species of the genus *Fusarium*. *Fusarium solani* also occurred in great abundance, but in one year of the study only. *Fusarium avenaceum* and *F. culmorum* were isolated less frequently. Pathogenic fungi isolated most frequently from the grain of both oat forms were *F. culmorum, F. avenaceum* and *F. poae* in a study conducted by Horoszkiewicz-Janka and Michalski (2006), *F. culmorum* in an experiment performed by Burgieł and Pisulewska (2003), and *F. poae* in a study by Kowalczyk and Maciorowski (2006). According to literature data (Xu et al. 2005), *F. poae* is the main causal agent of Fusarium head blight of wheat in the United Kingdom and Ireland. As demonstrated by Parry and Nicholson (1996) and Bottalico and Perrone (2002), *F. poae* is generally not dangerous to cereals, but it represents a serious threat to human and animal health as a producer of mycotoxins. The high number of *F. solani* colonies isolated in the first year of the present experiment may seem surprising. However, Kwaśna et al. (1991) reported that this species has been isolated from small grains by numerous authors (Łacicowa and Orlikowski 1973, Chełkowski et al. 1985, Mańka et al. 1985).

*Bipolaris sorokiniana* was isolated from disinfected kernels only, which indicates that this dangerous pathogen must have colonized the inner tissues of the grains. According to published sources, *B. sorokiniana* poses a serious problem to organic farmers (Baturo 2007). The frequency of its occurrence increases if hot weather continues through May, followed by rain and cooling at the beginning of June (Agarwal and Sinclair 1997).

The high abundance of *R. nigricans* on oat kernels in the last year of the study could have resulted from a very high average temperature in July (22.5°C – data provided by the Meteorological Station in Bałcyny). This thermophilous species requires an optimum temperature of 25–26°C for growth and development (Domsch and Gams 1972).

## Conclusions

1. The grain of hulled oat were colonized by a larger number of fungi, including pathogens, compared with naked oat.
2. *Alternaria alternata* dominated on the kernels of both oat forms.
3. Members of the genus *Fusarium* constituted the largest group of pathogens (with predominant *F. poae*).
4. *Bipolaris sorokiniana* may pose a serious threat to organically grown oat.
5. Well-developed kernels were colonized by more fungal colonies than small and showing disease symptoms.


## Streszczenie

### ZBIOROWISKA GRZYBÓW ZASIEDLAJĄCYCH ZIARNO OWSA OPLEWIONEGO I NIEOPLEWIONEGO UPRAWIANEGO WEDŁUG ZASAD ROLNICTWA EKOLOGICZNEGO

Ziarno owsa oplewionego odmiany ‘Chwat’ i owsa nieoplewionego odmiany ‘Polar’ pochodziło z doświadczenia polowego zlokalizowanego w latach 2004–2006 w Bałcynach koło Ostródy, gdzie owies uprawiano w systemie ekologicznym. Celem badań było określenie składu gatunkowego i liczebności grzybów zasiedlających ziarniaki tych dwóch form owsa.

Z ziarna owsa oplewionego otrzymano 697 kultur grzybów, a z nieoplewionego 536 kultur. Wśród wyizolowanych kolonii dominował gatunek *Alternaria alternata* (odpowiednio 21,3 i 33,5%). Dużą grupę stanowiły grzyby rodzaju *Fusarium* (głównie *F. poae* i *F. solani*). Dominowały one wśród izolatów uzyskanych z ziarna owsa oplewionego (56,5% wszystkich wyosobnień), a z ziarna owsa nieoplewionego uzyskano ich 36,9%.


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**Authors'address:**
**Prof. Dr. hab. Tomasz P. Kurowski, Dr. Urszula Wysocka**, Department of Phytopathology and Entomology, University of Warmia and Mazury, ul. Prawocheńskiego 17, 10-720 Olsztyn, Poland, e-mail: kurowski@uwm.edu.pl

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