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MALTING BARLEY SEED HEALTH DEPENDING ON DIFFERENT FUNGICIDE TREATMENT

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S u m m a r y

Field studies were carried out in the 2004 – 2005 growing seasons. The mycological analysis of malting barley (varieties Prestige and Sezam) grains was performed twice: on seeds stored for 30 days and on seeds stored for five months. The influence of fungicide treatment on species diversity and the amount of fungal pathogens on kernels of both varieties of malting barley were determined in the studies. Main fungal pathogens of both varieties of malting barley were field fungal species, such as: Alternaria *alternata, Epicocum purpurascens*, and fungi of the genus Fusarium. The extension of the grain storage period to five months resulted in an increased share of pathogenic species.

Key words: malting barley, grain, storing, fungi

INTRODUCTION

In recent years new technologies have been introduced in cereal growing, designed to create optimal conditions for plant growth and development. Adequate protection against diseases in the growing period enables the production of full-value grain suitable for further technological processing and for animal feed purposes. Cereal grains are colonised by many microorganisms, mainly bacteria and fungi. They are initially infected by the so-called "field fungi" which can be saprotrophs or pathogens. Popular field fungi include the following: *Alternaria alternata, Epicoccum purpurascens, Fusarium* spp. An important pathogenic species often found on barley grains is the fungus Bipolaris sorokiniana, the culprit of cereal seedling and root canker (K n u d s e n et al. 1995). But on stored seeds, the so-called "storage fungi" develop, belonging to the genus *Aspergillus, Penicillium* or from the family Mucoraceae (C h r i s t e n s e n , 1972). Grain infection reduces the vigour, restricts germination and is the cause of yield reduction (Š a r i ć et al. 1997). It affects the quality of malt, changes its colour and decreases the taste value. It results from negative changes in the composition of proteins found in the grain. Malting barley grain showing symptoms of strong infection by fungal pathogens cannot be used in the brewing industry; it is only used as animal feed (M a t h r e , 1997). Fungi colonising cereal grains can synthesise numerous secondary metabolites whose presence may be harmful to humans and animals (M u n k v o l d , 2003). Toxic fungal metabolites exhibit cancerogenic, cytogenic, embryogenic, teratogenic and mutagenic effects (P i ę t a , 1997).

The aim of the study was to determine the effect of different intensities of disease protection during the growing period on the health of two varieties of malting barley grain determined after up to 30 days from the harvest and after a 5-month storage period in a floor-storage grain store.

MATERIALS AND METHODS

The study material was malting barley (*Hordeum vulgare* L.) grains, varieties Prestige and Sezam, obtained from a strict field experiment carried out at the Agricultural Experimental Station in Bałcyny near the city of Ostróda. 7 methods of barley protection (with different intensity) were used and compared to the untreated control:

Object	A	B	C	D	E	F	G	H
					Dubelt J			
Seed dressing BBCH 00	–	–	Alert	Acanto + Unix	Corbel	Cerelux P	Corbel	Corbel
1st treatment BBCH 31								
2nd treatment BBCH 42					Amistar	Amistar ½	Amistar	Alert + Cerone
3rd treatment BBCH 72	–	–	–	–	–	–	Artea	–

Doses of preparations were compliant with the recommendations of the Polish Institute of Plant Protection; they were applied at 200 $dm^{-3} \times ha^{-1}$ of water, following good experimental practice. The active substance included: tebuconazol + triozoxid (Dubelt J), flusilazole and carbendazim (Alert 375 SC), picoxystrobin (Acanto 250 SC), fenpropimorph (Corbel 750 EC), flusilazole and fenpropimorph (Cerelux Plus), azoxystrobin (Amistar 250 SC), propiconazole and cyproconazole (Artea 330 EC), ethephon (Cerone 480 SL). For weed control, the herbicide Mustang 306 SE was used (s.a. – florasulam + 2,4 D).

Malting barley was grown on medium grey-brown podzolic soil, belonging to the 3rd agricultural usefulness complex. Sowing was carried out as early as possible, at a spacing of about 370 caryopses per 1 m^2. 45 kg P_20_5, 85 kg K_2O and 40 kg N were applied before sowing.

Mycological examination was performed on two dates:

1) – up to 30 days after the harvest,

2) – five months after the harvest.

The analysis was made using the method designed by N a r k i e w i c z - J o d k o (1991). The grain from the 2004 and 2005 harvest used for analysis was stored in a grain store of the Production and Experimental Facility in Bałcyny, in jute bags.

The pattern of thermal and soil moisture conditions in 2004 was favourable for barley growing. A wet spring guaranteed good water supply for plants at the tillering and shooting stages. But the total rainfall during maturation in July was lower than the long-term mean (Tab. 1). The year 2005 was definitely too dry, and this was the case throughout the whole critical period. The water shortage was alleviated as late as July.

RESULTS

Following the harvest, 3485 cultures of fungi belonging to 40 species were isolated from the grain of malting barley var. Prestige, in both years of study. The number of isolates in the years of study was different. 21.8% more fungal cultures were obtained in 2005 than in 2004. But no significant differences were found in the species composition (29 and 28 species in the respective years). The species *Alternaria alternate* was isolated in the greatest number, accounting for 45.88% of the total colony (Tab. 2). Other fungi colonising the grain in a great number included *Epicoccum purpurascens* (10.78%), *Mucor hiemalis* (5.67%) as well as fungi of the genus *Fusarium* (30.38%), being typical pathogens. Among fungi of the genus *Fusarium, F. equiseti* (544 col.), *F. oxysporum* (183 col.) and *F. poae* (93 col.) were predominant. Among other pathogenic fungi, the species *Bipolaris sorokiniana* (130 col.– 3.73%) accounted for a large share of the total number of isolates. *Botrytis cinerea* was isolated sporadically.

Barley grains in the combination E, in which two foliar fungicide treatments were applied, were infected most slightly by fungi. Fungi potentially pathogenic to cereals: + *Bipolaris sorokiniana, Botrytis cinerea, Cylindrocarpon destructans* and representatives of the genus *Fusarium*, accounted for 28.8% (2004) and 31.3% (2005) in this combination.

After a 5-month storage period, an increase in the number of isolated fungi was observed (Tab. 3). 3679 colonies were obtained, belonging to 36 species. Among these fungi, the species *Alternaria alternata* was isolated most frequently, accounting for 43% of the total number of isolates. *Cylindrocarpon destructans* was also isolated in a great number (9.8%). The ge-

Table 1
Pattern of weather conditions in growing periods in years 2004-2005 (data according to the Meteorological Station in Tomaszkowo).

Study period	march	april	may	june	july	august
Daily mean temperature (ºC)						
2004	3	8.9	11.8	15.3	17	19.2
2005	-3.1	8.2	11.6	14.2	19.7	16.9
Long-term mean (1991-2000)	1.2	6.6	12.4	15.7	16.9	16.5
Suma opadów (mm) – Precipitation total (mm)						
2004	28.2	51.5	87.1	90.6	78.8	41.9
2005	29.3	22	68.2	35.4	83.9	39.6
Long-term mean (1991-2000)	27.4	35.2	56.7	68.3	81.3	57.1

nus *Fusarium* was represented by 13 species, among which *F. graminearum*, *F. equiseti* and *F. oxysporum* dominated. After the 5-month storage period, a slight increase in the number of *Epicoccum purpurascens* and a marked decline in the number of fungi of the family *Mucoraceae*, included in typical storage fungi, were observed.

Grains from the control combination were most strongly infected by fungi after the two-month storage period, and grains from the combination D and G, in which foliar fungicide treatment was applied, were infected in the slightest degree. However, in both these trial objects pathogenic species: *Bipolaris sorokiniana, Botrytis cinerea, Cylindrocarpon destructans*, and fungi of the genus *Fusarium* accounted for over 50% of all isolates.

3260 cultures of fungi belonging to 44 species were isolated from the grain of malting barley var. Sezam (Tab. 4) after the harvest. The so-called "field fungi", belonging to the following species: *Alternaria alternata* (45.0%), *Fusarium* spp. (29.7%), *Epicoccum purpurascens* (10.2%) and *Bipolaris sorokiniana* (6.5%), were isolated in the greatest number. Typical "storage fungi" accounted for 5.0%, and they were represented by the genera *Mucor* and *Rhizopus*. Among fungi of the genus *Fusarium*, the species F. *equiseti* and F. poae were predominant.

The smallest number of fungi was isolated from barley grains obtained from the control (untreated) and the combination G with full chemical protection in the form of seed dressing and three foliar treatments with the fungicides Corbel, Amistar and Artea. The smallest percentage share of pathogenic fungi was noted on barley grains obtained from the trial object B (only seed dressing) and in the first year of study from grains obtained from the combination G.

Potentially pathogenic fungi were represented most numerously in these combinations by *Fusarium equiseti* and *Bipolaris sorokiniana*. The species A*lternaria alternata* and *Epicoccum purpurascens* dominated in all the combinations.

Out of the storage fungi, *Mucor hiemalis* as well as single cultures of *Mucor circinelloides* and *Mucor racemosus* were isolated quite frequently.

After the 5-month period of storage of barley grain, the number of fungi colonising it did not change significantly, but the percentage shares of particular species changed. A total of 3232 fungal cultures were isolated (33 species) (Tab. 5). A marked increase, by as much as 10%, was found in the number of fungi of the genus *Fusarium* (from 29.7% up to 39.1%). They were represented by 15 species, among which *Fusarium equiseti*, *F. avenaceum, F. oxysporum* were predominant. The number of *Epicoccum purpurascens* cultures increased. But a significant decline in the number of *Alternaria alternata* colonies (from 45.0% down to 36.8%) and of fungi of the family Mucoraceae was noted; *Bipolaris sorokiniana* was also isolated less frequently.

Barley grains from the trial object B, in which only seed dressing was applied, were colonised by fungi in the greatest number. 474 fungal cultures from 21 species were isolated. Among them, pathogenic fungi accounted for 42% in 2004 and 20% in 2005, mainly of the genus *Fusarium* and *Bipolaris sorokiniana.* The least number of fungal cultures was isolated from grains obtained from the plots on which full threefold protection was applied (trial object G). 344 cultures belonging to 15 species were obtained. Among them, fungi potentially pathogenic to cereals dominated, in particular from the genus Fusarium, and they accounted for 50% in 2004 and up to 85% in 2005. A similar increase in the number of pathogenic fungi was observed in the trial object E where the fungicides Corbel and Amistar were applied.

Table 2
Fungi isolated from grains of spring barley, variety Prestige, 30 days after harvest.

Fungal species	30 days after harvest																Suma Total
	A		B		C		D		E		F		G		H		
	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	
Acremoniella atra (Corda) Sacc.	4		2						2								8
Acremonium strictum W. Gams					3												3
Alternaria alternata (Fr.) Keissl.	55	98	85	142	103	132	92	112	64	106	98	106	91	112	85	118	1599
Arthrinium phaeospermum (Corda) M.B. Ellis			3						2								5
Arthrinium sphaerospermum Fuckel		2		4							1					2	9
Aspergillus niger Tiegh.				2								2		2			6
Aspergillus sp.															1		1
Aureobasidium bolleyi (R. Sprague) Arx							1	4					2	2			9
Bipolaris sorokiniana (Sacc.) Shoemaker	18	6	8	10	10	6	6	6	14	2	13	4	5	12	8	2	130
Botrytis cinerea Pers.								4							4		8
Chaetomium globosum Kunze	5	2				2											9
Cladosporium cladosporioides (Fresen.) G.A. de Vries		8											1				9
Cladosporium herbarum (Pers.) Link		2															2
Cladosporium macrocarpum Preuss	1																1
Epicoccum purpurascens Ehrenb.	41	14	27	2	18	4	59	16	26		30	6	38	26	59	10	376
Fusarium avenaceum (Fr.) Sacc.	5		13		18		4	2					5		9	2	58
Fusarium chlamydosporum Wollenw. & Reinking	2					2							1		1		6
Fusarium culmorum (W. G. Sm.) Sacc.		2	1	2			28				3		1		41		78
Fusarium equiseti (Corda) Sacc.	8	48	2	96		62	2	68	1	58	1	68	6	58	2	64	544
Fusarium graminearum Schwabe							1										1

cd. table 2

Fusarium oxysporum Schltdl.	35		31		60		3		22				30		2		183
*Fusarium poae (*Peck) Wollenw.			2	2	2	2			1		76	2	3		3		93
Fusarium solani (Mart.) Sacc.							2										2
Fusarium sporotrichioides Sherb.				22						4		8		4		8	46
Fusarium tricinctum (Corda) Sacc.					2		5				1		1		1		10
Fusarium spp.			9			2	3	2	2		2		4		1		25
Gliomastix murrorum (Corda) S. Hughes						2						2		2			6
Gonatobotrys simplex Corda									1				4				5
Graphium spp.														2			2
Humicola fuscoatra Traaen														2			2
Microdochium nivale (Fr.) Samuels & I.C. Hallett	1		1		4		4								3		13
Monodyctis glauca (Cooke et Harkn.) Hughes.									3								3
Monodyctis levis (Wiltsh.) Hughes.																2	2
Mucor hiemalis Wehmer		22				40		6		34		24		46		24	196
Penicillium sp.									1								1
Periconia macrospinosa Lefebvre & Aar.G. Johnson					3		1										4
Rhizopus nigricans Ehrenb.			1			2							1			4	8
Scopulariopsis brevicualis (Sacc.) Bainier		2		2				2									6
Trichoderma hamatum (Bonord.) Bainier		2		2				4									8
non sporulating fungi		4						2						2			8
number of isolates	**175**	**212**	**185**	**286**	**223**	**256**	**211**	**228**	**139**	**204**	**225**	**222**	**193**	**270**	**220**	**236**	
number of isolates from trials	**387**		**471**		**479**		**439**		**343**		**447**		**463**		**456**		**3485**

Table 3
Fungi isolated from grains of winter barley, variety Prestige, 5 months after harvest.

Fungal species	5 month after harvest																Suma Total
	A		B		C		D		E		F		G		H		
	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	
Acremoniella atra (Corda) Sacc.	1		3														4
Acremonium roseolum (G. Sm.) W. Gams	2																2
Acremonium strictum W. Gams	3		1						3								7
Alternaria alternata (Fr.) Keissl.	117	125	93	133	77	130	70	109	94	112	24	124	69	114	91	104	1586
Arthrinium sphaerospermum Fuckel								1					2				3
Aureobasidium bolleyi (R. Sprague) Arx											5				1		6
Bipolaris sorokiniana (Sacc.) Shoemaker	12	7	10	12	11	4	8	2	13	10	2	6	8	5	4	4	118
Botrytis cinerea Pers.	1	1	4														6
Cladosporium cladosporioides (Fresen.) G. A. de Vries	2		1		14		2		6		5		18		7		55
Cylindrocarpon destructans (Zinssm.) Scholten	65		71		65		13		59		20		18		51		362
Epicoccum purpurascens Ehrenb.	1	50	0	35	6	35	56	46	2	41	1	31	33	46	9	38	430
Fusarium avenaceum (Fr.) Sacc.			1				2	1	3		3	5	5				20
Fusarium cerealis (Cooke) Sacc.					2						1						3
Fusarium concolor Reinking			3		2		1		1		3						10
Fusarium culmorum (W. G. Sm.) Sacc.	9		2		11	6	5		4		13		6	2	3		61
Fusarium equiseti (Corda) Sacc.		16		11		7		28		28		29		8		26	153
Fusarium fusarioides (Gonz. Frag. & Cif.) C. Booth	3		2	7		1	1				2	7					23
Fusarium graminearum Schwabe	102		62		82		3		63		49		3		61		425
Fusarium oxysporum Schltdl.	1		4		4		7		8		45		20	2	5	1	97

cd. table 3

Fusarium poae (Peck) Wollenw.						1				1		1		5	3			11
Fusarium sporotrichioides Sherb.							2				1							3
Fusarium spp.	2		3		1		4	1	4		26		3		9			53
Fusarium tricinctum (Corda) Sacc.	1	7	2	10	1	29	2	14		7	3	18	2	6	7	13		122
Gelasinospora reticulispora (Greis et Greis Dengler) C. et M. Moreau								1						1				2
Gonatobotrys simplex Corda			2															2
Humicola fuscoatra Traaen											1							1
Humicola grisea Traaen	1																	1
Microdochium nivale (Fr.) Samuels & I. C. Hallett	4		5		7		11		8		1		7	1	4			48
Minimedusa polyspora (J. W. Hotson) Weresub & P. M. LeClair					1													1
Monodyctis glauca (Cooke et Harkn.) Hughes.													1					1
Mortierella alpina Peyronel	4		7															11
Mortierella spp.	4		5		10													19
Mucor hiemalis Wehmer													2					2
Mucor spp.									2									2
Periconia macrospinosa Lefebvre & Aar. G. Johnson											1							1
Rhizopus nigricans Ehrenb.			2				2		2					4	6	7		23
non sporulating fungi				**1**	**1**								**1**		**2**			**5**
number of isolates	**335**	**206**	**283**	**209**	**295**	**213**	**189**	**203**	**272**	**199**	**206**	**221**	**198**	**194**	**263**	**193**		
number of isolates from trials	**541**		**492**		**508**		**392**		**471**		**427**		**392**		**456**			**3679**

Table 4
Fungi isolated from grains of winter barley, variety Sezam, 30 days after harvest.

Fungal species	30 days after harvest																Suma Total
	A		B		C		D		E		F		G		H		
	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	
Acremoniella atra (Corda) Sacc.									1								1
Acremonium strictum W. Gams			5														5
Alternaria alternata (Fr.) Keissl.	81	66	121	110	104	84	138	92	51	88	79	108	91	80	77	100	1470
Arthrinium sphaero-spermum Fuckel						4			1								5
Aureobasidium bolleyi (R. Sprague) Arx		2	3	4		4		2		2						2	19
Aureobasidium pul-lulans (de Bary) G. Arnaud									2								2
Bipolaris sorokiniana (Sacc.) Shoemaker	18	12	5	10	23	18	7	14	26	8	15	10	9	30	2	4	211
Botrytis cinerea Pers.			1									2					3
Chaetomium globosum Kunze			1						4								5
Cladosporium clado-sporioides (Fresen.) G. A. de Vries		2	3	2						2		2				2	13
Cladosporium macrocarpum Preuss			5														5
Epicoccum purpurascens Ehrenb.	34	10	26	12	48		22	14	42	8			68		41	8	333
Fusarium avenaceum (Fr.) Sacc.	6		6		3	4			7	2	17	2			9		56
Fusarium cerealis (Cooke) Sacc.					3												3
Fusarium chlamydosporum Wollenw. & Reinking	3								1		3						7
Fusarium culmorum (W. G. Sm.) Sacc.	1		1		43								19				64
Fusarium equiseti (Corda) Sacc.	7	52	1	42		50		62	1	70	70	64	7	42	9	80	557
Fusarium graminearum Schwabe			3						5						2		10
Fusarium oxysporum Schltdl.	20		3		2				24				9		6		64
*Fusarium poae (*Peck*)* Wollenw.			20		3		41		13		9	2	2	2	44		136
Fusarium semitectum Berk. & Ravenel							1										1
Fusarium solani (Mart.) Sacc.					1												1
Fusarium sporotrichioides Sherb.				4		8										14	26

cd. table 4

Fusarium tricinctum (Corda) Sacc.	5		2		2				1	2		2			1	2	17
Fusarium spp.	1		4		3	2			4						1		15
Gelasinospora reticulispora (Greis et Greis Dengler) C.et M. Moreau									3								3
Gliocladium penicillioides Corda				2													2
Gliomastix murrorum (Corda) S. Hughes	1			2													3
Gonatobotrys simplex Corda									1								1
Humicola fuscoatra Traaen				2													2
Humicola grisea Traaen									4								4
Microdochium nivale (Fr.) Samuels & I. C. Hallett	5		1				1		2				1				10
Monodyctis glauca (Cooke et Harkn.) Hughes.			3						4		1				1		9
Monodyctis levis (Wiltsh.) Hughes.									3								3
Mucor circinelloides (Cooke et Harkn.) Hughes.									5				1				6
Mucor hiemalis Wehmer		16		22		16		28	3	14		26	2	30	1	8	166
Mucor racemosus Fresen.							1										1
Periconia macrospinosa Lefebvre & Aar. G. Johnson											4						4
Rhizopus nigricans Ehrenb.								2									2
Scopulariopsis brevicualis (Sacc.) Bainier												2					2
Scopulariopsis brumptii Salv.-Duval				2		2											4
Trichoderma hamatum (Bonord.) Bainier						2											2
Trichoderma polysporum (Link) Rifai			1														1
Trichoderma viride Schumach.			1														1
non sporulating fungi						2						2			1		5
number of isolates	**182**	**160**	**216**	**214**	**235**	**196**	**211**	**214**	**208**	**196**	**198**	**222**	**209**	**184**	**195**	**220**	
number of isolates from trials	**342**		**430**		**431**		**425**		**404**		**420**		**393**		**415**		**3260**

Table 5
Fungi isolated from grains of winter barley, variety Sezam, 5 months after harvest.

Fungal species	5 month after harvest																Suma Total
	A		B		C		D		E		F		G		H		
	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	
Acremoniella atra (Corda) Sacc.	1		1														2
Alternaria alternata (Fr.) Keissl.	81	117	73	135	88	116	88	92	70		59	59	40		81	91	1190
Arthrinium sphaerospermum Fuckel												1					1
Aureobasidium bolleyi (R. Sprague) Arx					1				6				1		2		10
Bipolaris sorokiniana (Sacc.) Shoemaker	14	2	13	2	7	2	8	4	11	3	9	1	7	3	4	17	107
Botrytis cinerea Pers.		1						4		1		5		2			13
Cylindrocarpon destructans (Zinssm.) Scholten	6		2		22		10		12		12		14		10		88
Epicoccum purpurascens Ehrenb.	26	21	80	20	20	38	19	33	24	32	35	45	30	30	17	40	510
Fusarium avenaceum (Fr.) Sacc.	14		16		31		67		28	3	55	16	22		57	1	310
Fusarium cerealis (Cooke) Sacc.			4								5						9
Fusarium chlamydosporum Wollenw. & Reinking			2														2
Fusarium concolor Reinking										4							4
Fusarium culmorum (W. G. Sm.) Sacc.		5	9	7	1	21		29		24		5		22	1	4	128
Fusarium equiseti (Corda) Sacc.	18	45	5	23	13	15	3	23	2	126	4	65	6	137	7	41	533
Fusarium fusarioides (Gonz. Frag. & Cif.) C. Booth		1						4		1		12		2			20
Fusarium graminearum Schwabe			1										2				3
Fusarium oxysporum Schltdl.	43	3	56	6	4	8	1	10	5	8		9	11	4	6	6	180
Fusarium poae (Peck) Wollenw.				1								5		1		1	8
Fusarium semitectum Berk. & Ravenel				1													1
Fusarium sporotrichioides Sherb.									2								2
Fusarium spp.	2		1				3				1	3					10
Fusarium tricinctum (Corda) Sacc.	1		5		2		1		7		1				1	1	19
Gliocladium virens J. H. Mill., Giddens & A. A. Foster												1					1

cd. table 5

Gonatobotrys simplex Corda			2						2								4
Humicola grisea Traaen									2				5		1		8
Microdochium nivale (Fr.) Samuels & I.C. Hallett	3		4		4		4		8		4		5		3		35
Monodyctis glauca (Cooke et Harkn.) Hughes.	11										1				1		13
Mortierella spp.	1		3														4
Mucor hiemalis Wehmer									2								2
Mucor racemosus Fresen.					2				1								3
Periconia macrospinosa Lefebvre & Aar.G. Johnson	3		1														4
Rhizopus nigricans Ehrenb.				1			2		1			1				2	7
Zygorhynchus heterogamus (Vuill.) Vuill.											1						1
number of isolates	**224**	**195**	**278**	**196**	**195**	**200**	**206**	**199**	**183**	**202**	**187**	**228**	**143**	**201**	**191**	**204**	
number of isolates from trials	**419**		**474**		**395**		**405**		**385**		**415**		**344**		**395**		**3232**

DISCUSSION

The investigated grain of malting barley, var. Sezam and Prestige, was colonised after the harvest by typical "field" fungi: *Alternaria alternata*, *Epicoccum purpurascens* and representatives of the genus *Fusarium*. In literature, we find reports on the common occurrence of these fungi on cereal grains and seeds of many plants (Narkiewicz-Jodko, 1986; Majchrzak, 1998; Parry et al. 1995). In own study, the species *Alternaria alternata* was the most frequently isolated fungus, accounting for from 36% up to 45% of total isolates. *Alternaria alternata* is a facultative parasite which synthesises toxic metabolites: alternariol (AOH), alternariol methyl ether (AME), altenuene (ALT), altertoxin I, II and III (ATX-I, – II, and – III), tenuazonic acid (TeA) (Li et al. 2001; Scott 2001). Toxic metabolites produced by this species may inhibit the growth of cereal shoots, as well as they exhibit a toxic effect on cells of mammals (Narkiewicz-Jodko, 1986; Silvana da Mottia and Soares, 2000; Watanabe et al. 2007). The harmfulness of fungal toxins from the genus *Alternaria* is related to their very common occurrence in the environment, primarily on affected grains and fruit (Watanabe et al. 2007). As reported by Brazauskienė, storage of grain at a temperature of 25°C for a period of 6-8 months reduces seed infection by *Alternaria* spp. by 50% (Brazauskienė et al. 2006). But the lowering of storage temperature does not reduce the level of infection by fungi belonging to this genus, since they are tolerant to low temperatures (Majchrzak, 1998). Therefore, seed infection by fungi of the genus *Alternaria* can be of great significance in regions characterised by a cool climate (Smith et al. 1988).

In our study, fungi of the genus *Fusarium* were also isolated in a great number. They belong to widely distributed plant pathogens inducing many plant diseases and producing a number of phytotoxic compounds (Brown et al. 2006; Niessen, 2007). *Fusarium equiseti* was the species which occurred most numerously on malting barley grains. As reported by Aigbe and Fawole (1999), this fungus occurs most frequently in regions characterised by a warm climate, though its presence has been observed on grains of cereals grown in the former USSR countries as well as in Norway and France (Marasas et al. 1987, Morrison et al. 2002, Ioos et al. 2004). In Poland the sporadic occurrence of this species on barley grains has been described by Perkowski et al. (1997). According to many researchers, this fungus is not included in the *Fusarium* complex inducing ear fusariosis (Logrieco et al. 2003), but it may cause root diseases, decay of tubers, fruit and seeds of different plants, including cereals (Aigbe and Fawole 1999; Demirci and Dane 2003; Fedel-Moen and Harris, 1987). F. equiseti synthesises numerous secondary metabolites of different toxicity, among others, trichotecens A and B, butenolide, equisetin, zearalenon and fusarochromanone (Morrison et al. 2002).

In our study, the greatest number of fungi of the genus *Fusarium* was found after the application of ½ of a dose of Amistar (azoxystrobin) used at the stage

BBCH 42. Magan et al. (2002) have found that low doses of azoxystrobin may stimulate the production of mycotoxins both in *in vitro* conditions and on wheat grains.

Other authors have reported that the application of triadimenol doses sublethal to *Fusarium graminearum* resulted in increased production of DON and zearalennon (Ramirez et al. 2004). In the opinion of Ramirez et al. (2004), the application of chemical treatment partially reduces the incidence of typically toxinogenic fungi.

Among potentially pathogenic species, *Bipolaris sorokiniana, Botrytis cinerea* and *Cylindrocarpon destructans* were isolated. They are known polyphags affecting many plants. According to Łacicowa et al. (1990, 1992), barley is susceptible to infection by Bipolaris sorokiniana at each growth stage. Grain yield losses as a result of damage caused by this pathogen may reach 30%. The occurrence of *Botrytis cinerea*, a fungus which is rarely mentioned as a cereal pathogen, on barley is also worth noting. However, in the opinion of the same authors, this species, as an occasional pathogen, is sometimes one of the causes of stem base diseases of barley (Łacicowa et al. 1990, 1992). According to Michalski and Horoszkiewicz (2003), many pathogens are transferred with plant seeds.

CONCLUSIONS

1. Grains of both studied varieties of malting barley were colonised by typical field fungi, such as: *Alternaria alternata, Epicoccum purpurascens*, and fungi of the genus Fusarium.
2. Among fungi potentially pathogenic to cereals, *Fusarium equiseti, F. avenaceum, F. oxysporum* and *Bipolaris sorokiniana* were isolated in the greatest number.
3. Grains of malting barley var. Prestige were colonised by fungi more numerously.
4. After the 5-month storage period, more pathogenic fungi, mainly of the genus *Fusarium*, were isolated from barley grains. Among these fungi, the species *F. equiseti* accounted for the largest percentage share on stored grains.
5. The largest number of fungi of the genus *Fusarium* was isolated from both malting barley varieties from the trial objects on which ½ of azoxystrobin dose was applied (trial object F).
6. Fungi of the genus *Fusarium* occurred least frequently on malting barley grains in the combination G (Dubelt + Corbel + Amistar + Artea).
7. The application of the fungicide Amistar (azoxystrobin) reduced most strongly the occurrence of the species *Alternaria alternate*; this species occurred on grains from the plants obtained from the combination B (Dubelt J).

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Stan zdrowotny ziarna jęczmienia browarnego w zależności od sposobu ochrony przed chorobami

Streszczenie

Badania polowe prowadzono w latach 2004-2005. Analizę mikologiczną nasion jęczmienia browarnego Prestige i Sezam wykonywano 2 krotnie: na ziarnie przechowywanym przez 30 dni oraz na ziarnie przechowywanym przez okres pięciu miesięcy. W badaniach stwierdzono wpływ ochrony fungicydowej na skład gatunkowy i liczebność grzybów zasiedlających ziarno obu odmian jęczmienia browarnego. Ziarno obydwu odmian jęczmienia browarnego zasiedlone było przede wszystkim przez gatunki grzybów polowych: *Alternaria alternata, Epicoccum purpurascens* oraz grzyby z rodzaju *Fusarium*. Wydłużenie okresu przechowywania ziarna do 5 miesięcy spowodowało wzrost udziału gatunków patogenicznych.