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THE EFFECT OF FUNGICIDE SEED TREATMENT ON THE PRODUCTIVITY AND HEALTH OF HUSKED OAT GRAIN*

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K e y w o r d s: oat, photosynthesis, transpiration, fungal infections, correlation, protein fractions.

A b s t r a c t

The experiment investigated the effect of Raxil 060 FS fungicide treatment on the yield, photosynthesis and transpiration rates, and the health status of husked oat grain cv. Flämingsstern. The results indicate that Raxil 060 FS had a beneficial influence on the total oat grain yield and selected yield components. Gas exchange parameters (photosynthesis and molar transpiration) were not affected by the experimental factor in the first year of the study, whereas in the second year tebuconazole was found to exert a positive effect on the analyzed parameters. Raxil 060 FS contributed to a decrease in the abundance of *Fusarium* spp. on oat grain, but it had varying effects on the remaining fungal species. Fungicide seed treatment had no significant influence on the content of the analyzed protein fractions.

WPŁYW ZAPRAWY FUNGICYDOWEJ NA PRODUKTYWNOŚĆ I ZDROWOTNOŚĆ ZIARNA OWSA OPLEWIONEGO

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S ł o w a k l u c z o w e: owies, fotosynteza, transpiracja, porażenie grzybami, korelacja, frakcje białek.

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A b s t r a k t

W doświadczeniu badano wpływ zaprawy fungicydowej Raxil 060 FS na plon ziarna, intensywność fotosyntezy i transpiracji oraz zdrowotność ziarna owsa oplewionego odmiany Flämingsstern. W badaniach wykazano korzystny wpływu zaprawy Raxil 060 FS na plon ziarna owsa i niektóre elementy struktury plonu. Wskaźniki wymiany gazowej (fotosynteza i transpiracja molowa) pod wpływem badanego czynnika nie uległy zróżnicowaniu w pierwszym roku badań. W drugim roku eksperymentu wykazano natomiast korzystny wpływ tebukonazolu na badane parametry wymiany gazowej. Zaprawa nasienna Raxil 060 FS wpłynęła na obniżenie liczebności *Fusarium* spp. na ziarnie owsa, nie stwierdzono zaś jednoznacznego wpływu zaprawy w przypadku pozostałych gatunków grzybów. Nie wykazano wyraźnego zróżnicowania w zawartości frakcji białek pod wpływem badanego czynnika.

Introduction

Owing to its chemical composition, oat grain has a high dietary value and health-promoting properties. Oat grain contains proteins with balanced amino acid levels, high concentrations of unsaturated fatty acids, water-soluble beta-glucans and antioxidants (BARTNIKOWSKA et al. 2003). Cereal grains intended for human consumption should be characterized by high quality and be free from pathogens that cause contamination and produce mycotoxins, thus posing a health risk for humans and animals (MIELNICZUK 2001).

According to ZAWIŚLAK and ADAMIAK (1998), oat is a cereal crop with relatively low fungicide requirements, while JAŃCZAK (1999) demonstrated that seed dressing is recommended as an effective protective measure against pathogens colonizing seeds and the soil environment. KORBAS and KUBIAK (2000) also reported that seed dressing is an important consideration in spring cereals due to the high rates of seedling infections responsible for yield decrease. According to ROŻEK and WNUK (1994), plant protection products have a minor phytotoxic effect on crops, and they significantly inhibit disease incidence and maximize seed yield.

The following research problems were formulated in the present study: is seed dressing treatment justified? What is the effect of seed dressing treatment on the productivity and health of oat grain? The objective of this study was to determine the effect of the seed dressing fungicide Raxil 060 FS on the yield, yield components, selected gas exchange parameters, health status and the content of protein fractions in husked oat grain cv. Flämingsstern.

Materials and Methods

A large-area experiment was carried out at the Production and Experimental Station in Bałcyny (NE Poland) in 2005 and 2006. The experimental

material consisted of husked oat grain cv. Flämingsstern. The investigated parameters were determined in four replications per each treatment with an area of 20 m^2. The seeds were divided into two groups:

1. seeds treated with the fungicide Raxil 060 FS (tebuconazole)
2. untreated seeds.

The scope of the study was as follows:

1. Determination of the key biometric parameters of oat plants (plant height, number of grains per panicle, TGW) and grain yield per hectare at 15% moisture content.

2. Determination of gas exchange parameters.

Gas exchange parameters were determined using a LI-COR 6400 portable gas analyzer. The studied indicators (photosynthesis and molar transpiration rates) were determined at a fixed CO_2 concentration of 400 ppm and light intensity of 1000 μmol m^{-2} s^{-1}. The photon source was a LED Light Source lamp emitting light with the main peak spectrum at 670 nm and the second peak at 465 nm. Measurements were carried out at the following growth stages: I – at the stem elongation stage, II – beginning of heading stage, III – at the flowering stage (at the highest, fully developed leaf). The noted values were registered, the measurements were carried out in five replications, and the presented results contain average values.

3. Determination of the health status of oat grain by traditional methods.

The harvested oat grain was subjected by a mycological analysis using the artificial culture method. A phytopathological evaluation by the artificial culture method was carried out on 100 randomly selected kernels which were rinsed with water and surface disinfected with 70% ethanol and 1% sodium oxochlorate. The kernels were placed on Petri dishes with solidified PDA. The cultures were incubated for 7–10 days at a temperature of 20–24°C. Fragments of the emerged mycelia were transferred onto PDA slants. The fungi colonizing oat kernels were identified to genus and species by traditional microscopic observation, based on the available monographs (ELLIS 1971, GILMAN 1957, KWAŚNA et al. 1991).

4. Determining the content of protein fractions in oat grain.

A 3 g seed sampled was ground in the IKA A10 (Labortechnik) analytical mill, and the resulting particles were passed through a sieve with 400 μm mesh size (particles smaller than 250 μm ether had a 90% share). The solvent was evaporated, 100 mg of the powdered seeds was placed in Eppendorf test tubes, and three protein fractions were extracted according to the method proposed by WIESER et al. (1998):

1. albumins + globulins – 1 cm^3 of the mixture (0.4 mol/L NaCl + 0.067 mol/L $HKNaPO_4$ with pH of 7.6) was extracted in two replications;

2. prolamin – 1 cm^3 of the mixture (60% ethanol) was extracted in three replications;

3. glutelins – 1 cm^3 of the mixture (50% propanol-1 + 2 mol/L urea + 0.05 mol/L Tris HCl with pH of 7.5) was extracted with 1% DTE under nitrogen, in two replications.

The first two protein fractions were extracted at room temperature using the Eppendorf thermomixer (10-minute extraction). Glutelins were extracted in the thermomixer at 60°C. After each extraction, proteins were centrifuged at 11000 x *g*. The collected fractions were freeze-dried, dissolved in 2 cm^3 of the corresponding phase (1–3), purified using the Spartan-3NY 0.45 μm filter and transferred to glass vials. Protein fractions were identified using the Hewlett Packard Agilent 1050 HPLC with the following parameters: RP-18 Vydac 218TPP54 column, 5 μm, 250 x 4,6 mm, Zorbax 3000SB-C18 precolumn, 4.6 x 12.5 mm, column temperature – 45°C, mobile phase flow rate – 1 ml/min, injection volume – 20 μl. The separation was performed using a two-component gradient. Share of component A: 0 min 75%, 5 min 65%, 10 min 50%, 17 min 25%, 18 min 15%, 19 min 75% (the first component, *A*, was water with the addition of 0.1% TFA, the second component, *B*, was ACN with the addition of 0.1% TFA). A HP detector was applied at a wavelength of 210 nm. The results were analyzed using the Hewlett Packard HPLC 3D Chem Station application. Protein fraction analyses were carried out at the Department of Plant Raw Materials Processing and Chemistry, Faculty of Food Sciences at the University of Warmia and Mazury in Olsztyn.

5. Statistical analysis

The results were processed statistically in STATISTICA software, version 6 (StatSoft, Inc. 2003), using an analysis of variance. Differences between means were determined at a significance level of $p = 0.05$ for grain yield and biometric parameters, and at $p = 0\ 01$ for photosynthesis and molar transpiration rates. The mean values of the investigated parameters were classified into uniform groups with the use of Fisher's test.

Results and Discussion

A significantly higher oat grain yield was noted in the treatment where seeds were dressed with the fungicide Raxil 060 FS (Table 1). The harvested grain was marked by high TGW and a higher number of grains per panicle (Table 1). The use of tebuconazole had no significant effect on plant height.

ŚWIDERSKA-OSTAPIAK and STANKOWSKI (2006) found that the seed dressing fungicides Sarfun 500 SC (carbendazim) and Dithane 75 WG (mancozeb) had an insignificant influence on oat yield, compared with the control treatment. The difference in yield levels between both treatments was small, at 1 dt ha^{-1}, which suggests that oat did not respond to seed dressing. The cited authors

Table 1

Selected biometric parameters of husked oat (means of 2005–2006)

Cultivar	Treatment	Plant height [cm]	Number of seeds per panicle	Thousand seeds weight [g]	Seeds yield [t ha^{-1}]
Flämingsstern	seeds dressed	79.6^{a}	56.5^{b}	36.4^{b}	5.6^{b}
	seeds undressed	80.5^{a}	41.1^{a}	31.5^{a}	5.1^{a}

Homogeneous groups *a, ab, b*, according Fisher's LSD test

also demonstrated that yield components were not affected by fungicide seed treatment. In a study by SZUMIŁO and RACHOŃ (2006), the applied protection levels had no significant effect on oat grain yield, although intensive chemical protection contributed to a 9.2% increase in productivity. The above authors also reported that intensive plant protection measures caused a significant increase in panicle density regardless of cultivar, whereas different levels of chemical protection had a minor effect (within the limits of statistical error) on the number and weight of grains per panicle and TGW.

Apart from the significant impact of seed dressing with tebuconazole on the total oat yield and yield components, the results of this study point also to positive correlations between yield and the number of grains per panicle (correlation coefficient $R = 0.58$) – Figure 1a, between yield and plant height ($R = 0.38$) – Figure 1b, and between plant height and the number of grains per panicle ($R = 0.39$) – Figure 1c.

The applied fungicide did not affect the studied gas exchange parameters in the first year of the study (Table 2). In the second year, Raxil 060 FS caused a significant increase in photosynthesis and transpiration rates at the stem elongation stage and at the beginning of heading (Table 3). PSZCZÓŁKOWSKA (2008) and OLSZEWSKI (2004) who investigated the response to fungicides in winter wheat cv. Kris at various growth stages and in faba bean grown under field and greenhouse conditions, respectively, observed no significant effect of plant protection chemicals on gas exchange parameters in the studied crops.

No significant correlations between the rate of photosynthesis and oat yield were observed in the present study (Figure 1d). As demonstrated by PALA (2002), high photosynthetic efficiency is not always accompanied by high yield potential. Such relationships have been shown for potatoes, soybeans and wheat (PALA 2002). In this experiment, there was a negative correlation between molar transpiration and oat yield (Figure 1e). A higher yield was obtained from plants characterized by a lower rate of transpiration, and a lower yield – from plants with high transpiration efficiency.

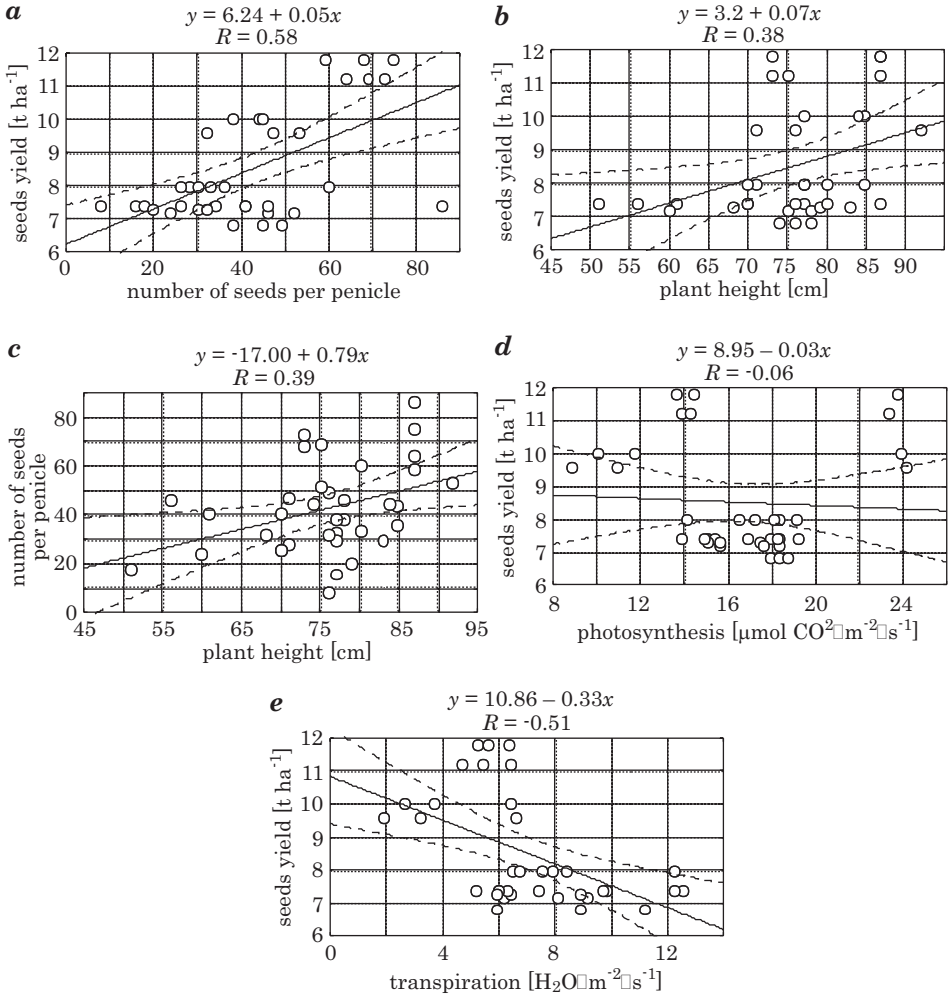

Fig. 1. Linear regresion betwen: *a* – seeds yield and number of seeds per penicle; *b* – seeds yield and plant height; *c* – number of seeds per penicle and plant height; *d* – seeds yield and photosynthesis; *e* – seeds yield and transpiration

Table 2

Gas exchange parameters of husked oat in 2005

Cultivar	Treatment	Photosynthesis (μmol $CO_2 m^{-2} s^{-1}$)			Transpiration (mmol $H_2O m^{-2} s^{-1}$)		
		I	II	III	I	II	III
Flämingssterm	Seeds dressed	17.95^A	15.62^A	16.57^A	6.02^A	10.00^A	6.85^A
	Seeds undressed	16.95^A	17.25^A	17.55^A	6.57^A	11.12^A	8.22^A

I – measurement of gas exchange parameters at the stem elongation stage; II – measurement of gas exchange parameters beginning of heading stage; III – measurement of gas exchange parameters at the flowering stage

Table 3

Gas exchange parameters of husked oat in 2006

Cultivar	Treatment	Photosynthesis (μmol $CO_2m^{-2}s^{-1}$)			Transpiration (mmol $H_2Om^{-2}s^{-1}$)		
		I	II	III	I	II	III
Flämingssterm	Seeds dressed	13.95^A	14.05^A	23.65^A	5.52^A	5.26^A	6.46^A
	Seeds undressed	11.30^B	10.38^B	24.00^A	3.45^B	2.87^B	6.41^A

I – measurement of gas exchange parameters at the stem elongation stage; II – measurement of gas exchange parameters beginning of heading stage; III – measurement of gas exchange parameters at the flowering stage

Oat grain samples from both treatments were characterized by similar fungicide infection levels (Table 4 and Table 5). The predominant species was *Alternaria alternata*, whereas toxin-producing fungi of the genus *Fusarium* were represented by single isolates of *Fusarium poae* and *Fusarium avenaceum*. It should be stressed that oat grain harvested in the treatment where seeds were dressed with fungicide showed a lower degree of colonization by *Fusarium* spp. (Table 4 and Table 5). MIELNICZUK (2001) and KIECANA et al. (2005) also reported the presence of *Fusarium avenaceum* and *Fusarium poae* on oat grain. KIECANA et al. (2005) found that *Fusarium poae* greatly contributed to fusariosis on oat panicles and grain infection. According to JAŃCZAK (1999), KORBAS and KUBIAK (2000), seed dressing fungicides effectively protect seedlings against pathogens colonizing seeds and the soil environment. In a study by BURGIEŁ and PISULEWSKA (2003), the predominant fungal species on oat kernels were *Alternaria alternata*, *Epicoccum purpurascens*, *Penicillium* spp. and *Fusarium culmorum*.

Table 4

Number of fungal isolates in husked oat seeds cv. Flämingssterm in 2005

Fungal specied	Seeds dressed	Seeds undressed
Species of the genus *Fusarium*		
Fusarium avenaceum (Fr.) Sacc.	1	1
Fusarium poae (Peck) Wollenw.	–	2
Total	1	3
Other fungal species		
Alternaria alternata Keissler Nees	42	44
Cladosporium cladosporioides (Fres) de Vries	–	3
Drechslera sorokiniana (Sacc.) Subram. and Jain	1	–
Epicoccum purpurascens Ehrenberg	16	11
Penicillium ssp.	1	1
Total	60	59
Total isolated fungi	61	62

Table 5

Number of fungal isolates in husked oat seeds cv. Flämingssterm in 2006

Fungal specied	Seeds dressed	Seeds undressed
Species of the genus *Fusarium*		
Fusarium avenaceum (Fr.) Sacc.	–	3
Fusarium poae (Peck) Wollenw.	1	1
Fusarium spp.	–	1
Total	1	3
Other fungal species		
Alternaria alternata Keissler Nees	42	45
Cladosporium cladosporioides (Fres) de Vries	2	4
Bipolaris sorokiniana (Sacc.) Shoemaker	2	5
Epicoccum purpurascens Ehrenberg	16	10
Penicillium ssp.	4	1
Total	66	65
Total isolated fungi	67	70

As demonstrated by the results of this experiment, fungicide treatment had no significant effect on the content of the investigated protein fractions (albumins+globulins, prolamin and glutelins) in control and experimental oat grain samples (Table 6).

Table 6

Content of protein fractions in of husked oat seeds cv. Flämingssterm (calculated as mAU·s)

Treatment	Albumins +globulins	Prolamins	Glutelins
Seeds undressed	34 075	17 910	12 844
Seeds dressed	33 268	17 722	13 596

Conclusions

1. Raxil 060 FS had a beneficial influence on the total oat grain yield and selected yield components.

2. Gas exchange parameters were not affected by the experimental factor in the first year of the study, whereas in the second year tebuconazole was found to exert a positive effect on the analyzed parameters.

3. Raxil 060 FS contributed to a decrease in the abundance of *Fusarium* spp. on oat grain, but it had varying effects on the remaining fungal species.

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References

BARTNIKOWSKA E. 2003. *Przetwory z ziarna owsa jako źródło ważnych substancji prozdrowotnych w żywieniu człowieka*. Biul. IHAR, 229: 235–245.

BURGIEŁ Z., PISULEWSKA E. 2003. *Grzyby zasiedlające ziarno owsa nagonasiennego*. Biul. IHAR, 229: 205–210.

ELLIS M.B. 1971. *Dematiaceous Hyphomycetes*. Commonwealth Mycological Institute Kew, Surrey, England.

GILMAN J.C. 1957. *A manual of soil fungi*. The Iowa State University, Ames USA.

JAŃCZAK C. 1999. *Zaprawianie ziarna – konieczne w ochronie zbóż jarych*. Plon, 11: 6.

KIECANA I., MIELNICZUK E., PERKOWSKI J., GOLIŃSKI P. 2005. *Infection of panicles with Fusarium poae* (*Peck*) *Wollenw. and mycotoxin content in oat grain*. Acta Agrobot., 59(2): 91–102.

KORBAS M., KUBIAK K. 2000. *Ochronić ziarno siewne*. Top Agrar Polska, 1: 44–45.

KWAŚNA H., CHEŁKOWSKI J., ZAJKOWSKI P. 1991. *Grzyby*. Tom XXII. (*Flora Polska*). PAN Instytut Botaniki, Warszawa-Kraków.

MIELNICZUK E. 2001. *The occurrence of Fusarium on panicles oat* (*Avena sativa L.*). J. Plant Protection Research, 41(2): 173–180.

OLSZEWSKI J. 2004. *Wpływ wybranych stresów abiotycznych i biotycznych na intensywność fotosyntezy i transpiracji, plonowanie oraz zdrowotność bobiku i grochu siewnego*. Rozprawy i Monografie, 85. Wydawnictwo UWM, Olsztyn, 109.

PALA J. 2002. *Genetyczne, fizjologiczno-biochemiczne i ekologiczne uwarunkowania plonowania roślin*. [W:] *Fizjologia plonowania roślin*. Red. R.J. Górecki, S. Grzesiuk. Wydawnictwo Uniwersytetu Warmińsko-Mazurskiego, Olsztyn, 27–73.

PSZCZÓŁKOWSKA A. 2008. *Diagnostyka patogenów grzybowych metodą PCR i tradycyjną oraz produktywność pszenicy ozimej* (*Triticum aestivum* L.) w warunkach zróżnicowanej ochrony fungicydowej. Rozprawy i monografie, 140, UWM Olsztyn.

ROŻEK S., WNUK A. 1994. *Wpływ wybranych pestycydów na zawartość niektórych składników w nasionach i w kiełkach dwóch odmian bobiku*. Acta Agraria et Silvestria, 32: 75–83.

SZUMIŁO G., RACHOŃ L. 2006. *Porównanie plonowania i jakości owsa nagoziarnistego i oplewionego w warunkach zróżnicowanej ochrony chemicznej*. Biul. IHAR, 239: 85–92.

ŚWIDERSKA-OSTAPIAK M., STANKOWSKI S. 2006. *Wpływ ilości wysiewu i zaprawiania ziarna na plon i komponenty plonu owsa nagoziarnistego i oplewionego*. Biul. IHAR, 239: 93–102.

WIESER H., ANTES S., SEILMEIER W. 1998. *Quantitative determination of gluten protein types in wheat flour by reversed-phase high-performance liquid chromatography*. Cerael Chem., 75(5): 644–650.

ZAWIŚLAK K., ADAMIAK E. 1998. *Płodozmian i pestycydy jako czynniki integrowanej uprawy owsa*. Acta Acad. Agricult. Tech. Olst. Agricultura, 66: 131–142.