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CORRELATION BETWEEN MALTING QUALITY OF BARLEY CULTIVARS AND DEVELOPMENT OF FLOUR MITE (*ACARUS SIRO* L.)

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Key words: *Acarus siro*, malting barley, malting quality.

Abstract

Among the factors which disqualify barley grain from being used for malting purposes is damage caused by grain and flour insect pests, as well as presence of live or dead grain and flour pests, including various species of mites. The aim of the study has been to find out whether grain of malting barley cultivars is a suitable habitat for the development of flour mite. The authors also tried to establish the correlation between the development of flour mite and the malting quality of several barley cultivars. The experiment has demonstrated that crushed grain of malting barley cultivars is a suitable habitat for the development of flour mite. By knowing the correlation coefficient for the malting quality of a given barley cultivar, it is possible to specify the suitability of its grain for the development of flour mite, although the specification thus obtained must be viewed in the aspect of grain fragmentation. The content of protein in finely ground grain (F1) did not affect the development of flour mite. In a combination with the grain ground to fraction F2, higher contribution of protein resulted in depressed abundance of the flour mite's offspring population. It seems possible that not all protein substances of barley grain are available to flour mite.

KORELACJA MIĘDZY WARTOŚCIĄ BROWARNĄ ODMIAN JĘCZMIENIA A ROZWOJEM ROZKRUSZKA MĄCZNEGO (*ACARUS SIRO* L.)

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Słowa kluczowe: *Acarus siro*, jęczmień browarny, wartość browarna.

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Abstrakt

Jedną z głównych cech dyskwalifikujących ziarno jęczmienia na cele browarne są uszkodzenia przez szkodniki zbożowe i mączne oraz obecność żywych lub martwych szkodników zbożowo-mącznych, w tym również różnych gatunków roztoczy. Celem badań było ustalenie, czy ziarno browarnych odmian jęczmienia jest siedliskiem, w którym może rozwijać się rozkruszek mączny. Podjęto również próbę ustalenia korelacji między rozwojem badanego gatunku roztocza a wartością browarną odmian jęczmienia. Stwierdzono, że rozdrobnione ziarno browarnych odmian jęczmienia jest dobrym siedliskiem do rozwoju *A. siro*. Dzięki znajomości współczynnika wartości browarnej można opisać jakość siedliska dla rozwoju rozkruszka mącznego, ale tylko w kontekście czynnika, jakim jest stopień rozdrobnienia ziarna. Zawartość białka w ziarnie silnie rozdrobnionym (F1) nie wpłynęła na rozwój rozkruszka mącznego. W ziarnie rozdrobnionym do frakcji F2 stwierdzono, że wyższa zawartość tego składnika powodowała spadek liczebności populacji potomnej badanego gatunku roztocza. Prawdopodobnie nie wszystkie substancje białkowe ziarna są przyswajalne przez *A. siro*.

Introduction

Barley is one of the first cereal crops used for human consumption. At present barley is the fourth cereal, after wheat, maize and rice, in terms of the total cultivation area and yields. In Poland, barley makes up 12% of the cereals sown, which means that average annual barley yields reach 3.3 million tons. Barley grain is used for production of groats, bran and extract flour. But most of the barley grain produced (70-80% of the yield) is used for farm animals' consumption. However, barley is still irreplaceable as raw produce to make malt, which is used in brewing, sugar, fermentation, pharmaceutical and other industries (PECIO 2002). Barley grain used for brewing must meet certain technological requirements, which in terms of their values and range are specified by a synthetic index known as malting quality (MQI). This index is expressed on a 9-point scale. When assessing grain quality for brewing purposes malters consider for example grain uniformity (minimum value of 85%), impurities (up to 6%, including up to 1% of kernel-foreign grain), moisture content (up to 16%), protein content (maximum 85%), germination energy (minimum 92%) and cultivar uniformity (minimum 85%). One of the parameters which disqualify barley grain from further brewing is damage caused by grain and four pests or presence of live or dead grain and flour pests, including various species of mites. Flour mite is one of the most noxious mites foraging on stored cereal grains and grain products (NIETUPSKI, CIEPIELEWSKA 2005). There are may difficulties with reducing its number in storehouses (IGNATOWICZ 1996). Its presence is favoured by high moisture level of grain, infestation by other storage pests and mechanical damage which can occur during grain harvest, transport and storage.

The aim of this study has been to find whether the grain of malting barley cultivars is a suitable habitat for development of flour mite. Another objective

has been to establish if there is some correlation between the development of flour mite and the malting quality of several barley cultivars.

Material and Methods

Material

The experiment focused on the development of flour mite on grain of several malting barely cultivars. The material for the tests comprised seeds of eleven barley cultivars: Granal, Sezam, Binal, Barke, Blask, Scarlett, Annabell, Gwarek, Brenda, Stratus and Refren. The grain was harvested in 2003 and 2004 at the Experimental Station in Wrocikowo near Olsztyn. The above barely cultivars were selected for the tests because they could be used in brewing industry, which was demonstrated by their synthetic malting quality index (MQI) described by Research Centre For Cultivar Testing in Slupia Wielka (Table 1).

Table 1

Some factors defining the malting suitability of the barley cultivars and the parameters of flour mite's populations

Cultivar	Malting quality*	Protein content (% d.m.)*	Grain resistance index (GRI)		Number of flour mite's offsprings		
			F1**	F2***	F1	F2	mean
Granal	8.30	11.6	14.38	12.42	74.70	31.80	53.25^{a****}
Sezam	8.10	11.9	18.08	14.80	227.00	84.90	155.95^{d}
Binal	8.00	11.8	15.81	12.14	114.90	38.15	67.15^{ab}
Barke	8.00	11.7	17.01	13.58	164.40	58.80	111.6^{c}
Brenda	7.90	11.5	15.49	13.64	104.40	59.80	82.1^{abc}
Blask	7.70	11.3	15.93	15.35	118.90	100.10	109.5^{c}
Scarlett	7.45	11.3	17.48	9.63	189.50	18.00	103.75^{bc}
Annabell	7.40	10.9	16.22	13.49	129.70	57.30	93.5^{bc}
Gwarek	7.15	11.7	18.69	13.75	272.40	61.90	167.15^{d}
Refren	7.15	11.7	16.33	13.06	134.10	47.30	90.7^{abc}
Stratus	6.55	11.1	18.47	13.15	255.00	51.60	153.3^{d}
Control	–	15.0	17.10	10.72	168.60	24.90	96.75^{bc}
Mean					162.8^{b}	51.32^{a}	

* according to COBORU 2004, ** grain fraction (F < 1 mm), *** grain fraction (2,2 mm < F < 3,15 mm), **** means marked with the same letter do not differ statistically (Student's test)

The development of flour mite was observed on barley grain ground to two fractions. The fractions (F) used for the experiment were sieved through mesh of:

$$F^* < 1.0 \text{ mm (F1)}$$
$$2.2. \text{ mm} < F < 3.15 \text{ mm (F2)}$$

F* – size of the barley grain fraction analysed

The control combination consisted of cv Mewa wheat grain. The grain for the tests was ground at the Chair of Food Plant Processing and Chemistry of the University of Warmia and Mazury in Olsztyn.

Methods

Acarological observations

Whole and ground barley grains were placed in glass breeding chambers size 3 x 2 cm and 6 mm in thickness, with a drilled conical hole. The entry hole diameter was 8 mm, and the exit hole was 3 mm in diameter. The cone was filled with a sample of barley grain mass examined, on which 16 adult individuals of flour mite were placed. The mites originated from maternal populations bred at the Chair of Phytopathology and Entomology, the UWM Olsztyn. The experiment was established in 10 replications and was conducted under controlled conditions, in a Protherm HS – 2/M climatic chamber, at constant temperature of 20°C and relative air humidity of 75%.

In order to assess whether the barley cultivars tested were suitable for the foraging by flour mite, the grain resistance index (GRI):

$$GRI = (\log_n F1 \cdot 100\%) / D,$$

F1 – number of offspring, D – time of the offspring's development (days)

The results were subjected to analysis of variance. The estimation of the differences between the means was performed on real data, using *t*-Student's test. The correlation coefficient was calculated between the abundance of the offspring generation of flour mite, and the malting value index and protein content in barley grain.

Results and Discussion

The observations revealed that the grain of the eleven malting barley cultivars was a suitable habitat for the development of flour mite. This was

evidenced by the high value of grain resistance index (GRI) derived for the barley cultivars, depending on a grain fraction (Table 1). Analysis of variance showed that the experimental factors analysed as well as their mutual interactions had highly significant influence ($p = 0.05$) on the development of flour mite populations.

Development of flour mite on the fractions of barley grain

Barley kernels can suffer mechanical damage during grain harvest, transport and storage. Uniform mass of grain can contain kernels with split hulls or broken kernels. Such grain is likely to be settled by secondary storage pest insects. In the present experiment we examined the development of flour mite on barley grain with damaged hull or broken kernels (fraction F2; 2.2 mm < 2.2 f < 3.15 mm) and on dust obtained as overtails from a sieve with a mesh size less than 1 mm (F1). The most favourable conditions for the development of flour mite occurred on flour and finely ground cereal grain (BOCZEK, DAVIES 1998, THIND, CLARKE 2001). Similar results were obtained in our investigations. Flour mite developed more numerous populations on finely ground barley grain (F1) – Table 1. The analysis of the population abundance on finely ground barley kernels suggests that this type of habitat is as attractive for flour mite as wheat grain of a comparable size fraction. The grain of four barley cultivars (Scarllett, Sezam, Stratus and Gwarek) proved to be even more attractive for flour mite than the control combination. A change in the conditions under which flour mite developed, caused by increasing the granulation of grain (F2), resulted in highly significant changes in the numbers of the flour mite's offspring (Table 1). Flour mite developing on F2 grain produced less abundant offspring generations than on F1 grain. Although the abundance of offspring populations decreased significantly, the flour mite continued to develop, which means that any small damage appearing during the grain transport or storage could be a chance for flour mite to grow. This risk is even higher in the case barley grain. Out of the eleven barley cultivars tested, ten proved to create more suitable conditions for the development of flour mite than the control wheat grain.

Malting quality of the barley cultivars versus the development of flour mite

Brewing industry makes use of barley grain which maintains certain parameters, specified by the malting quality index (MQI), which is expressed

on a 9-point scale (COBORU 2004). Among the 11 barley cultivars examined, 7 qualify as yielding grain suitable for brewing purposes, that is their values of MQI were higher than 7.4 (Table 1). The present experiment involved a comparison of the development of flour mite on barley grain characterised by different malting quality. It was found out that the malting quality index and its value could be helpful in assessing the suitability of grain as a habitat for the development of flour mite, but only in conjunction with the degree of grain fragmentation. The analysis of correlation and regression between the experimental factors revealed the relationship described by the correlation coefficient at r = -0.45. Finely ground grain (F1) created the best conditions for the development of flour mite on the barley grain representing the lowest malting quality value (cv. Gwarek, Stratus) – Figure 1a. The grain of such cultivars as Granal, Binal and Barke, which are willingly used for production of malt, proved to be the least favourable habitat for the development of flour mite. A reverse correlation, however, was observed when analysing the relationships between the abundance of populations produced by flour mite and the malting quality index of barley grain in the combinations with flour mite foraging on coarser grain fraction (F2). The correlation coefficient there attained a positive value (r = 0.35), which implied a tendency for higher malting quality grain to create better conditions for flour mite (Figure 1b).

One of the essential parameters affecting the malting quality of barley grain is the protein content (GARCIA DEL MORAL et al. 1998, PECIO 2002, BERNE 2005). Ground and broken kernels are more readily settled by flour mite, as it is easier for the pest to access nutrients. The results of our tests show that the correlation between the protein content in grain and the abundance of the flour mite's populations depended on the degree of grain fragmentation. Finely ground barley grain (F1) created very good conditions for flour mite. Easy access to nutrients that the foraging mites had found eliminated any larger differences in the number of offspring individuals from each combination, even though the grain differed in the protein content (Figure 2a). Higher granulation of grain (F2) as a habitat for the development of flour mite revealed the effect of protein content on the development of mites. Unexpectedly, the analysis of correlation and regression showed that for the combination with higher protein content in barley grain the abundance of the flour mite's offspring population was lower (Figure 2b). This perhaps could be explained through analysis of chemical composition of barley grain proteins. It is possible that not all protein substances in cereal grain are absorbable by phytophages (WARCHALEWSKI et al. 2002).

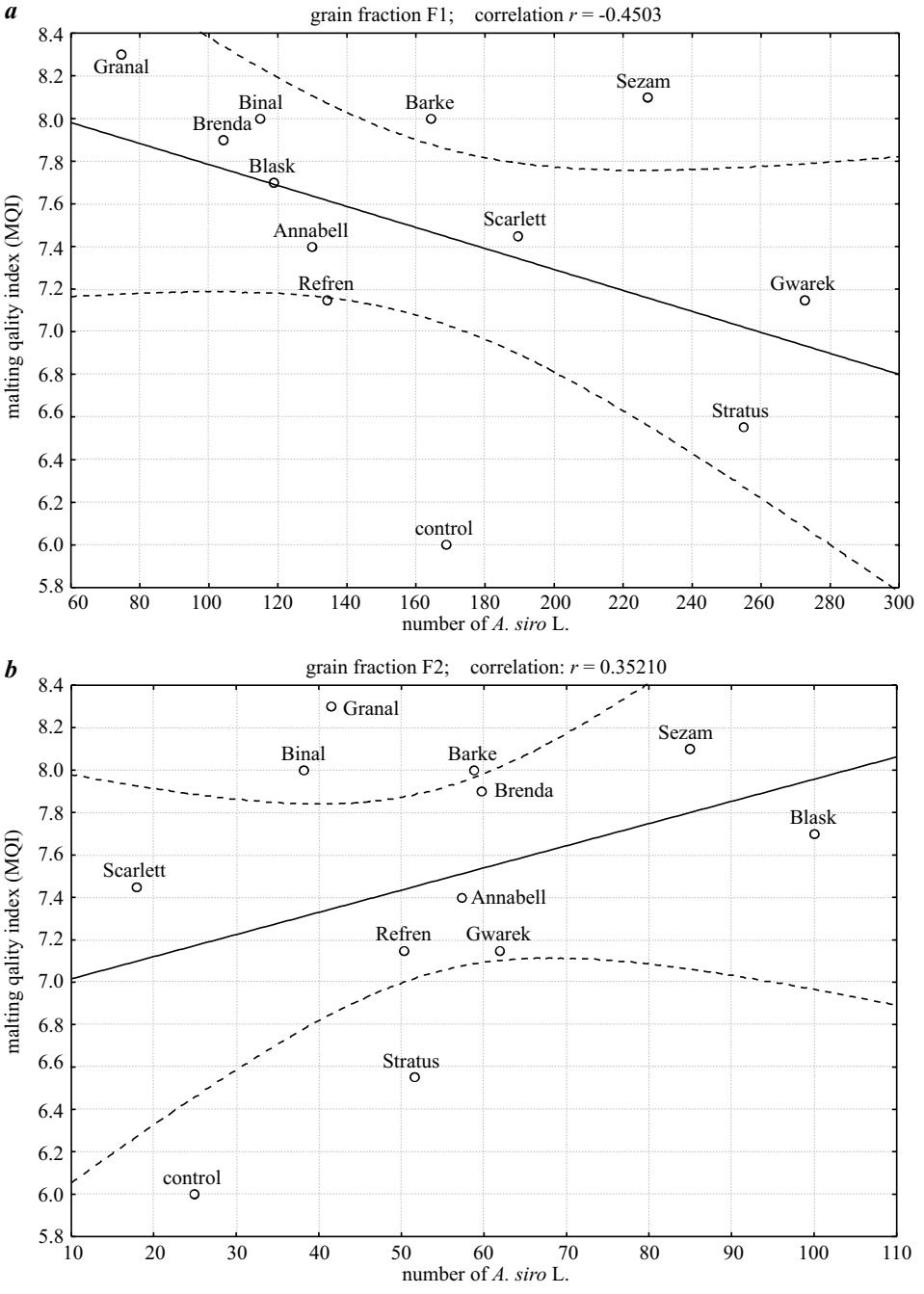
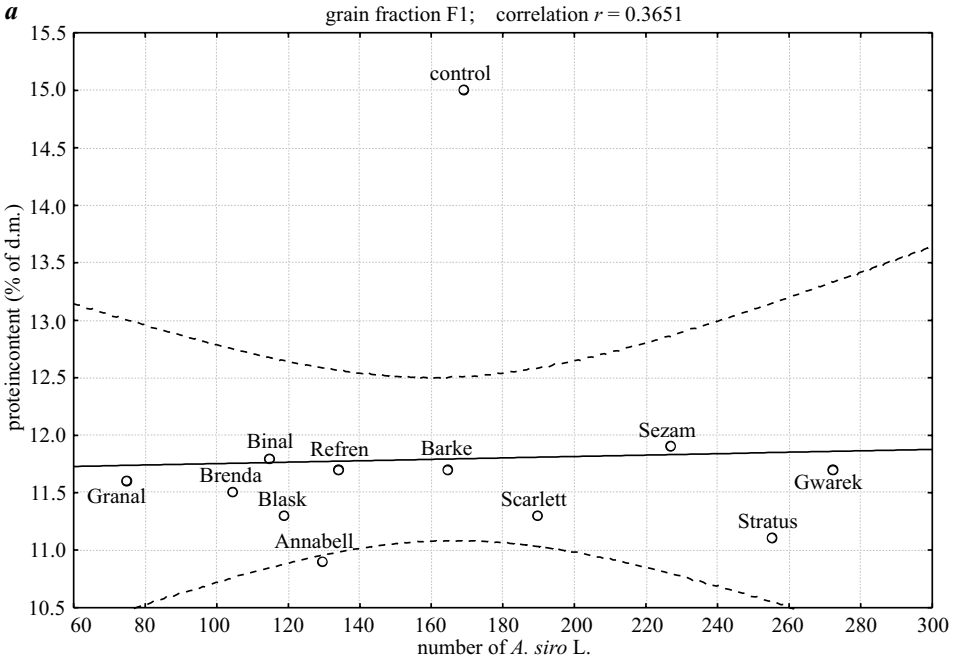


Fig. 1. Correlation between the malting quality index (MQI) for the grain of the eleven barley cultivars examined and the abundance of flour mite offsprings



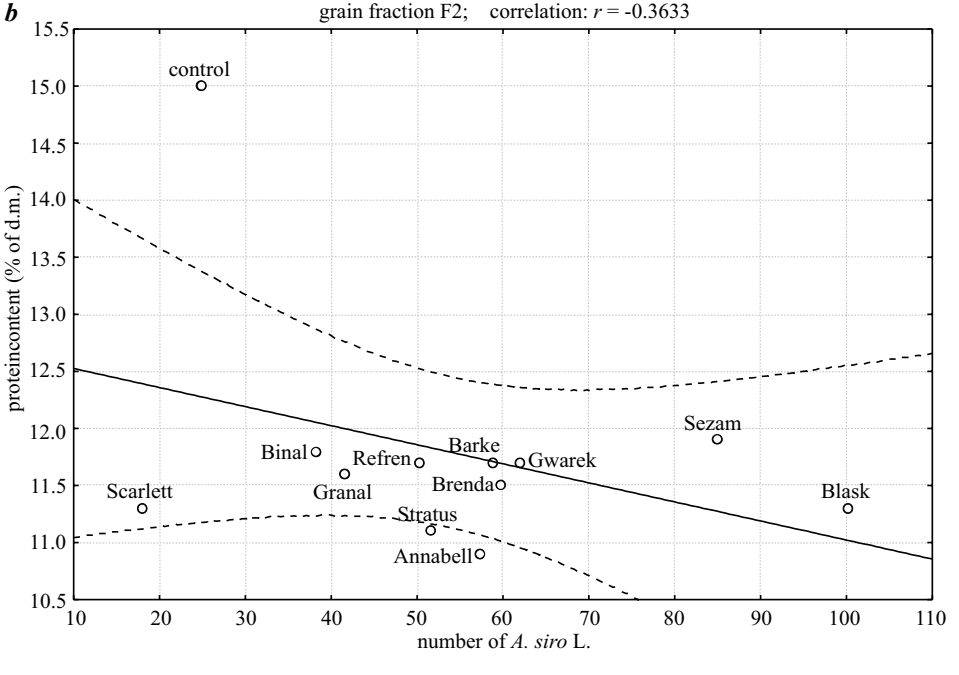


Fig. 2. Correlation between the protein content (%) in the grain of the barley cultivars and abundance of flour mite offsprings

Conclusions

1. Finely ground (F1) grain of malting barley cultivars is a suitable substract for development of flour mite as wheat grain.

2. The value of malting quality index could be useful in describing barley grain as a potential habitat for flour mite, provided that a degree of grain fragmentation is included in the analysis.

3. The development of flour mite is not affecting by higher protein content in finely ground grain (F1). In a combination with the grain ground to fraction F2, it was noticed that higher protein content resulted in lower abundance of the flour mite's offspring population. It is possible that not all protein substances contained in grain are available to flour mite.

Translated by JOLANTA IDŹKOWSKA

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