Vulnerability of wheat varieties to stored-product psocids

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Abstract

Ten wheat varieties registered in the Czech Republic were tested under laboratory conditions (27°C, 75% rh) for their susceptibility to post-harvest infestation by the psocid Liposcelis bostrychophila Badonnel, 1931. The criteria used were the production of psocid progeny and damage to the whole kernels caused by their infestation.

The parthenogenetic species L. bostrychophila were reproduced in all tested varieties. A very high correlation was found between psocid progeny production and loss in gram weight ($r = 0.97$, $p < 0.0001$), or between progeny production and the number of damaged kernels ($r = 0.9$, $p < 0.001$). The variety Linda was most resistant (0.5% weight loss, 7% kernels damaged) and Vigma most susceptible (1.5% weight loss, 54% kernels damaged). In almost all cases the psocids started to infest kernels by feeding on germs, so the properties of the endosperm did not influence the results very much. The seeds with damaged germs did not germinate. Varietal differences in vulnerability of wheat to psocids were closely connected with the initial state of the germ cover. The resulting damage caused by psocid feeding was highly correlated ($r = 0.89$, $p < 0.001$) with the percentage of kernels with damaged germ cover (small crevices) prior to psocid infestation.

Introduction

Alternatives are sought in grain storage management to reduce both damage caused by stored pests and the use of insecticides. One possibility is an orientation toward cultivars resistant to stored grain pests. Resistance of various wheat cultivars to various stored product beetles has been tested in many countries (Gupta, Kadyan, 1971, Singh et al., 1974, Nawrot, 1981, Coombs, Porter, 1986, Sinha et al., 1988). Kurová (1994) studied the susceptibility of several wheat cultivars used in the Czech Republic to Sitophilus granarius, a primary grain pest, developing within the kernel. The present study was aimed at psocids, secondary pests living and developing in the space between kernels in bulk of stored grain.

Psocids are commonly found in stored grain worldwide (Sinha, 1988, Rees, 1994, Buch, 1994, Roesh and Jones, 1994, Ho and Winks, 1995, Santos et al., 1996). In the Czech Republic they occurred in 51% of grain storage facilities, and were recorded in grain mass in 31% of stores (Kurová, unpublished data). Psocids used to be regarded as mere nuisance, feeding especially on moulds. In the past years a rapid outbreak of occurrence of these tiny insects (especially of Liposcelid species) in stored products has been observed (Turner, 1994) and also the general opinion on their pest status has been changing. Although psocids develop on moulds (they prefer field and harvest fungi to storage moulds, as shown by Mills et al., 1992), they are also able to multiply on, and cause damage to, grain proper (Watt, 1965, McFarlane, 1982, Rees and Walker, 1990, Mills et al., 1992, Pike, 1994).

The purpose of this study was to determine if there are differences in the multiplication of psocids (Liposcelis bostrychophila) on whole grains of a number of wheat cultivars and how this reproduction depends on cultivar quality.

The criteria used were progeny production and damage caused by psocid feeding to whole kernels.

Materials and Methods

The stock culture of the psocid Liposcelis bostrychophila used in experiments has been maintained for many generations at the Department of Pest Control, Research Institute of Crop Production, at 27°C, 75% relative humidity (RH), kept on wheat germs, milled oat flakes and dried yeast. Seed samples of ten wheat cultivars were obtained from the Breeding Station at Stupice (Czech Republic).

Ten 2 g replicates of each cultivar were placed in 20 ml glass container (3 cm diameter). All containers comprised whole sterilized grains, which were individually checked before use under a stereomicroscope. The range of initial damage of germ cover (small microscopical crevices and cracks, which were normally not visible by naked eye) was recorded. The containers were left fully open in a climatized chamber at 27°C and 75% rh for 3 weeks to equilibrate the grain moisture to the experimental environment. Seed moisture was determined gravimetrically after moisture
equilibration and once again at the end of the experiment, using oven-drying at 130°C for 1 h. After the conditioning period 5 replicates of each cultivar were infested with psocids (20 females of L. bostrychophila per container, 7 to 14 days old), and 5 replicates were used as control for correction of weight losses and determination of moisture.

After 3 months the psocid populations were extracted by sifting and counted. To measure weight losses of wheat kernels caused by psocid feeding, the samples were weighed (analytical balance Mettler AE 240) before and after infestation. Any gain or loss in weight of the control samples, treated in the same way but without psocids, was used as a correction factor for the infested samples. Results were submitted to the ANOVA and the Duncan multiple range test. After the end of experiment, the individual kernels were re-examined under a stereomicroscope to determine the damages caused by psocid feeding. The kernels with an opening on the top were dissected to see the extent of germ and endosperm harm.

Results

Progeny production

Significant differences (p < 0.001) were found in progeny production of L. bostrychophila among the wheat cultivars tested. In Table 1 the cultivars are arranged in ascending order of progeny numbers as recorded after 3 months, when the experiment was terminated. The highest number of adults and nymphs (223) were found in the cultivar Viginta. The lowest number of psocid progeny (24) was produced in the cultivar Linda. This value is 11% of the progeny production in Viginta.

Weight losses

Significant differences were found in weight losses of tested cultivars caused by psocid feeding (Table 1). The lowest weight loss was found in Linda (0.5%) and highest in Viginta (1.4%). The weight losses were positively correlated (p<0.0001, r=0.97) with progeny production (Fig. 1a).

Damage caused by feeding

The kernels damaged by psocid feeding had small holes bored through the seed coat covering the germ near the top of the grain, and the germ inside was partially or completely eaten out. The damage was positively correlated with progeny production in each wheat cultivar (p<0.001, r=0.91). Again, the most extensive damage was observed in Viginta (54% kernels damaged) and the most negligible in Linda (6%) (Table 1, Fig. 1b). Positive correlation (p<0.001, r=0.89) between the percentage of damaged kernels and the percentage of initial mechanical defects of kernels (microscopic cracks and scrapes on germ cover) was also recorded (Fig. 2).

Table 1. Multiplication of L. bostrychophila on various wheat cultivars and damage caused by its infestation.

<table>
<thead>
<tr>
<th>Wheat cultivars</th>
<th>Total number of adults and nymphs</th>
<th>Initial damage of germ cover</th>
<th>Damaged kernels caused by psocid feeding</th>
<th>Weight losses of kernels</th>
<th>Technical quality index</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± CD</td>
<td>%</td>
<td>%</td>
<td>g</td>
<td></td>
</tr>
<tr>
<td>Linda</td>
<td>24 ± 11</td>
<td>6.9</td>
<td>6.0</td>
<td>0.01</td>
<td>5</td>
</tr>
<tr>
<td>Vlada</td>
<td>64 ± 3.4</td>
<td>25.4</td>
<td>22.2</td>
<td>0.01</td>
<td>9</td>
</tr>
<tr>
<td>Sparta</td>
<td>77 ± 9.6</td>
<td>29.9</td>
<td>30.9</td>
<td>0.02</td>
<td>4</td>
</tr>
<tr>
<td>Hana</td>
<td>85 ± 15</td>
<td>23.7</td>
<td>16.9</td>
<td>0.01</td>
<td>9</td>
</tr>
<tr>
<td>Sida</td>
<td>91 ± 21</td>
<td>34.5</td>
<td>31.7</td>
<td>0.02</td>
<td>5 – 6</td>
</tr>
<tr>
<td>Regina</td>
<td>103 ± 9.6</td>
<td>25.3</td>
<td>25.3</td>
<td>0.02</td>
<td>7 – 8</td>
</tr>
<tr>
<td>Trane</td>
<td>106 ± 8.9</td>
<td>33.8</td>
<td>26.2</td>
<td>0.01</td>
<td>1</td>
</tr>
<tr>
<td>Mona</td>
<td>126 ± 22</td>
<td>42.6</td>
<td>29.6</td>
<td>0.02</td>
<td>8</td>
</tr>
<tr>
<td>Simona</td>
<td>138 ± 22</td>
<td>47.4</td>
<td>43.7</td>
<td>0.02</td>
<td>4</td>
</tr>
<tr>
<td>Viginta</td>
<td>223 ± 49</td>
<td>45.4</td>
<td>54.2</td>
<td>0.03</td>
<td>7</td>
</tr>
</tbody>
</table>

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Moisture content and quality of cultivars

No significant correlation \( r = 0.4 \) was found between population size and damage caused by psocids and moisture content of endosperm (Fig. 3).

The most susceptible cultivar, Viginta, has technological quality index 7, i.e., the lowest limit for wheat milling quality. The most resistant cultivar, Linda, with quality index 5, belongs to soft feeding wheat cultivars. The variety Hana showed an index of technological quality 9, i.e., the highest value found in all tested cultivars, with highest hardness (370 BU) and vitreousness (82%), but the vulnerability by psocid feeding was moderate.

Discussion

Mills et al. (1992) studied feeding and multiplication of L. bostrychophila on the whole and cracked wheat and other grain screenings of one Canadian cultivar. Whole grains were less suitable for psocid reproduction than cracked grains. I am not aware of any papers comparing psocid...
reproduction on various grain cultivars

In the described experiment psocids differed in reproduction on respective tested cultivars. They damaged germs of kernels in close connection with the initial state of the germ cover. Almost in all cases the endosperm was not harmed. Thus the correlation between cultivar quality and psocid infestation did not become evident because the endosperm, which determines cultivar quality, was not damaged. There was also no relation to moisture content of the endosperm. On the other hand, psocids are able to feed also on the endosperm in the case of long-lasting infestations (Watt, 1964, McFarlane, 1982, Rees and Walker, 1990, Kurová, unpublished data). In that case the susceptibility scale of cultivars may be different, possibly more related to cultivar quality, similarly as in the weevil Sitophilus granarius boring in kernel endosperm (Kurová, 1994).

It is evident that psocids (Liposcelis sp.) can harm stored wheat (not only broken and cracked, but also whole kernels). The extent of damage is determined by various circumstances—environmental conditions in the store, duration and size of psocids infestation, presence of other pests, fungi, and various admixtures in grain bulk. Wheat variety may also play its role. The vulnerability of cultivars is connected (at least in the beginning of infestation) with the mechanical state of germ coat of the kernels. Microscopic defects of germ coat may be characteristic of the variety (some varieties are probably more susceptible to mechanical abrasion) or result from the treatment when harvested, after harvest and during storage.

References


Nawrot, J 1981 The susceptibility of grain of various wheat varieties and cultivars to the post-harvest infestation by granary weevil (Sitophilus granarius). Prace Naukowe Instytutu Ochrony Roslin, 23, 139 – 141


