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Genetic resources for organic wheat breeding: impact on resistance to common bunt

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To develop winter wheat varieties suitable for organic farming, it is necessary to collect plant genetic resources resistant to common bunt, because no seed treatment (with synthetic pesticides) is allowed. For this purpose, the breeding lines developed at the Lithuanian Institute of Agriculture and winter wheat varieties registered in Lithuania were investigated during 2001–2004, using artificial inoculation with *Tilletia tritici* and *Tilletia leavis* spores. It was found that among advanced breeding lines 0.0–1.7% were very resistant and 0.0–16.2% resistant to common bunt. Among the gene collection varieties tested, 0.0–7.7% were very resistant and 1.6–36.2% resistant to common bunt depending on the year of testing. Most lines and varieties were infected by 10% to 50%. This means that development and collection of plant genetic recourses resistant to common bunt is one of the limiting factors in organic wheat breeding. Investigations of common bunt resistance of Lithuania-registered winter wheat varieties showed that among 26 varieties two – 'Begra', 'Baltimor' – were resistant while 'Korweta' and 'Bill' medium-resistant to common bunt. These varieties can be used in crosses to improve resistance to common bunt. The infection in most varieties reached 16.5–55.3%. The most susceptible varieties were 'Flair', 'Aspirant' and 'Pegasos' (infection 75.9–87.4%). The Lithuanian winter wheat variety 'Milda' was medium-susceptible and 'Ada', 'Seda', 'Alma', 'Širvinta' susceptible to *Tilletia tritici.*

Key words: winter wheat, immunoresistance, common bunt

INTRODUCTION

Common bunt (*Tilletia tritici* (DC.) Tul. and *Tilletia leavis* Kühn) is potentially one of the most devastating plant diseases and occurs in all wheat-growing regions of the world [1]. The fungus grows systematically in infected wheat plants and develops ovaries filled with fungal spores. During threshing, the bunt balls break and the spores attach to the healthy seeds during seed handling. When spore-contaminated seeds are sown, the spores germinate synchronously with seeds and infect the germinating plants. For common bunt, the factor of primary loss in relation to incidence is 0.925 [2]. The secondary loss is due to grain contamination with stinking and toxic bunt spores. Control of common bunt is therefore crucial for the production of quality wheat. A field severity of less than 0.1% infected wheat heads can be enough to make grains unsuitable for food without expensive and very time-consuming cleaning [3].

Since cheap and effective seed treatments with organic mercury started in the 1920s, research on this disease has been limited. In order to prevent multiplication of bunt infections from year to year, the sum of all involved control measures must therefore have an effectiveness of more than 99%. In conventional agriculture this control level is exclusively reached by seed treatments [4]. According to EC regulations, seed used in organic agriculture after 2003 must be produced under requirements of organic farming. The use of synthetic and chemical seed dressings to prevent the transmission of seed diseases is prohibited in organic agriculture [5]. Consequently, repeated cultivation of winter wheat with farm-saved seeds may in short term lead to high infection with common bunt. According to EC policy, to make organic agriculture more substantial, wheat breeding for common bunt resistance is one of the most important tasks and the adequate genetic resources are required. The main objectives in this study were to test the Lithuania-registered winter wheat varieties as well as the breeding material and new advanced breeding lines of winter wheat developed at the Lithuanian Institute of Agriculture (LIA).

MATERIALS AND METHODS

The experiments were carried out at the LIA during 2000–2004 in an artificially inoculated nursery. The material subjected to bunt resistance tests included Lithu-

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ania registered cultivars and cultivars with good resistance to leaf diseases used as initial breeding material and advanced lines from competitive trial nursery.

The seed of wheat genotypes were inoculated each year with 5g spores/1000g seed. Bunt spores were obtained from bunt-infected ears collected from experimental wheat nurseries at LIA. Inoculation was carried out by shaking the seed with teliospores in flasks for 5 min. When the soil temperature became favourable (below 10 °C) for bunt development, generally at the end of the first ten-day period of October, 5 g of seed was sown per line per 1 m length row in three replications at a depth of 10 cm. Rows were arranged in plots containing six rows with an area of 1 m^2. The experimental fields were fertilized with 150 kg ha^{-1} N (in spring before resumption of wheat vegetative growth), 90 kg ha^{-1} P_2O_5 and 90 kg ha^{-1} K_2O active ingredients (before sowing). Susceptibility was determined after harvesting at medium milk development stage as the number of infected ears from the total ears counted. The following scale was used to measure the resistance of the varieties: infected ears 0.0 = very resistant, 0.1–5.0 = resistant, 5.1–10.0 = moderately resistant, 10.1–30.0 = moderately susceptible, 30.1–50.0 susceptible, 50.1–100.0 = very susceptible [6].

RESULTS

The growing conditions during the period 2000–2004 were different but in general conducive to the development of common bunt. The most critical period limiting the infection of winter wheat is two weeks after sowing [7]. The best conditions for inoculation are when soil temperature is 5–10 °C and moisture content is optimal for plant development. Such conditions occurred in the autumn of 2000 and resulted in the highest infection in the experiment in 2001. The temperatures and soil moisture content in the following years (2002 and 2003) were close to optimal for the disease development. In the autumn of 2003, soil temperature was relatively high and conditions for inoculation of wheat plans were worse. The experiment in 2001 involved 124 varieties from LIA genetic collection and 137 breeding lines, in 2002 178 varieties and 110 breeding lines, in 2003 193 varieties and 95 breeding lines, and in 2004 130 varieties and 68 breeding lines. It was found in the experiment that most accessions were infected more than 10%. The distribution of common bunt resistance among the test varieties and lines in 2001–2004 is shown in Figure. Investigation of 28 Lithuania-registered varieties revealed only two varieties resistant to common bunt.

DISCUSSION

Our experimental evidence suggests that common bunt resistance of winter wheat varieties is highly problematic. Similar conclusions have been made by several authors too [6, 8, 9]. We found that very resistant to common bunt in 2001 were 0.7% of breeding lines and 0.0% of varieties, in 2002 1.8 and 1.7, respectively, in 2003 0.0 and 6.7, in 2004 0.0 and 7.7%. Varieties and lines infected 5.1 to 10.0% constituted from 0.7 (2001) to 36.8% (2004). Most lines were infected 10 to 50%. The resistance of advanced breeding lines in 2003 and 2004 increased. Nevertheless, the results have indicated that to develop varieties suitable for organic farming it is necessary to initiate a special breeding programme including highly resistant parental varieties or forms developed specially for it. In the production of certified seed no more than seven infected ears and per 150 m^2 are tolerated [10]. This means that to produce certified seed of varieties not resistant to common bunt is hardly possible. Chemical seed treatment is not permitted in organic farming. Investigations of common bunt resistance of Lithuania-registered winter wheat revealed that among 26 varieties there were no varieties very resistant

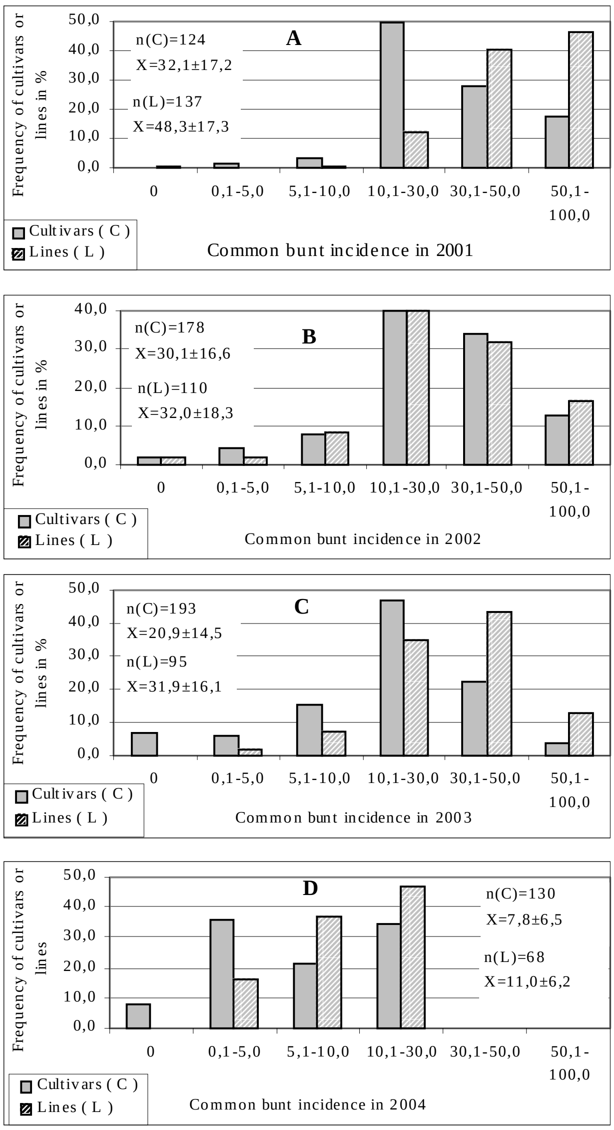

Figure. Resistance of winter wheat genotypes to common bunt in
2001 (A), 2002 (B), 2003 (C), 2004 (D)

Table. **Resistance to common bunt of winter wheat cultivars registered in Lithuania**

No.	Cultivar	The highest disease incidence in 2001–2004	Resistance
1	Begra	3.7 ± 1.8	Resistant
2	Baltimor	3.9 ± 2.3	"–"
3	Korweta	6.2 ± 1.5	Medium resistant
4	Bill	8.2 ± 8.2	"– "
5	Jubiliatka	16.5 ± 6.1	Medium susceptible
6	Milda	21.9 ± 10.9	"– "
7	Olivin	29.3 ± 10.1	"– "
8	Ada	33.0 ± 9.6	Susceptible
9	Toronto	35.6 ± 4.6	"– "
10	Seda	35.7 ± 15.5	"– "
11	Širvinta 1	39.4 ± 8.2	"– "
12	Hereward	40.5 ± 16.5	"– "
13	Cardos	40.6 ± 5.5	"– "
14	Marabu	47.2 ± 13.7	"– "
15	Bussard	48.1 ± 14.6	"– "
16	Alma	48.2 ± 3.5	"– "
17	Zentos	49.0 ± 8.1	"– "
18	Tauras	52.7 ± 5.6	Very susceptible
19	Lina	55.3 ± 7.5	"– "
20	Ibis	60.4 ± 12.4	"– "
21	Decan	64.2 ± 15.7	"– "
22	Astron	69.9 ± 4.9	"– "
23	Flair	75.9 ± 14.4	"– "
24	Kris	81.0 ± 7.4	"– "
25	Aspirant	83.3 ± 6.1	"– "
26	Pegassos	87.4 ± 7.6	"– "
LSD (P = 0.000) 24.6			

to common bunt. Two varieties, 'Begra' and 'Baltimor', were resistant, 'Korweta' and 'Bill' medium-resistant to common bunt (Table). These varieties can be included in crosses to improve the common bunt resistance level. The infection of most winter wheat varieties was 16.5–55.3%. The most susceptible varieties 'Flair', 'Aspirant' and 'Pegasos' were infected 75.9–87.4%. The Lithuanian winter wheat variety 'Milda' is medium-susceptible, 'Ada', 'Seda', 'Alma', 'Širvita' are susceptible to *Tilletia tritici and Tilletia leavis*. This means that development and collection of common bunt resistant plant genetic material is one of the limiting factors for organic wheat breeding. Screening of wheat for resistance to common bunt is one of the most difficult resistance tests among wheat diseases. The tests are time-consuming and results in some years are of low reliability due to not optimal temperature conditions for pathogen growth in the autumn. Artificial conditions in growth chambers provided the optimal environment for disease development, but this method of testing is rather costly and is suitable only for small-scale testing of wheat genotypes [11].

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GENETINIAI IÐTEKLIAI EKOLOGINEI KVIEÈIØ SELEKCIJAI: ATSPARUMAS KIETOSIOMS KÛLËMS

S a n t r a u k a

Ekologiniø þieminiø kvieèiø selekcijai bûtina sukaupti genetinius iðteklius – veisles ir selekcines linijas, pasiþyminèias atsparumu kietosioms kûlëms, nes ekologiniuose ûkiuose neleidþiama cheminiais preparatais beicuoti sëklø. Tam tikslui 2001–2004 m. Lietuvos þemdirbystës institute buvo tiriamos dirbtiniu bûdu kûlëmis apkrëstos þieminiø kvieèiø selekcinës linijos ir Lietuvoje registruotos veislës. Buvo nustatyta, kad tik 0,0–1,7% selekciniø linijø buvo labai atsparios, o 0,0–16,2% atsparios kietosioms kûlëms. Tarp Lietuvoje registruotø þieminiø kvieèiø veisliø tik 'Begra' ir 'Baltimor' buvo atsparios, o 'Korweta' ir 'Bill' – vidutiniðkai atsparios kietosioms kûlëms. Ðias veisles galima ávairiai kryþminti norint pagerinti atsparumà kûlëms. Jautriausios ðiai augalø ligai buvo veislës 'Flair', 'Aspirant' ir 'Pegasos', jø uþsikrëtimas siekë 75,9–87,4%. Ið lietuviðkø þieminiø kvieèiø veislë 'Milda' buvo vidutiniðkai jautri, 'Ada', 'Seda' ir 'Ðirvinta' – jautrios *Tilletia tritici ir Tilletia leavis.*