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POWDERY MILDEW RESISTANCE IN KENTUCKY BLUEGRASS ECOTYPES FROM POLAND

ABSTRACT

A total of 444 ecotypes Kentucky bluegrass (*Poa pratensis* L.) collected in Poland were screened for resistance to powdery mildew. A field experiment was established at Hof Steimke, DSV (Deutschen Saatveredelung), Germany. The ecotypes originated from Polish Gene Bank, IHAR – Botanical Gar–den, Bydgoszcz. The average powdery mildew resistance score for tested ecotypes was 4.3, and the same score for eight varieties used as a control was 4.8. From the control varieties (Limousine, Alicja, Julia, Berbie, Ottos, Jori, Eska and Oxford) the most resistant to infection was Limousine. Plants showed resistance scores 5 or 7, on average 6.17. Sixty–two ecotypes (14.0%) which were scored on average more than 6 were included in two groups: with high resistance (15 ecotypes) and with mod–erate resistance (47 ecotypes). Ecotypes which plants were scored on average less than 6 were in–cluded in a susceptible group (scores on average 4.0 – 5.9), and a very susceptible group (scores on average 2.0 – 3.9). There were 226 ecotypes in the susceptible group (50.9%) and 156 (35.1%) in the very susceptible group.

High resistance to powdery mildew showed ecotypes collected from nine habitats: meadow, wet meadow, peat meadow, pasture, field, forest, waterside, ditch and roadside. The highest percentage of ecotypes with high resistance was collected from wet meadows. The value of these newly identified highly resistant ecotypes for control of powdery mildew on Kentucky bluegrass is discussed.

Key words: ecotypes, *Erysiphe graminis*, Kentucky bluegrass (*Poa pratensis* L.), resistance

INTRODUCTION

Kentucky bluegrass (*Poa pratensis* L.) is native to all of Europe, northern Asia and the mountain region of North Africa. Although the species is spread over all cold and temperate parts of the U. S., it is not native to North America. It is considered to be one of the most valuable forage and turf grasses (Meyer 1982).

The powdery mildew caused by *Erysiphe graminis* DC. ex Merat is a serious foliar disease that affects grasses (Pieróg 1982, Smiley *et al*. 1992, Prończuk and Prończuk 1994, Prończuk 1996). It

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occurs commonly on Kentucky bluegrass turfs grown in shaded areas and in fields used for seed production (Vargas *et al.* 1981, Meyer 1982, Msikita and Wilkinson 1994). Growth of *E. graminis* and development of powdery mildew is favored by reduced air circulation, high relative humidity, low light intensity and air temperatures ranging from 16˚C to 22˚C (Butt 1978). Fungicide applications, well–balanced use of fertilizers, and mowing are currently used to reduce the severity of powdery mildew in the field. However, pathotypes that are resistant to commonly used fungicides have been reported in other crops. Also, fungicide cost and environmental concerns regarding pesticide use may limit their use (Johnson 1981, Schuman and Wilkinson 1992, Burpee 1993, Gullino and Kuijpers 1994, Ebdon *et al*. 1999). Systemic fungicides applied to Kentucky bluegrass turf often cause visible alterations in plant morphology (Kane and Smiley 1983).

An alternative approach to control of powdery mildew is breeding for resistance (Wijk 1993). However, varieties of Kentucky bluegrass with high levels of resistance to powdery mildew are not yet available (Msikita and Wilkinson 1994). Development of new varieties adapted to particular environmental conditions, and resistant to pest and diseases is slow process, taking from 2 to 6 years in the USA (Jacklin 1990) or 10 to 15 years in Europe. Apomixis (Meyer 1982) and variability in ploidy levels of this grass (Funk and Ahmed 1973) limit this process. Most of varieties originate from ecotypes and this breeding method is especially common in Europe. Breeding of new varieties of Kentucky bluegrass using hybridization is much more common in the USA where for 76 varieties 38% originated from crosses. Also, attempts have been made to improve the breeding efficiency of grasses by using apomixis gene (s) (Naumova 1996), tissue culture (Msikita and Wilkinson 1994) or intraspecific hybridization (Akerberg 1942, Brittingham 1941, 1943, Nygren 1953, Clausen 1961, Pepin and Funk 1971, Dale *et al.* 1975, Meyer 1982).

Good germplasms are essential for successful breeding programs in many crops including grasses (Harlan 1975, Ramanatha and Riley 1994). Several of the native Eurasian turfgrass species, which grown here for hundreds years, can be bred into successful turfgrass varieties (Martusewicz 1980, Asay 1991, Brede and Sun 1995, Swanson 1996, Czarnecka 1997, Wouw *et al.* 1999, Góral 1998). Ecotypes from natural stands or from old turf areas are well adapted to their environments and can be fruitful sources of resistance for control of diseases (Arseniuk 1983, Burdon and Jarosz 1989). Many Gene Banks, including the Polish Gene Bank – IHAR Radzików, possess hundreds of ecotypes collected from many different ecological and geographical stands (Majtkowski 1996). These collections are very valuable sources for improving many breeding characteristics including disease resistance. However, they must be characterized for further evaluation and using in breeding programs.

The objective of this study was to determine the level of resistance to powdery mildew of Polish ecotypes of Kentucky bluegrass from Polish Gene Bank.

MATERIALS AND METHODS

Plant material

Seed samples of 444 Kentucky bluegrass ecotypes from the Polish Gene Bank, Plant Breeding and Acclimatization Institute – Botanical Garden, Bydgoszcz, were collected in expeditions organized by Institute during 1979 – 1981 in Poland. Most of them originated from natural meadows, pastures, roadsides and fields and were collected from individual plants (Table 1).

Table 1

Number and percentage of ecotypes collected in different ecological stands.

Habitat	Number of ecotypes		Percentage of ecotypes with high and moderate resistance [%]
	Total	With high and moderate resistance[1]	
Meadow	223	34	14.3
Wet meadow	8	3	37.5
Peat meadow	14	1	7.1
Forest meadow	6	0	0
Pasture	18	1	5.6
Field	43	9	11.6
Field road	8	0	0
Forest	18	2	11.1
Lakeside	7	0	0
Waterside	10	1	10.0
Ditch	20	5	15.0
Roadbed	2	0	0
Roadside	58	6	10.3
Bank	2	0	0
Orchard	2	0	0
Brushwood	3	0	0
Gravel pit	3	0	0
Unknown	2	0	0

[1] ecotypes scored on average more than 6 using 1–9 scale

Field experiment

A field experiment was established at Hof Steimke, DSV (Deutschen Saatveredelung), Germany during 1992 – 1994. Six seedlings from each ecotype were planted in 60 cm × 60 cm arrangements. Eight varieties namely Limousine, Alicja, Julia, Berbie, Ottos, Jori, Eska and Oxford, were used as controls. These varieties were chosen because they are commonly grown in Europe. Based on the results obtained in

another trials, Limousine was a control with high level of resistance. Alicja, Jori and Eska were used as controls very susceptible for infec–tion by powdery mildew and varieties Julia, Berbi, Ottos and Oxford as susceptible (Prończuk, unp. data). Control varieties were planted five times every 89 tested ecotypes.

Disease assessment

For Kentucky bluegrass apomixis limited the variability in ecotype. Therefore, according to the method described by van Wouw *et al.* (1999), about characterization of forage germplasm, 1 observation on each plant (6 observation per ecotype) was optimal to obtain statisti–cally accurate assessment of the variation. Until now, it was not found any genotype fully resistant to infection by *E. graminis* and resistance of Kentucky bluegrass to powdery mildew is polygenic. Therefore, the resistance of tested ecotypes was scored using a quantity scale, accord–ing to percentage of leaf area infected (Prończuk 1993).

Score		% of leaf area infected	Score		% of leaf area infected
9	=	0	4	=	60 – 75
8	=	1 – 10	3	=	75 – 90
7	=	10 – 20	2	=	90 – 100
6	=	20 – 30	1	=	no plants
5	=	30 – 50			

It was done in 1993, when the control varieties express, that the pres–sure of the disease was enough heavy and to do the assessment reliable.

RESULTS

The average powdery mildew resistance score of 444 tested ecotypes was 4.3 and similar average score (4.8) was observed for eight control varieties. The control variety Limousine was the most resistant, and showed resistance scores 5 or 7, in average 6.17 (Table 2). Taking this into account, sixty – two (14.0%) ecotypes which were scored on average more than 6 were included in two groups: with high and with moderate resistance (Table 3, Fig. 1). In the first group 15 (3.4%) ecotypes which possessed the highest resistance were included. All 6 tested plants of these ecotypes showed resistance score 7. In the second group, there were 10 ecotypes that scored on average 6.6 – 6.9 (one tested plant had a score 5 and the others scored 7), 23 ecotypes scored on average 6.1– 6.5 (two plants scored 5 and the other scored 7) and 14 ecotypes scored on average 6.0 (three plants showed resistance reaction 5 and three plants resistance reaction 7).

Ecotypes which plants were scored in average less than 6 were in–cluded in a susceptible group (scored on average 4.0 – 5.9) and a very

susceptible group (scored on average 2.0 – 3.9). In the susceptible group, there were 226 ecotypes (50.9%), and in the very susceptible group, there were 156 ecotypes (35.1%) (Fig. 1).

Table 2

Scores of resistance to powdery mildew of eight standard varieties.

Variety	Mean score[1]	Coefficient of variability [%]	No. of plants with score								
			1	2	3	4	5	6	7	8	9
Limousine	6.17	22.7	0	0	0	0	12	0	17	0	0
Alicja	3.83	32.9	0	2	12	0	11	0	0	0	0
Julia	4.6	24.0	0	0	8	0	20	0	0	0	0
Berbie	5.41	27.7	0	0	3	0	17	0	9	0	0
Ottos	5.37	26.1	0	1	3	0	16	0	10	0	0
Jori	3.93	38.2	0	3	13	0	11	0	2	0	0
Eska	3.97	29.2	0	3	11	0	16	0	0	0	0
Oxford	5.0	25.7	0	0	6	0	18	0	6	0	0
Mean	4.8	31.8									

[1]Powdery mildew was rated on a 1–9 scale, $LSD_{0.05}$ (Tukey) = 1.890

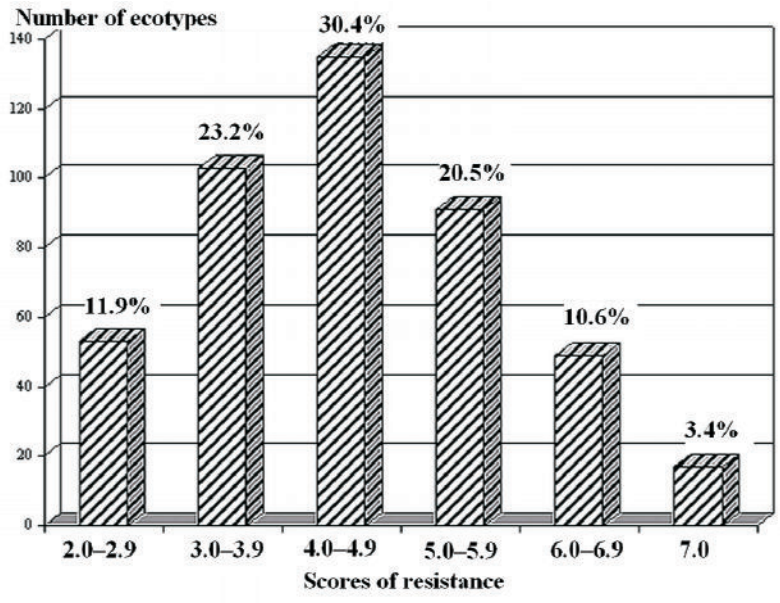

Fig. 1 Number and percentage of ecotypes with different scores of resistance

For seventeen different habitats from which tested ecotypes were col–lected only those originating from nine habitats (meadow, wet meadow, peat meadow, pasture, field, forest, waterside, ditch and roadside) showed moderate and high resistance to powdery mildew (Table 1). Most ecotypes with high resistance were collected from wet meadows.

Table 3.

Collection sites and scores of resistance to powdery mildew of sixty – ecotypes with high and moderate resistance.

No.	IHAR No.	Mean score[1]	No. of plants with score		Collection sites	Region of Poland[2]	Habitat
			5	7			
I – High resistance							
1	141605	7.0	0	6	Stara Wieś	NC	Meadow
2	141803	7.0	0	6	Charzykowy	NC	Field
3	141851	7.0	0	6	Bobowo	N	Field
4	141879	7.0	0	6	Dłużek	NE	Meadow
5	141880	7.0	0	6	Radomino	NC	Wet meadow
6	141884	7.0	0	6	Klocek	NC	Wet meadow
7	141898	7.0	0	6	Kierzkowo	N	Meadow
8	141902	7.0	0	6	Bobolice	NW	Meadow
9	141903	7.0	0	6	Ciechocinek	NC	Meadow
10	141927	7.0	0	6	Białośliwie	NC	Roadside
11	141946	7.0	0	6	Kopidłówek	?	Peat meadow
12	142113	7.0	0	6	Kaszczorek	NC	Ditch
13	142117	7.0	0	6	Gumieniec	N	Meadow
14	142119	7.0	0	6	Szczepankowo	NC	Pasture
15	142234	7.0	0	6	Wrocki	NC	Ditch
II – Moderate resistance							
16	141797	6.7	1	5	Wałycz	NC	Meadow
17	141804	6.7	1	5	Gruczno	NC	Wet Meadow
18	141819	6.7	1	5	Mokre	NC	Meadow
19	141852	6.7	1	5	Zalesie	NC	Roadside
20	141846	6.7	1	5	Mroczyn	NC	Meadow
21	141874	6.7	1	5	Wisełka	NW	Meadow
22	142123	6.7	1	5	Okonin	NC	Meadow
23	141731	6.6	1	4	Występ	NC	Meadow
24	141814	6.6	1	4	Okonek	NC	Ditch
25	142141	6.6	1	4	Zakrzewo	NC	Ditch
26	141623	6.3	2	4	Nakło	NC	Ditch
27	141811	6.3	2	4	Toporzyk	NW	Meadow
28	141845	6.3	2	4	Jaruzyn	NC	Meadow
29	141846	6.3	2	4	Miasteczko Kraj.	NC	Field
30	141849	6.3	2	4	Rudno	N	Field
31	141854	6.3	2	4	Pawłówek	NC	Meadow
32	141919	6.3	2	4	Jarzewnica	N	Meadow

[1]Powdery mildew was rated on a 1–9 scale $LSD_{0.05}$ (Tukey) = 0.650.
[2]N – North, NC – North Central, NE – North East, NW – North West.

Table 3

Continued

No.	IHAR No.	Mean score[1]	No. of plants with score		Collection sites	Region of Poland[2]	Habitat
			5	7			
			II – moderate resistance				
33	141922	6.3	2	4	Rynarzewo	NC	Meadow
34	141923	6.3	2	4	Miasteczko Kraj.	NC	Meadow
35	141947	6.3	2	4	Suliszewice	NNC	RoadsideMeadow
36	142053	6.3	2	4	Dziewierzewo		
37	142132	6.3	2	4	Wołcza Mała	NW	Meadow
38	142142	6.3	2	4	Krag	NW	Meadow
39	142164	6.3	2	4	Górzna	NC	Meadow
40	142165	6.3	2	4	Żukowo	N	Meadow
41	142194	6.3	2	4	Czechyn	NC	Meadow
42	142218	6.3	2	4	Górki	N	Meadow
43	142231	6.3	2	4	Elgiszewo	NC	Field
44	141830	6.2	2	3	Rosko	NC	Meadow
45	141886	6.2	2	3	Bydgoszcz	NC	Field
46	141894	6.2	2	3	Bydgoszcz	NC	Field
47	141920	6.2	2	3	Ciele	NC	Field
48	142196	6.2	2	3	Opolino	N	Field
49	141796	6.0	3	3	Zalewo	N	Forest
50	141817	6.0	3	3	Osiek–Pracz	NC	Meadow
51	141869	6.0	3	3	Dobrzyca	NC	Meadow
52	141895	6.0	3	3	Niewierz	NC	Meadow
53	141938	6.0	3	3	Ciechocinek	NC	Meadow
54	142120	6.0	3	3	Sławsko	N	Waterside
55	142149	6.0	3	3	Krag	NW	Meadow
56	142171	6.0	3	3	Karlowo	NC	Roadside
57	142177	6.0	3	3	Żarnowiec	N	Roadside
58	142181	6.0	3	3	Wiesiołka	NC	Meadow
59	142185	6.0	3	3	Panigrodź	NC	Meadow
60	142192	6.0	3	3	Buntowo	NC	Roadside
61	142201	6.0	3	3	Jeleni Ruczaj	NW	Forest
62	142207	6.0	3	3	Klocek	NC	Meadow

[1]Powdery mildew was rated on a 1–9 scale $LSD_{0.05}$ (Tukey) = 0.650.
[2]N – North, NC – North Central, NE – North East, NW – North West.

DISCUSSION

Disease resistance is one of the major objectives of grass breeding programs. The powdery mildew caused by *Erysiphe graminis* together with other leaf parasites such as *Puccinia* spp. and *Drechslera* spp. can cause qualitative and quantitative losses in production of grasses. This affects the yield of fodder grass as well as the yield of seeds and the aesthetic appearance of lawns (Paul and Dapprich 1997). However, in the past 20 years no or a little progress has been made to improve disease resistance in major grass species and Kentucky bluegrass is no exception. Over this period more than 100 Kentucky bluegrass varieties were registered in Europe (van Wijk 1993). However, none of them is fully resistant to infection by powdery mildew (Vargas *et al.* 1981, Meyer 1982, Msikita and Wilkinson 1994), and this was confirmed in this study. The average powdery mildew resistance score of 444 tested ecotypes (4.3) was similar to the same score for eight varieties used as a control (4.8). However, improvement of powdery mildew resistance in Kentucky bluegrass may be obtained by screening hundreds ecotypes. Our results showed that among the ecotypes, 25 (5.6%) were more resistant, and 37 (8.3%) had resistance at the same level as the most resistant control variety, Limousine (with a resistance score 6.17). Especially promising sources of powdery mildew resistance were 15 ecotypes (3.4%) with the highest resistance (score 7). These ecotypes may be used for improving Kentucky bluegrass. The effectiveness of the selection in the present study is similar or higher than assessed in other studies, where frequency of ecotypes used for breeding is about 1% for grasses (Hintzen and Wijk 1985, Paul 1989, Prończuk and Żurek 1994,) and for cereals (Nover and Lehman 1973, Jørgensen and Jensen 1997, Czembor and Johnston 1999). In our experiments, no ecotypes with resistance scores 8 or 9 were found.

Many of grass varieties were derived from ecotypes collected from natural stands or individual clones found in old turf areas (Meyer 1982). Ecotypes are local types, widely adapted to different natural and cultural environments (Harlan 1975). Ecotype breeding is the method, which is commonly used by Kentucky bluegrass breeders. It is based on selection of best–suited ecotypes for turf or forage purposes. Therefore, breeders germplasm collections or ecotypes preserved in gene banks are very valuable for improvement of Kentucky bluegrass (Martusewicz 1980, Nowicki 1982, Asay 1991, Brede and Sun 1995, Swanson 1996, Czarnecka 1997, Góral 1998, Wouw *et al.* 1999), especially for resistance to powdery mildew, as we have shown. However, confirmation of the breeding value of these ecotypes must be proved in trial tests over several years.

The highest percentage of resistance to powdery mildew ecotypes was observed in those collected from wet meadows. This suggests that, to obtain more powdery mildew resistant ecotypes, this habitat should be

investigated during collection missions. However, based on the results of this study, meadow, peat meadow, pasture, field, forest, waterside, ditch and roadside may be also a good source of ecotypes with resistance to powdery mildew.

E. graminis is able to develop new races, which may rapidly spread across Europe on susceptible Kentucky bluegrass varieties. However, until now it was not found any genotype fully resistant to infection by population of *E. graminis*. This suggest that the resistance of Kentucky bluegrass to powdery mildew, most probably, is determined by many genes with minor effect. This type of resistance (called horizontal resistance or field resistance) is much more difficult to overcome by pathogen. More over the durability of resistance to powdery mildew may be increased by use many different strategies for deploying resistant ecotypes. The most common strategy is species and variety mixtures (Vargas 1994). Newly identified ecotypes can be used together with proper use of fertilizers and fungicides.

CONCLUSIONS

1. None of 444 tested ecotypes from Poland showed complete resistance to powdery mildew infection (score 9).
2. Among all tested ecotypes 5.6% were more resistant, and 8.3% had resistance to powdery mildew infection at the same level as the most resistant control variety, Limousine. Ecotypes (3.4%) with the highest resistance (score 7) may be especially promising sources of powdery mildew resistance.
3. Many habitats like: wet meadow, meadow, peat meadow, pasture, field, forest, waterside, ditch and roadside may be a source of ecotypes with resistance to powdery mildew.

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