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SHORT COMMUNICATION

Screening oat landraces for resistance to *Blumeria graminis* f. sp. *avenae*

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Abstract

Landraces have considerable potential for use in increasing genetic diversity of cultivated crops. They present a unique source of specific traits for disease and pest resistance, nutritional quality and marginal environment tolerance. In this study we screened of 156 *A. sativa* and *A. strigosa* landraces originated from Poland, for resistance to powdery mildew disease, caused by *Blumeria graminis* f. sp. *avenae*. In general, the tested genotypes showed lower level of resistance than expected. Among *A. sativa* landraces five were resistant to single isolates, the rest of them showed intermediate or susceptible response to *B. graminis* f. sp. *avenae* isolates used in host-pathogen tests. One *A. strigosa* genotype was resistant to all tested isolates and could be valuable source of resistance against oat powdery mildew.

Keywords Oat · Powdery mildew · Landraces · Resistance

Diseases caused by fungal pathogen are one of the main factors reducing yield and grain quality in crops production. Among them the most important are rust diseases (leaf rust, brown rust, crown rust), powdery mildew, diseases caused by members of the genus *Fusarium* (Bentley et al. 2006; Kuzdraliński et al. 2017, 2018; Figueroa et al. 2018). One of the most important foliar diseases of oat is powdery mildew caused by *Blumeria graminis* DC. f. sp. *avenae* Em. Marchal. This disease appears every year and has been reported as a serious problem in many parts of the world (Roderick et al. 2000; Sebesta et al. 1991, Banyal et al. 2016, Xue et al. 2017). Limiting the losses caused by the occurrence of this pathogen is based on appropriate agrotechniques and introduction of resistant cultivars (Gacek 2000; Tratwal and Rosiak 2010). To date, ten genes conferring resistance to oat powdery mildew have been characterised, but based on reports from available literature only a few are high effective against existing *Blumeria graminis* DC. f. sp. *avenae* populations. (Okoń 2015; Okoń and Ociepa 2017). Resistance to powdery mildew is decreasing due to the emergence of new pathogen pathotypes by mutations and recombinations. Also using the same set of resistance genes in breeding programmes could result in the selection of pathotypes with the matching virulence genes, resulting in resistance breakdown (Czembor and Czembor 2001). Menardo et al. (2016) suggested that also hybridization between *formae speciales* is a mechanizm of adaptation to new crops introduced by agriculture. Because of these facts there is a need to search for novel and effective sources of resistance to powdery mildew in oat. A valuable source of genetic variation, and thus the source of resistance genes can be both wild species and landraces.

Landraces are dynamic, heterogeneous crops populations composed of numerous homozygous lines or individuals with various level of heterozygosity (Boczkowska and Onyśk 2016). Landraces envolved in response to natural selection for the local environment, mutations, migrations and genetic drift. Consequently they are well adapted to local conditions including biotic and abiotic stress factors (Frankel et al. 1995; Villa et al. 2005; Mohammadi et al. 2014; Pusadee et al. 2014). Several studies suggest that landraces may be a good source of new allelic diversity for breeding programs. They are valuable sources of quality traits (Pecetti et al. 2001; Moragues et al. 2006; Li et al. 2009; Teklu and Hammer 2009), agro-ecological adaptation (van Hintum and Elings 1991), abiotic stresses (Reynolds et al. 2006; Trethowan and Mujeeb-Kazi 2008) and resistance to pests and diseases (Saker et al. 2008; Li et al. 2009; Sánchez-Martín et al. 2011, 2012).

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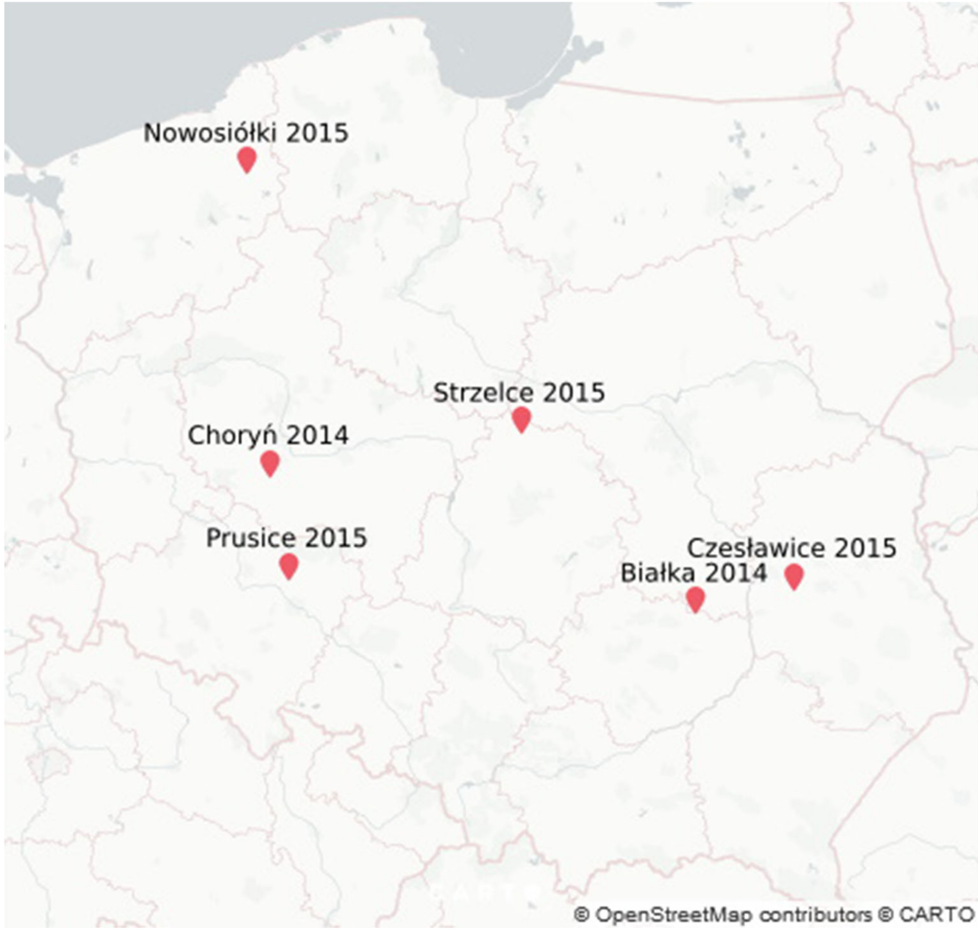

Fig. 1 Geographic origin of graminis f. sp. *avenae* isolates

Bacause of this fact, the aim of presented study was screening a group of 156 oat landraces belonging to *A. sativa* and *A. strigosa* species for resistance to *Blumeria graminis* f. sp. *avenae* causing powdery mildew in oats.

All genotypes were received from two gene banks: The Plant Breeding and Acclimatization Institute (IHAR), Radzikow, Poland and Leibniz Institute of Plant Genetics and Crop Plant Research, Gatersleben, Germany.

Host-pathogen tests described by Okoń and Kowalczyk (2012) were used to determine resistance of the analyzed genotypes. Disease on the leaves was rated 10 days after inoculation according to 0–4 modified scale (Mains 1934). Many studies aimed at identifying new sources of disease resistance are based on tests with one highly virulent pathogen isolate (Sánchez-Martín et al. 2012; Herrmann and Mohler 2018). Okoń et al. (2018) underline that it is necessary to perform tests based on a diverse set of pathogen isolates in order to obtain reliable results on the effectiveness of disease resistance. Observations based on isolates sampled in one region or in one year may be insufficient to draw reliable conclusions. In

Table 1 Virulence of *Blumeria graminis* f. sp. *avenae* isolates chosen for testing oat landraces

B. graminis f.sp. *avenae* Isolates	Control lines and cultivars[b]							
	Jumbo *Pm1*	Cc3678 *Pm2*	Mostyn *Pm3*	Av1860 *Pm4*	Am 27 *Pm5*	Bruno *Pm6*	APR122 *Pm7*	Fuchs
Choryń 2014	I	R	I	R	R	S	I	S
Białka 2014	R	R	S	R	R	S	R	S
Strzelce 2015	S	R	S	R	R	S	R	S
Nowosiółki 2015	S	R	S	R	R	S	S	S
Czesławice 2015	S	R	S	R	R	S	I	S
Prusice 2015	I	I	S	R	R	S	R	S

R resistant, *I* intermediate, and *S* susceptible

Table 2 Response of *A. sativa* landraces to selected *B. graminis* f. sp. *avenae* isolates

Accession number	Choryń 2014 (4)	Białka 2014	strzelce 2015 (2)	Nowosiółki 2015	Czesławice 2015	Prusice 2015	Accession number	Choryń 2014 (4)	Białka 2014	strzelce 2015 (2)	Nowosiółki 2015	Czesławice 2015	Prusice 2015
Pl 51,632	R	S	S	R	I	R	Pl 51,599	S	S	S	S	S	S
AVE 2663	S	S	S	R	R	R	Pl 51,600	S	S	S	S	S	S
Pl 51,610	I	S	S	R	S	R	Pl 51,603	S	S	S	S	S	S
Pl 52,265	S	S	S	R	S	R	Pl 51,604	S	S	S	S	S	S
AVE 2813	S	S	S	R	S	R	Pl 51,605	S	S	S	S	S	S
Pl 51,443	R	I	S	I	S	I	Pl 51,607	S	S	S	S	S	S
AVE 1481	S	S	S	S	S	I	Pl 51,609	S	S	S	S	S	S
Pl 50,345	S	S	S	S	S	I	Pl 51,611	S	S	S	S	S	S
Pl 50,381	S	S	S	I	S	S	Pl 51,614	S	S	S	S	S	S
Pl 50,524	I	S	S	S	S	S	Pl 51,617	S	S	S	S	S	S
Pl 50,528	S	S	I	S	S	S	Pl 51,618	S	S	S	S	S	S
Pl 50,593	S	I	S	S	S	S	Pl 51,619	S	S	S	S	S	S
Pl 50,616	I	S	S	S	S	S	Pl 52,192	S	S	S	S	S	S
Pl 50,622	I	S	S	S	S	S	Pl 52,193	S	S	S	S	S	S
Pl 50,673	S	S	S	I	S	S	Pl 52,194	S	S	S	S	S	S
Pl 50,709	I	S	S	S	S	S	Pl 52,195	S	S	S	S	S	S
Pl 50,760	S	S	S	I	S	S	Pl 52,267	S	S	S	S	S	S
Pl 50,945	I	I	S	S	S	S	Pl 52,306	S	S	S	S	S	S
Pl 51,441	I	S	S	I	S	S	Pl 52,338	S	S	S	S	S	S
Pl 51,442	S	I	S	S	S	S	Pl 52,429	S	S	S	S	S	S
Pl 51,522	S	S	S	S	S	I	Pl 52,430	S	S	S	S	S	S
Pl 51,606	I	I	S	S	S	S	AVE 1204	S	S	S	S	S	S
Pl 51,612	I	S	S	S	S	S	AVE 1205	S	S	S	S	S	S
Pl 51,615	S	S	S	I	S	S	AVE 1474	S	S	S	S	S	S
Pl 51,616	I	S	S	S	S	S	AVE 1477	S	S	S	S	S	S
Pl 51,634	S	S	S	I	S	S	AVE 1480	S	S	S	S	S	S
Pl 52,191	S	S	I	S	S	S	AVE 1483	S	S	S	S	S	S
Pl 52,351	S	S	S	I	S	S	AVE 1485	S	S	S	S	S	S
Pl 52,431	S	S	S	I	S	S	AVE 1486	S	S	S	S	S	S
AVE 1206	S	S	S	S	S	I	AVE 1487	S	S	S	S	S	S
AVE 1472	S	S	S	S	S	I	AVE 1490	S	S	S	S	S	S
AVE 1473	S	S	S	S	S	I	AVE 1491	S	S	S	S	S	S
AVE 1489	S	I	S	S	S	S	AVE 1492	S	S	S	S	S	S
AVE 1777	S	S	S	S	I	I	AVE 1493	S	S	S	S	S	S
AVE 1778	S	I	S	S	S	I	AVE 1494	S	S	S	S	S	S
AVE 1786	S	I	S	S	S	S	AVE 1496	S	S	S	S	S	S
AVE 1787	S	I	S	S	S	S	AVE 1497	S	S	S	S	S	S
AVE 1792	S	S	S	S	S	I	AVE 1498	S	S	S	S	S	S
AVE 1795	S	S	S	S	S	I	AVE 1542	S	S	S	S	S	S
AVE 1798	S	I	S	S	S	S	AVE 1543	S	S	S	S	S	S
AVE 1804	I	S	S	S	S	S	AVE 1544	S	S	S	S	S	S
AVE 1885	S	I	S	S	S	S	AVE 1588	S	S	S	S	S	S
AVE 1967	S	I	S	S	S	S	AVE 1775	S	S	S	S	S	S
AVE 2582	S	S	S	S	S	I	AVE 1779	S	S	S	S	S	S
AVE 589	S	S	S	S	S	I	AVE 1781	S	S	S	S	S	S
AVE 1807	S	S	S	S	S	S	AVE 1782	S	S	S	S	S	S

Table 2 (continued)

Accession number	Choryń 2014 (4)	Białka 2014	strzelce 2015 (2)	Nowosiółki 2015	Czesławice 2015	Prusice 2015	Accession number	Choryń 2014 (4)	Białka 2014	strzelce 2015 (2)	Nowosiółki 2015	Czesławice 2015	Prusice 2015
Pl 50,338	S	S	S	S	S	S	AVE 1783	S	S	S	S	S	S
Pl 50,432	S	S	S	S	S	S	AVE 1784	S	S	S	S	S	S
Pl 50,512	S	S	S	S	S	S	AVE 1785	S	S	S	S	S	S
Pl 50,521	S	S	S	S	S	S	AVE 1788	S	S	S	S	S	S
Pl 50,529	S	S	S	S	S	S	AVE 1789	S	S	S	S	S	S
Pl 50,531	S	S	S	S	S	S	AVE 1791	S	S	S	S	S	S
Pl 50,553	S	S	S	S	S	S	AVE 1793	S	S	S	S	S	S
Pl 50,554	S	S	S	S	S	S	AVE 1796	S	S	S	S	S	S
Pl 50,556	S	S	S	S	S	S	AVE 1797	S	S	S	S	S	S
Pl 50,587	S	S	S	S	S	S	AVE 1799	S	S	S	S	S	S
Pl 50,613	S	S	S	S	S	S	AVE 1800	S	S	S	S	S	S
Pl 50,627	S	S	S	S	S	S	AVE 1801	S	S	S	S	S	S
Pl 50,694	S	S	S	S	S	S	AVE 1803	S	S	S	S	S	S
Pl 50,705	S	S	S	S	S	S	AVE 1886	S	S	S	S	S	S
Pl 50,706	S	S	S	S	S	S	AVE 1887	S	S	S	S	S	S
Pl 50,712	S	S	S	S	S	S	AVE 1888	S	S	S	S	S	S
Pl 50,718	S	S	S	S	S	S	AVE 1889	S	S	S	S	S	S
Pl 50,725	S	S	S	S	S	S	AVE 1893	S	S	S	S	S	S
Pl 50,754	S	S	S	S	S	S	AVE 1894	S	S	S	S	S	S
Pl 50,758	S	S	S	S	S	S	AVE 1963	S	S	S	S	S	S
Pl 50,902	S	S	S	S	S	S	AVE 1965	S	S	S	S	S	S
Pl 50,904	S	S	S	S	S	S	AVE 1966	S	S	S	S	S	S
Pl 50,925	S	S	S	S	S	S	AVE 2057	S	S	S	S	S	S
Pl 51,439	S	S	S	S	S	S	AVE 2581	S	S	S	S	S	S
Pl 51,440	S	S	S	S	S	S	AVE 2585	S	S	S	S	S	S
Pl 51,519	S	S	S	S	S	S	AVE1805	S	S	S	S	S	S
Pl 51,521	S	S	S	S	S	S							

PL = National Center for Plant Genetic Resources (Radzików, Poland)

AVE = Leibniz Institute of Plant Genetics and Crop Plant Research, Gatersleben, Germany

R resistant, *I* intermediate, and *S* susceptible

Table 3 Response of *A.srigosa* landraces to selected *B. graminis* f.sp. *avenae* isolates

Accession number	Choryń 2014 (4)	Białka 2014	strzelce 2015 (2)	Nowosiółki 2015	Czesławice 2015	Prusice 2015
Pl 51,586	R	R	R	R	R	R
Pl 51,585	I	S	S	S	S	S
Pl 51,630	S	S	S	S	S	I
Pl 51,754	S	S	S	S	S	I
Pl 51,613	S	S	S	S	S	I
Pl 501,048	S	S	S	S	S	I
Pl 51,518	S	S	S	S	S	S
Pl 51,523	S	S	S	S	S	S
Pl 51,524	S	S	S	S	S	S
Pl 51,520	S	S	S	S	S	S
Pl 51,751	S	S	S	S	S	S

PL = National Center for Plant Genetic Resources (Radzików, Poland)

R resistant, *I* intermediate, and *S* susceptible

presented study, all accessions were tested using six single spore isolates of *B. graminis f.sp. avenae* of divers geographic origin (Fig. 1). Their virulence was verified using a set of cultivars and lines with defined resistance genes (Table. 1).

In general, the tested genotypes showed a low level of resistance to oat powdery mildew. Among the *A. sativa* landraces, there were no completely resistant genotypes (0–2 in Mains scale). Among the 145 accessions, two (Ave 2663 and 51,634) were resistant to three among six tested isolates, three (Ave2813, 52,565 and 51,610) were resistant to two isolates and one genotype (51443), were resistant to single isolates. Thirty-nine of tested landraces belonging to *A. sativa* showed intermediate response to single isolates, but we did not identify any genotype which showed intermediate response to all tested isolates (3 in Mains scale). Most of them were susceptible to all tested *B. graminis* f. sp. *avenae* isolates (4 in Mains scale) (Table 2).

Among tested *A. strigosa* genotypes one (Pl 51,586) showed resistant response to all six isolates used in host-pathogen tests. Five genotypes showed intermediate response to single isolates. The rest of them showed susceptible resopnce to *B. graminis* f. sp. *avenae* isolates used (Table 3).

Based on these tests we identify only one genotype fully resistant to *B. graminis* f. sp. *avenae* isolates. The use of different isolates allows us to conclude that the identified source of resistance is highly effective in Polish condition. Also using isolates collected in two different years may indicate that the resistance identified in the *A. strigosa* genotype could be also effective over a longer period of time.

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