Genetic Diversity of Barley Landraces from Near East, North Africa and Southern Europe in Relation to Resistance to Powdery Mildew

J. H. CZEMBOR[1], H. J. CZEMBOR[1] and M. MACKEY[2]

[1]Plant Breeding and Genetics Department, Plant Breeding and Acclimatization Institute (IHAR), Radzikow, 05-870 Błonie, Poland; [2]Australian Winter Cereals Collection, RMB 944 Calala Lana, Tamworth NSW 2340, Australia

E-mail: j.h.czembor@ihar.edu.pl

Abstract

This study was conducted to determine the resistance to powdery mildew in 218 barley landraces collected in Near East (Israel, Lebanon, Syria, Turkey, Iran, Iraq), North Africa (Egypt, Algeria, Morocco) and Southern Europe (Greece, Bulgaria, Yugoslavia, Italy, Spain). Plants with resistant reactions were found in 31 (14%) landraces from which 41 single plant lines were selected. These lines were tested with 20 differential isolates of powdery mildew. Eight (19.5%) lines originated from 7 landraces (5 from Israel, 1 from Syria and 1 from Greece) were resistant to all powdery mildew virulence genes prevalent in Europe. The value of new identified sources of highly effective powdery mildew resistance to breeding programes and barley production was discussed.

Keywords: *Hordeum vulgare*; *Blumeria graminis*; barley landraces; powdery mildew, genes for resistance

INTRODUCTION

Barley (*Hordeum vulgare* L.) is the fourth most important cereal crop in the world, after wheat, maize and rice. In European Union barley is the second (after wheat) most important cereal crop (CZEMBOR & CZEMBOR 2001). In Near East, North Africa and Southern Europe barley is often grown in marginal agricultural areas with low annual precipitation (often less than 220 mm). Landraces in this area are important as they are often the only rain-fed crop possible and they are cultivated on mountain slopes at elevations higher than other cereals (CECCARELLI & GRANDO 1999).

Fungus *Blumeria graminis* (DC.) Golovin ex Speer f. sp. *hordei* Em. Marchal (synamorph *Erysiphe graminis* DC. f.sp. *hordei* Em. Marchal) is considered one of the most destructive foliar pathogens of barley. In countries where mildew is a problem, yield losses in experimental tests usually exceed 25%. However average annual losses in barley production in Central Europe, including Czech Republic, are about 10% (DREISEITL & JUREČKA 1996, 1997; CZEMBOR & CZEMBOR 2001).

Breeding for resistance, as an alternative to use of chemicals approach to control of powdery mildew, has been very successful, inexpensive and environmentally safe (CZEMBOR 2000, 2002; HOVMØLLER *et al*. 2000). Barley landraces constitutes a rich genetic resource, and many examples of their successful use have been reported (CZEMBOR 1996, 2000). Consequently, barley landraces collected in Near East, North Africa and Southern Europe may possess mildew resistance genes different from those which already have been introduced into European barley cultivars (CZEMBOR 2001, 2002).

The objective of this study was to identify powdery mildew resistance genes in lines selected from barley landraces collected in Near East, North Africa and Southern Europe.

MATERIAL AND METHODS

Plant material. Samples of 218 barley landraces were used. Seed samples of these landraces originated from Australian Winter Cereals Collection. They were collected in Algeria (6), Bulgaria (12), Egypt (4), Greece (19), Iran (27), Iraq (8), Israel (36), Italy (13), Lebanon (1), Morocco (8), Spain (4), Syria (39), Turkey (35) and Yugoslavia (6).

Pathogen. Twenty isolates of *B. graminis* f.sp. *hordei* were used. They originated from the collections in Risø National Laboratory, Roskilde, Denmark; Danish Institute for Plant and Soil Science, Lyngby, Denmark; Edigenossische Technische Hochschule – ETH, Zurich, Switzerland and from the collection in IHAR Radzików, Poland. The isolates were chosen according to their virulence spectra on the Pallas isoline differential set and 7 additional differential cultivars. They were purified by single pustule isolation. Young seedlings of the cultivar Manchuria (CI 2330) were used to maintain and propagate all isolates. Frequent virulence checks were made to ensure the purity of isolates throughout the experiment.

Inoculation and disease assessment. The inoculation was carried out when plants were 10–12 days old (two-leaf stage) by shaking or brushing conidia from diseased plants. After 8–10 days of incubation, the infection types (ITs) on the primary leaf of the seedlings were scored. This scoring was done according to a 0–4 scale. Plants showing ITs 0–2 were included in the resistant group and plants with ITs 3 and 4 were included in the susceptible group.

Resistance tests. This investigation was conducted at IHAR Radzików, Poland. Cv. Manchuria was used as the susceptible control. Powdery mildew resistant plants were found in 31 (14%) landraces and 41 single plant lines were selected. These lines were grown in the greenhouse to obtain sufficient number of seed for further resistance tests. The progeny of these plants were tested with 20 differential isolates of powdery mildew. 1998/99. In all resistance tests the plants were grown in the IHAR Radzików greenhouse with 16 h of lighting and a 18–22°C range of temperature.

RESULTS

Eight lines originating from 7 landraces showed resistance to all isolates. One of these lines showed IT 0 and the other 7 lines showed IT 2 for most isolates. The most frequent IT was 2 and the least frequent was 3. For most lines it was impossible to postulate a particular gene or genes for resistance. Four different resistance alleles (*Mlat*, *Mla12*, *Mla7* and *Mlap*) were postulated to occur in the tested lines alone or in combination.

DISCUSSION

Ten results presented on this poster confirmed the value of barley landraces collected from Near East, North Africa and Southern Europe as a genetic resource for resistance to *B. graminis* f.sp. *hordei*. Eight single plant lines selected from these landraces showed resistance to all isolates used. Isolates used in this experiment had virulences corresponding to all major resistance genes used in Europe, except *mlo*. Thus, lines that showed resistance to all isolates should have resistance throughout Europe. Therefore, these lines are of potential value for barley breeders concerned with powdery mildew.

The environmentally safest and cheapest control of powdery mildew on barley is to cultivate resistant varieties (CZEMBOR & CZEMBOR 2001; DREISEITL & JØRGENSEN 2000). Currently 35 resistance alleles are used in cultivars grown in Europe (JØRGENSEN 1994; CZEMBOR & CZEMBOR 2001). However the powdery mildew fungus is extremely variable and all these genes with the exception of *mlo* were successively overcome by the appearance of pathotypes with matching virulence. As each race-specific resistance was broken, cultivars had to be discarded because they were too disease susceptible to be of further value (VĚCHET & KOCOUREK 1986; DREISEITL 1997; HOVMØLLER *et al.* 2000). Thus, different strategies to prolong durability of resistance genes were proposed. These strategies included use of multiline cultivars, combining different resistance genes into one variety, use of partial resistance combined with race specific resistance, and the deployment of many cultivars with different resistance genes in space (e.g. cultivar mixtures) and time (winter versus spring barley) (FINCKH *et al.* 1999; CZEMBOR & CZEMBOR 2001).

This study showed that barley landraces are promising sources of resistance to powdery mildew. New sources of resistance to powdery mildew identified in selections from barley landraces may increase the diversity of powdery mildew resistance genes available to barley breeders. These resistance genes used properly in different strategies may ensure cheap and environmentally safe control of powdery mildew on barley.

Acknowledgements: The authors thank Dr. H. J. SCHAERER (Edigenossische Technische Hochschule – ETH, Zurich, Switzerland) for the powdery mildew isolates and Dr. L. MUNK

(Royal Agricultural and Veterinary University, Copenhagen, Denmark) for the near-isogenic lines of Pallas.

References

CECCARELLI S., GRANDO S. (1999): Barley landraces from the Fertile Crescent: a lesson for plant breeders. In: BRUSH S.B. (ed.): Genes in the Field. IPGRI, IDRC, Lewis Publishers, Ottawa, Canada: 51–76.

CZEMBOR J.H. (1996): Presence and Expression of resistance genes to powdery mildew of barley in selections from Tunisian barley landraces. [Ph.D. Thesis.] Plant Pathology Dep., Montana State Univ., Bozeman, USA.

CZEMBOR J.H. (2000): Sources of resistance to powdery mildew in barley landraces from Libya. Sver. Utsadesfor. Tidskrift, **110**: 232–240.

CZEMBOR J.H. (2001): Sources of resistance to powdery mildew (*Blumeria graminis* f.sp. *hordei*) in Moroccan barley land races. Can. J. Plant Pathol., **23**: 260–269.

CZEMBOR J.H. (2002): Resistance to powdery mildew in selections from Moroccan barley landraces. Euphytica, **125**: 397–409.

CZEMBOR H.J., CZEMBOR J.H. (2001): Resistance to powdery mildew in barley cultivars and breeding lines included in 1998–2000 Polish registration trials. Plant Breed. Seed Sci., **45**: 19–28.

DREISEITL A. (1997): Změny v populací padlí travního na ječmeni v České republice (1993–1994). Ochr. Rostl., **33**: 281–296.

DREISEITL A., JØRGENSEN J.H. (2000): Powdery mildew resistance in Czech and Slovak barley cultivars. Plant Breeding, **119**: 203–209.

DREISEITL A., JUREČKA D. (1996): Vyskyt chorob ječmene jarního v České Republice v letech 1989–1995. Ochr. Rostl., **32**: 221–229.

DREISEITL A., JUREČKA D. (1997): Vyskyt listovych chorob ječmene ozimého v České Republice v letech 1989–1996. Ochr. Rostl., **33**: 177–186.

FINCKH M.R., GACEK E.S., CZEMBOR H.J., WOLFE M.S. (1999): Host frequency and density effects on powdery mildew and yield in mixtures of barley cultivars. Plant Pathol., **48**: 807–816.

HOVMØLLER M.S., CAFFIER V., JALLI M., ANDERSEN O., BESENHOFER G., CZEMBOR J.H., DREISEITL A., FLATH K., FLECK A., HEINRICS F., JÖNSSON R., LIMPERT E., MERCER P., PLESNIK S., RASHAL I., SKINNES H., SLATER S., VRONSKA O. (2000): The Eurpean barley powdery mildew virulence survey and disease nursery. Agonomie, **20**: 729–744.

JØRGENSEN J.H. (1994): Genetics of powdery mildew resistance in barley. Crit. Rev. Plant Sci., **13**: 97–119.

VĚCHET L., KOCOUREK F. (1986): Study of the course of *Erysiphe graminis* f.sp. *hordei* epidemic. Ochr. Rostl., **22**: 25–31.