Avena barbata, a Potential New Source of Crown Rust Resistance in Oat

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Introduction

Crown rust, caused by *Puccinia coronata* f. sp. *avenae* Erik., is the most damaging fungal disease of domesticated oat, *Avena sativa* L., in the world. The disease is most damaging when heavy dews coincide with moderate temperatures during the growing season. In the U.S., there are two major oat production areas. Winter oats, sown in the fall and harvested in the spring, are grown in parts of the southern U.S., often as a dual purpose (forage/grain) crop. Spring oats, sown in the early spring and harvested mid-summer, are grown in the upper Midwest mainly as a grain crop. In the winter oat region, *P. coronata* successfully overwinters and crown rust epidemics can be severe as multiple infection cycles with urediniospores can occur over the long growing season. In the spring oat region, the alternate host of *P. coronata*, common buckthorn (*Rhamnus cathartica* L.), is a widespread, pervasive, noxious weed in wooded areas and shelter belts adjacent to oat fields. Aeciospores from buckthorn as well as urediniospores from southern winter oat production areas serve as abundant initial sources of inoculum in the spring oat region.

Host resistance has been the primary means of controlling losses to crown rust in cultivated oat. The use of race-specific, seedling genes for resistance to crown rust has a long history in the U.S. Initially, cultivated hexaploid oat, *A. sativa*, was used as a source of crown rust resistance (*Pc*) genes. As cultivars with these genes were deployed, they rapidly succumbed to new virulent races of *P. coronata*. Virulence to *Pc* genes derived from A. sativa is now nearly fixed in the North American population of *P. coronata*. Subsequently, oat breeders turned to the wild hexaploid animated oat, *A. sterilis*, as a source of new *Pc* genes, but virulence to many of these genes was already present in the *P. coronata* population, or increased rapidly as they were deployed in new cultivars. Virulence to all the reported *Pc* genes from *A. sterilis* is present in, and the virulence complexity of the U.S. crown rust population has continued to increase unabated. More recent efforts at finding new, effective *Pc* genes have centered on diploid or tetraploid *Avena* species. Crown rust resistance in the diploid black oat, *A. strigosa*, has been known and documented for quite some time, but introgression of resistance into hexaploid oat is difficult due to differences in ploidy levels and the lack of homology of chromosomes between the two species. The cultivar Leggett recently released by the AAFC Winnipeg program contains *Pc94* from the *A. strigosa* accession RL1697 with wide spectrum resistance. An effective crown rust resistance gene (*Pc91*) from the tetraploid species, *A. magna* CI 8330, was successfully transferred via the synthetic hexaploid Amagalon into the oat cultivar Hi-Fi released by North Dakota State University in 2001.

Avena barbata Pott ex Link is a wild tetraploid (2n=28) species that is widely distributed in the Mediterranean region, North Africa, Middle East, South Asia, and much of Europe. It has also been introduced to Australia and the Americas. It is adapted to a range of natural and artificial habitats ranging from sea level to the snow line. In the U.S. it is considered a restricted species because it is listed as a noxious weed by the state of Missouri and is considered a moderately invasive species of natural areas in California.

Genes for resistance to powdery mildew (*Eg-4*) and stem rust (*Pg-16*) have been successfully transferred from *A. barbata* into cultivated hexaploid oat. Although resistance to crown rust in collections of *A. barbata* has been reported, no systematic evaluation of the U.S. collection for broad spectrum resistance to *P. coronata* has been conducted.

Materials and Methods

Seed of 402 accessions of *Avena barbata* and *A. barbata* ssp. *barbata* were received from the USDA Small Grains Collection in Aberdeen, ID. Five to ten seeds of each accession were planted for initial greenhouse testing. 359 accessions actually germinated. Seven day-old seedlings were inoculated with suspension of urediniospores of a relatively avirulent isolate of P. coronata, 06MN097 (race DBBC). Crown rust reactions were recorded 14 days later. Accessions rated at least MR with race DBBC were further inoculated with a bulk population of urediniospores from the 2006 St. Paul buckthorn nursery. This a very diverse population that contains virulence to every known Pc gene. Seed of accessions that were at least MR when inoculated with the 2006 buckthorn bulk population were planted for further seedling tests using a bulk population of *P. coronata* from the 2007 buckthorn nursery. Plants that were at least MR as seedlings were repotted and tested as adult plants with 2007 buckthorn bulk population.

Avena barbata Pott ex Link, the wild slender oat

Range of reactions of *A. barbata* accessions to *P. coronata*; from susceptible (S) on the left to highly resistant (HR) on the right.

Table 1. Reactions of selected accessions of *Avena barbata* to race DBBC and bulk populations of *Puccinia coronata* from the St. Paul buckthorn nursery. Accessions in bold print have been crossed to *A. sativa* cvs. Otana or Ogle.

		Seedling			Adult
Accession	Origin	DBBC	06Bulk	07Bulk	07Bulk
Clav8082	**Israel**	**R**	**R**	**MR/R**	**HR/R**
Clav9060	Canada	HR	R	HR/S	HR
Clav9067	Canada	MR	MR/MS	MR/MS/S	-
Clav9091	Libya	R	R	HR	MR
Clav9125	Canada	R	MR	MR	-
PI282710	**Israel**	**R**	**HR**	**R**	**HR/R**
PI282723	**Israel**	**R**	**R/S**	**HR**	**R/MR/HR**
PI287203	Israel	R	R	HR	HR/R
PI287205	Israel	MR	MR	S/R	MS/MR
PI295885	**Israel**	**R**	**R**	**HR/S**	**HR**
PI295891	**Israel**	**HR**	**R**	**R/MR**	**HR/R**
PI317945	**Israel**	**HR**	**HR**	**HR**	**HR/R**
PI317953	**Israel**	**HR**	**HR**	**R/MR**	**HR**
PI320588	**Israel**	**HR**	**HR**	**HR**	**HR**
PI320598	Israel	MS	R	MS/MR	MR/MS
PI320610	Israel	R/MR	R	MR/R	MR/R
PI320630	Israel	MR	-	HR	MS
PI320638	Israel	R	R/S	MR	MR
PI320659	Israel	R	MR	MS/MR	MR
PI320696	**Israel**	**MR/MS**	**MR**	**HR/R**	**R**
PI320727	Israel	MR	-	S/R	MS
PI337737	Italy	R/MR	MR/R	MS/MR	MS
PI337741	**Italy**	**MR**	**R/MR**	**MR**	**R**
PI337744	Italy	MR	MS/MR	MR	R
PI337763	**France**	**R**	**R/MR**	**MR/R/S**	**MR/R**
PI337795	Morocco	R	R	HR	R
PI337811	Turkey	MR	MR/MS	MR/MS	MR
PI337823	**Greece**	**R**	**R**	**MR/R**	**MR**
PI337863	**Italy**	**R**	**MR**	**MS/MR**	**MR**
PI337864	**Italy**	**R**	**R/MR**	**R/MR**	**MR/R**
PI337867	Italy	HR	MR	HR/R/MR	HR/R/MR
PI337868	Italy	R	R/MR	MR	MR
PI337877	Italy	R	MR	MR	MR/R
PI337878	**Italy**	**R**	**MR**	**MR/R**	**R**
PI337886	**Italy**	**R**	**R**	**R**	**R**
PI337893	**Italy**	**HR**	**HR**	**HR**	**HR**
PI337904	Italy	MR	R	MS/MR	MR
PI337945	Tunisia	R/MR	R/MR	MR	MR
PI337961	Italy	R	MR/S	MR/MS	MR
PI337962	Italy	R/MR	MR/MS	MR/R	MR/R
PI337966	France	R	R/MR/S	MR/R/MS	MR/R
PI337975	Algeria	R	R/MS	MR	MR
PI367293	**Spain**	**R**	**R**	**R**	**R**
PI367296	**Spain**	**R**	**R**	**MR/R**	**R**
PI367318	Portugal	R	R	R	HR
PI367319	Portugal	R	R	MR	HR/R
PI367338	Portugal	S	MR	R/MR	R/MR
PI411376	Turkey	R	R	MR/R	R/MR

Results and Discussion

140 accessions of *A. barbata*, 39% of the US germplasm colllection, were at least MR when tested as seedlings with the relatively avirulent race DBBC. Of these, 48 (13% of the total) were at least MR when further tested as seedlings and adult plants against the bulk populations of *P. coronata* from the St. Paul buckthorn nursery (Table 1). Many of the accessions appeared to be heterogeneous in reaction. A sampling of plants from several apparently heterogeneous accessions when tested as seedlings to the 2007 bulk population were transplanted and tested as adult plants. In all cases, plants rated as S as seedlings were rated S as adults.

The high frequency of accessions with apparent broad-spectrum resistance to P. coronata is evidence that A. barbata is a potentially rich source of crown rust re