Proceedings of the Iowa Academy of Science

Volume 90 | Number | Article 8

1983

Evaluation of Sources of Resistance in Oats to Puccinia coronata by use of Many Fungus Cultures

L. J. Michel
Iowa State University

M. D. Simons
Iowa State University

Proc. Iowa Acad. Sci. 90(4): 144-146. 1983

Evaluation of Sources of Resistance in Oats to *Puccinia coronata* by use of Many Fungus Cultures[1]

L. J. MICHEL and M. D. SIMONS

Department of Plant Pathology, Iowa State University, Ames, IA 50011

Thirty-four single sorus cultures of *P. coronata* were used separately to inoculate seedlings of 70 strains of oats known to carry genes for resistance. Infection types ranged from immune to fully susceptible. When infection types were arbitrarily divided into "resistant" or "susceptible" categories, the 70 lines comprised 45 patterns of host reaction, which ranged from resistance to all cultures to susceptibility to all cultures. Three strains were resistant to all 34 cultures, and nine were susceptible to only a single culture. The most virulent culture parasitized 45 of the oat strains, the least virulent, only six.

INDEX DESCRIPTORS: *Avena sativa*, *Avena sterilis*, *Puccinia coronata*, disease resistance.

The only practical means of controlling crown rust (*Puccinia coronata* Cda.) of oats (*Avena sativa* L.), always a potentially destructive disease, is through the use of resistant cultivars. The appearance in the mid-1950's of *P. coronata* races 264 and 290 (Simons et al., 1957) that parasitized all known sources of resistance, however, cast doubt on the feasibility of controlling the disease by resistance. Fortunately, at about the same time, the potential value of strains of the wild oat *Avena sterilis* L. from the Mediterranean and Near East was beginning to be recognized. This species contained many potentially valuable traits for improving oat cultivars, including seedling resistance to *P. coronata*. In the early 1960's (Simons, Wahl, and Silva, 1962; Dinoor and Wahl, 1963), strains of *A. sterilis* from Israel were reported to be highly resistant as seedlings to the virulent new races of *P. coronata* in North America. This work was expanded by Wahl (1970), who documented the great abundance and diversity of genes for crown rust resistance in strains of *A. sterilis* in Israel. Martens, McKenzie, and Harder (1980) showed that the conclusions based on material collected in Israel were generally applicable to wild oats indigenous to the entire middle-eastern region.

This abundant source of resistance genes was discovered at an opportune time because the serious impact of genetic vulnerability resulting from genetic uniformity for disease resistance was just beginning to be fully realized (Day, 1977). Genetic diversity is regarded as the answer to the problem, and natural populations of *A. sterilis* could provide genes for such diversification for crown rust resistance. Schemes to achieve diversity in the oat crop for resistance to crown rust have been reviewed and summarized by Frey, Browning, and Simons (1980) and Browning and Frey (1981). Basic to the success of these schemes, which have been shown experimentally to be feasible, is an abundant supply of resistance genes. Investigators using any approach to diversity are faced with the practical problem of differentiating among resistance genes. The principal objective of this study was to differentiate among available genes for resistance to *P. coronata*. A second objective was to locate isolates of *P. coronata* that would be best suited to screening resistant strains of oats and for use as test material in breeding programs.

MATERIALS AND METHODS

Over the years, we had accumulated 70 lines of oats known to carry genes, mostly from *A. sterilis*, for resistance to *P. coronata*. Intercrossing these 70 lines and testing segregating populations for reaction to appropriate cultures of *P. coronata* would be a sure and effective means of determining the relationships of the resistance genes involved. The work involved in such genetic analyses, however, far exceeded our available resources. We used an alternative method in which the 70 resistant strains were tested with many different crown rust cultures, an approach based on the gene-for-gene hypothesis developed by Flor (1956). Besides differentiating among resistance genes, this approach also furnishes information on the breadth of resistance carried by different sources and about the relative degree of resistance to different cultures of *P. coronata*.

The 34 isolates that were used in the final phases of the study were chosen for their diversity of virulence. They also were diverse in terms of year of origin, 10 having been isolated in the 1950's, 9 in the 1960's, 14 in the 1970's, and 1 in 1981.

Plants were grown in the greenhouse at 20 C until the first leaf was fully expanded, at which time urediospores were applied to them using the oil-spore suspension method and other procedures described by Browder (1971). Reactions were classified 10 days later according to the scale published by Murphy (1935). This scale includes six categories of reaction ranging from extremely resistant to fully susceptible (see Table 1). For certain purposes of the study, we followed the common convention of recognizing only two categories, resistant and susceptible, the latter including moderately susceptible and susceptible reaction types.

RESULTS AND DISCUSSION

The data shown in Table 1 (reactions of 30 oat strains to 20 cultures of *P. coronata*) are representative and illustrate the important findings. When all strain-culture combinations were classified as either resistant or susceptible, 45 distinct patterns of reaction were evident. One pattern was represented by nine strains, most of the others by only one or two strains.

Three strains were resistant to all 34 cultures. One of these, IA H547, was a cultivated-type oat derived from *A. sterilis*. The other two were strains of the tetraploid oat, *Avena barbata* Brot. Nine strains were susceptible to only a single culture, each culture being different. Seven strains were susceptible to only two cultures. In contrast, a few strains were susceptible to all or most of the 34 cultures. These strains had good resistance as older plants in the field.

A principal objective of this study was to differentiate among potentially promising strains of oats known to be resistant to most biotypes of *P. coronata* occurring in the natural population. In this regard, eight of the oat strains had a pattern of reaction identical to IA H544, which we are using in the oat breeding program. Three other strains (IA X421, IA H555, and CAN Pc-46) we are using or have special interest in were duplicated once among the lesser-known strains. Another example of useful differentiation among relatively resistant oat strains was furnished by IA H382. IA H382 was resistant

[1]Cooperative contribution: Agricultural Research Service, U.S. Department of Agriculture, and Journal Paper J-10959 of the Iowa Agriculture and Home Economics Experiment Station, Ames; Project 2447.

Table 1. Reactions[a] of 30 strains of oats to 20 cultures of *Puccinia coronata*.

	Culture of *P. coronata*																			
Strain	3	4	5	6	7	8	9	10	13	14	16	17	19	20	24	26	27	28	31	34
IA H610-322	4	0	4	I	0	I	1	4	4	0	4	0	0	I	3	0	I	I	3	0
PI 411227	4	0	4	I	0	0	0	4	4	0	4	0	I	I	3	0	I	I	4	0
IA H610-335	1	I	0	I	0	I	I	4	I	3	0	0	0	I	3	0	0	I	0	I
IA H611-445	4	4	4	4	4	4	4	4	4	4	4	4	0	4	4	4	4	4	4	4
IA D615-16	1	4	0	0	0	I	0	0	0	0	0	1	0	I	0	0	0	0	0	0
IA D626-1	4	3	0	0	0	0	2	0	I	0	0	I	0	I	0	0	0	1	0	I
IA H659-59	0	0	I	0	0	0	I	0	I	4	0	I	0	I	0	0	0	I	0	I
PI 411236	1	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PI 411276	2	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PI 411207	0	0	0	I	0	4	0	3	0	4	0	0	0	0	4	0	0	0	4	0
PI 411250	0	0	0	I	0	4	0	4	0	4	0	0	0	I	4	0	0	0	4	0
PI 411355	0	0	0	I	0	4	0	4	0	4	0	0	I	I	4	0	0	0	4	0
WI X2505-4	1	1	1	4	0	0	0	0	0	4	0	0	0	I	0	0	0	0	0	0
IA H382	0	1	0	4	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	I
IA Y345	0	0	0	0	0	I	0	4	0	0	0	0	0	0	2	I	0	0	0	0
IA H544	1	I	I	I	0	4	0	4	0	4	0	I	I	I	4	0	0	I	0	0
IA H547	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	I
IA X421	1	0	I	0	0	4	0	3	I	4	0	I	I	I	2	0	0	I	0	0
IA X434	4	4	0	0	0	0	4	1	1	I	0	I	0	I	0	0	I	4	0	0
IA H561	0	I	I	I	0	3	I	4	I	2	0	0	0	I	4	0	0	I	0	I
IA H555	I	0	I	I	4	I	I	1	I	I	I	0	0	I	0	I	I	0	0	I
IA H441	0	I	4	I	0	1	I	0	I	I	I	0	0	I	0	I	I	I	0	0
IA H548	0	0	0	0	0	I	0	4	0	0	0	0	0	0	4	0	0	I	0	0
CAN Pc-38	1	4	0	0	0	0	0	0	0	0	1	I	0	4	I	0	0	0	1	0
CAN Pc-39	0	0	0	0	0	0	0	4	0	0	0	0	2	I	4	0	0	0	0	0
CAN Pc-46	0	0	0	0	4	0	0	4	0	0	2	4	0	0	4	0	0	0	4	4
CAN Pc-50	I	4	I	I	I	I	I	I	4	I	I	I	I	I	I	I	I	I	I	0
TAM-0-301	0	0	0	I	I	0	0	0	0	0	0	2	0	I	1	0	0	I	0	4
TAM-0-312	1	0	0	I	0	0	0	0	I	1	0	4	0	I	0	0	0	I	2	4
Ascencao	4	0	0	I	2	0	0	1	2	0	4	0	I	0	1	4	I	I	2	0

[a]I: no evidence of infection; 0: chlorotic flecking, no sporulation; 1: chlorotic flecking with very small uredia in some of the flecks; 2: chlorotic flecking with small uredia in most flecks; 3: mid-sized uredia surrounded by distinct chlorosis; 4: full-sized uredia surrounded by faint chlorosis.

to most cultures, but was susceptible to cultures 6, 14, 15, and 29. The strain WI X2505-4 showed an identical pattern of reaction except for resistance to cultures 15 and 29. The commercial cultivar, Jaycee, which is in the percentage of WI X2505-4, is generally regarded as having no significant degree of resistance to *P. coronata*. Nevertheless, it was resistant to cultures 14 and 29, suggesting that it had furnished some of the resistance carried by WI X2504-4.

Of practical interest from the plant breeding standpoint was that several strains regarded as relatively new have broad resistance across the 34 crown rust cultures. All were cultivated-type oats derived from *A. sterilis*. Two (IA D615-16 and IA H659-59) were susceptible to only a single culture, and three others were susceptible to only two of the 34 cultures. Such material may be useful in developing disease-resistant cultivars.

A strategy often suggested for use of resistance genes to control crown rust is to combine, or stack, two or more genes in the same cultivar to achieve resistance to a broader range of pathogen genotypes. We found many combinations of only two oat strains that would give resistance to all 34 cultures. Examples of two such strain combinations are shown in Table 2. In all, there were 182 such combinations that could, in theory, be used this way.

The categorization of all reaction types as simply "resistant" or "susceptible" obviously is an artifical convention, and the approach used in this study furnished information on relative degree of resistance to different cultures of *P. coronata*. The reactions observed formed a continuum from those in which there was no visible effect of infection to "fully susceptible," the latter indistinguishable from reactions seen on cultivars regarded as universally susceptible. The significance of different degrees of resistance to practical epidemiology is debatable, but studies such as this provide basic data on different reaction types that may be important. The strain CAN Pc-50, for example, had an immune reaction (no visible evidence of infection) to almost all cultures to which it was resistant. In contrast CAN Pc-46, also resistant to most cultures, was not immune to any culture and showed a strong flecking reaction to most. The resistance of certain other strains was commonly characterized by the presence of small uredia. Such information could conceivably be of value in predicting the future course of development of virulence in the pathogen.

Testing the many lines involved in breeding and prebreeding programs of oat cultivar development is laborious and expensive. Because of this, an important secondary objective of our study was to evaluate cultures of *P. coronata* for relative efficiency in testing

Table 2. Differential reactions[a] of members of two pairs of oat strains to cultures of the crown rust fungus, illustrating combined resistance to all cultures.

Oat strain	Rust culture no.											
	2	3	4	7	9	10	24	28	29	31	32	34
IA X434	R	S	S	R	S	R	R	S	R	R	R	R
CAN Pc-46	S	R	R	S	R	S	S	R	S	S	S	S
	3	5	6	10	13	14	15	16	24	29	31	
IA H 382	R	R	S	R	R	S	S	R	R	S	R	
IA H610-322	S	S	R	S	S	R	R	S	S	R	S	

[a]All four strains were resistant to all other cultures.

breeding material and potential sources of resistance. We assumed that the culture virulent toward the greatest number of oat strains would, by and large, be most efficient for such testing. Culture 10 was most virulent, parasitizing 45 of the 70 strains of oats. Culture 19 had the narrowest range of virulence, parasitizing only 6 of the 70 oat strains. Thus, the use of culture 10 alone would provide a great deal of practical data on the resistance of experimental oat strains while number 19 would be virtually worthless.

REFERENCES

BROWDER, L. E. 1971. Pathogenic specialization in cereal rust fungi, especially *Puccinia recondita* f. sp. *tritici:* concepts, methods of study, and application. U.S. Dept. Agric. Tech. Bul. 1432, 51 pp.

BROWNING, J. A., and K. J. FREY. 1981. The multiline concept in theory and practice. p. 37-46. *In* J. F. Jenkyn and R. T. Plumb (eds), Strategies for the Control of Cereal Disease. Blackwell Scientific, Boston.

DAY, P. R. 1977. The genetic basis of epidemics in agriculture. Ann. N.Y. Acad. Sci. 287:1-400.

DINOOR, A., and I. WAHL. 1963. Reaction of noncultivated oats from Israel to Canadian races of crown rust and stem rust. Can. J. Plant Sci. 43:263-270.

FLOR, H. H. 1956. The complementary genic systems in flax and flax rust. Adv. Genet. 8:29-54.

FREY, K. J., J. A. BROWNING, and M. D. SIMONS. 1980. Management systems for host genes to control disease loss. Indian J. Genet. Plant Breed. 39:10-21.

MARTENS, J. W., R. I. H. MCKENZIE, and D. E. HARDER. 1980. Resistance to *Puccina graminis avenae* and *P. coronata avenae* in the wild and cultivated *Avena* populations of Iran, Iraq, and Turkey. Can. J. Genet. Cytol. 22:641-649.

MURPHY, H. C. 1935. Physiologic specialization in *Puccinia coronata avenae*. U.S. Dept. Agr. Tech. Bul. 433, 43 pp.

SIMONS, M. D., H. H. LUKE, W. H. CHAPMAN, H. C. MURPHY, A. T. WALLACE, and K. J. FREY. 1957. Further observations of races of crown rust attacking the oat varieties Landhafer and Santa Fe. Plant Dis. Rep. 41:964-969.

SIMONS, M.D., I. WAHL, and ADY RAUL DA SILVA. 1962. Strains of noncultivated *Avena* spp. resistant to important races of the crown rust fungus. Phytopathology 52:585-586.

WAHL, I. 1970. Prevalence and geographic distribution of resistance to crown rust in *Avena sterilis*. Phytopathology 60:746-749.