Effect of Crown Rust on Oat Groat Protein

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Scientific Journal Series Paper 10,535 of the Minnesota Agricultural Experiment Station.
Accepted for publication 16 February 1979.

ABSTRACT

SINGLETON, L. L., D. D. STUTHMAN, and M. B. MOORE. 1979. Effect of crown rust on oat groat protein. Phytopathology 69:776-778.

Oat (*Avena sativa* L.) cultivars of differing susceptibility to crown rust were evaluated in the field in 1971 and 1972 to ascertain their percentage of groat protein (PGP) and total protein yield (TPY) with and without infection by *Puccinia coronata* f. sp. *avenae*. Without rust in both years, the 12 cultivars exhibited significant differences in both PGP and TPY. Crown rust epidemics were characterized as moderate in 1972 and severe in 1971, owing to differences in time of epidemic initiation at distinct plant growth stages. With rust, PGP and TPY for all cultivars decreased an average of 1.1% and 75 g per plot in 1971, compared with 0.4% and 20 g per plot in 1972, respectively. Thus, the greater epidemic severity in 1971 led to a larger average reduction in PGP and TPY than in 1972. However, the TPY and PGP responses of cultivars with rust varied more in 1972. In both years with rust, some cultivars (Coachman and Tippecanoe) were affected to a greater degree than Kota regardless of epidemic severity because of differences in their crown rust resistance. The data also suggest that cultivars with high PGP potential may respond more significantly to the effects of crown rust than cultivars with low PGP potential. The effects of crown rust on protein accumulation are most striking when measured in terms of TPY.

Crown rust of oats (*Avena sativa* L.) caused by *Puccinia coronata* f. sp. *avenae* Fr. & Led. may interfere with field evaluations of oat cultivars. Broadfoot (2) reported in 1931 that grain from rusted wheat had a slightly higher protein content than that from rust-free wheat. In 1934, Caldwell et al (3) reported that severe leaf rust reduces the protein content of susceptible soft winter wheat cultivars and that the protein reduction appears to be

00031-949X/79/000138$03.00/0

proportional to rust severity. In 1945, Peturson et al (5) reported that wheat leaf rust increases the protein content of grain in 1 of 3 years. In 1948, they (6) reported that, with one exception, leaf rust decreased the protein in grain. Considering protein in oat groats in greenhouse studies, Murphy (4) reported a slight increase in crude protein as a result of crown rust infection. More recently, Spilde et al (7) suggested that groat protein was slightly decreased by crown rust. Similar results were obtained by R. A. Forsberg and M. D. Simons (*personal communication*).

This paper presents protein measurements of 12 oat cultivars with and without crown rust.

MATERIALS AND METHODS

In 1971 and 1972, twelve oat cultivars (Table 1) were planted at St. Paul, MN, in a randomized, complete block with a split-plot arrangement of treatments, replicated four times. Cultivars were assigned to whole-plots. Whole-plots were isolated with 2.4-m wide drill strips of a wheat/barley mixture (3:1, v/v). Each whole-plot was subdivided into two paired subplots (each 1.8 × 1.8 m) separated by a single row of the wheat/barley mixture. Each subplot consisted of 13 rows (15-cm row spacing) and was seeded at 72–90 kg/ha.

For inoculations with *P. coronata* f. sp. *avenae*, a spreader hill of the cultivar Coachman (15 seeds per hill) was planted in the center of each subplot. Treatments with and without rust were assigned randomly to each of the subplot pairs. Each subplot without rust was sprayed with maneb (4.5 kg/ha) at 7–10 day intervals beginning at the time of inoculation. Rusted subplots were treated as follows: the Coachman spreader hill was inoculated before full boot growth stage with an oil/spore mixture (0.1–0.15 ml/hill) of aeciospores or urediospores of *P. coronata* f. sp. *avenae*. After 8–10 days, plants in the inoculated spreader hills were thinned to yield 50–150 pustules per hill. Crown rust severities, recorded as percentages of flag leaf surface covered with rust, were taken periodically.

Volumetric samples (50 ml) of oats were dehulled with an impact dehuller. Colorimetric determinations (1) of oat groat protein were made on 0.5 g of whole groats in 1971. In 1972, the samples were analyzed by V. L. Youngs at the USDA Oat Quality Laboratory in Madison, WI. Data analyses for split-plot design were as outlined by Steel and Torrie (8). Weight (g) of protein per plot was estimated by multiplying seed yield per plot by percentage of protein in the groats.

RESULTS AND DISCUSSION

Without rust, the percentage of groat protein (PGP) for all cultivars averaged 18.1% (range, 14.8–20.5%) in 1971 and 16.0% (range 12.8–18.6%) in 1972. Similarly, the total protein yield (TPY) averaged 196 g per plot (range, 174–219 g) in 1971 and 185 g per plot (range, 151–215 g) in 1972.

The cultivars exhibited significant differences in PGP and TPY in both years without rust (Table 1). The higher PGP and TPY values in 1971 also suggest that the growing season was more favorable for protein accumulation in 1971 than in 1972.

Crown rust on flag leaves of all genotypes was more severe in 1971 than in 1972 (Table 1). The 1971 epidemic was initiated while the early maturing cultivars (Tippecanoe, Minhafer, and Iowa M70) were heading, whereas the 1972 epidemic began when the midseason cultivars (Coachman, Kota, Kelsey, Ajax and Portage) were heading. Thus, the greater epidemic severity in 1971 resulted primarily from an earlier initiation of the epidemic. The severity of crown rust differed among cultivars in both years, as expected, because the cultivars had been selected to represent plants with a range of crown rust resistance. However, the cultivars were an unselected population relative to their groat protein potential.

With rust, PGP and TPY for all cultivars decreased an average of 1.1% and 75 g per plot in 1971, compared with 0.4% and 20 g per plot in 1972, respectively. Thus, along with the greater epidemic severity in 1971, the average reduction in PGP and TPY was larger. With rust in 1971 (Table 1), all cultivar reductions in TPY were significant. Also, all cultivars except Kota declined in PGP, but only seven reductions were significant. In 1972, with rust (Table 1), TPY was reduced in all cultivars except Minhafer and Portage, and only six TPY reductions were significant. Furthermore, with rust in 1972, PGP declined in only six cultivars, and only three of these lost significantly. Also, the PGP for Kota and CI 8235 did not change with rust, and the remaining cultivars showed nonsignificant increases in their PGP. Thus, generally, the TPY and PGP responses were more variable under the influence of the moderate epidemic in 1972 than in 1971. In this respect with rust, the PGP responses were more variable than the TPY responses in both years.

Some cultivars were affected more than others by crown rust regardless of the epidemic severity. For example, in both years, PGP declined significantly in Coachman and Tippecanoe, but not at all in Kota. Thus, some cultivars may be more sensitive to the effects of crown rust because their degree of crown rust resistance

TABLE 1. Percentage of groat protein and total protein yield of 12 oat cultivars of different susceptibility to crown rust caused by *Puccinia coronata* f. sp. *avenae* in years of severe (1971) and moderate (1972) rust infection, compared with growth free of rust

	1971[w]				1972[w]				
		Groat protein (%)		Total protein yield (g per plot)			Groat protein (%)		Total protein yield (g per plot)	
Cultivar	CRS[x] (%)	Without rust	With rust	Without rust	With rust	CRS[x] (%)	Without rust	With rust	Without rust	With rust
Tippecanoe	85	19.3 abc[y]	17.3**[z]	219 a[y]	107**[z]	57	18.6 a[y]	17.3**[z]	151 b[y]	135
Coachman	85	18.5 abc	17.0**	191 ab	87**	50	17.3 ab	15.7**	188 ab	142**[z]
65B 1301	43	17.3 bcd	16.0**	175 b	79**	15	15.1 c	14.0*	181 ab	153**
Kota	40	17.1 bcd	17.1	215 ab	123**	18	14.9 c	14.9	215 a	178**
Kelsey	30	14.8 d	14.1	175 b	94**	4	12.8 d	13.3	183 ab	156**
Ajax	27	20.5 a	19.5*	194 ab	104**	5	15.8 bc	15.4	191 ab	169*
65B 1286	20	16.8 cd	16.5	174 b	141**	3	14.8 c	15.0	194 ab	161**
Minhafer	15	18.2 abc	16.1**	192 ab	121**	5	16.5 bc	15.9	157 b	158
Multiline M70	8	19.6 ab	18.8	204 ab	161**	6	17.7 ab	17.2	192 ab	188
Portage	5	19.1 abc	18.0*	200 ab	144**	1	16.5 bc	16.6	184 ab	186
68 Ob. 8038	5	17.7 bc	17.3	215 ab	145**	6	15.9 bc	16.2	196 ab	185
CI 8235	5	18.0 abc	16.8*	203 ab	147**	1	15.8 bc	15.8	182 ab	173
Mean		18.1	17.0	196	121		16.0	15.6	185	165

[w]Values are the means of four replications.

[x]CRS = crown rust severity as percentage of flag leaf area at 69 and 71 days after planting in 1971 and 1972, respectively.

[y]Values followed by common letters within a column refer to percentage groat protein or total protein yield of cultivars without rust and are not significantly different at $P = 0.01$.

[z]Asterisks indicate the level of significant differences for comparisons of cultivars without and with rust for each cultivar. (* denotes significance at $P = 0.05$ and ** denotes significance at $P = 0.01$).

differs. Furthermore, it is possible that cultivars with higher protein potential may be more subject to the effects of crown rust. As shown, in both years (Table 1), Tippecanoe and Coachman without rust exhibited high PGP potential and with rust both showed significant reductions in PGP. On the other hand, Kelsey, with a low PGP potential without rust, never showed significant reduction in PGP with rust. Therefore, cultivars with high PGP potential may be more affected by crown rust than are cultivars with low PGP potential.

According to reports, rust may increase protein slightly (2,4), decrease it (3,6, and Forsberg, Simmons [*personal communications*]), or not influence protein content (7). Our data indicate that these differences may derive from one or more of the following: (i) duration and severity of the epidemic, (ii) degree of crown rust resistance of the plant cultivars, (iii) protein content of the plant in rust-free conditions. The data also suggest that the effects of crown rust on protein accumulation are most striking when measured in terms of total protein yield.

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