Wheat Peduncle Structure in Relation to Slow Rusting by *Puccinia graminis* f. sp. *tritici*

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ABSTRACT

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Two hundred forty-eight wheat (*Triticum aestivum*) lines were rated for seven characters of the peduncle and slow rusting caused by *Puccinia graminis* f. sp. *tritici* as indicated by area under the disease progress curve (AUDPC). The characters studied were thought capable of restricting stem rust development. The lines varied from one another for the several characters and for slow rusting. The correlation coefficients for the relationship between each character and AUDPC were statistically nonsignificant.

Certain morphological and anatomical characters of the wheat peduncle may influence the development of stem rust (1–4,10–12). While it seems reasonable that these characters of the stem may restrict the pathogen to certain tissues, their effect on the development of stem rust epidemics has not been fully documented. The objective of this work was to provide further evidence on this relationship.

MATERIALS AND METHODS

In 1975, 248 wheat lines obtained from the U.S. Department of Agriculture's collection of elite stem rust resistant lines and from the International Center for the Improvement of Maize and Wheat (CIMMYT) were planted in the stem rust nursery at St. Paul, MN. Each line was planted as a hill with 10–15 seeds; the hills were 30 cm apart in pairs of rows also 30 cm apart in three replications. Plots were surrounded by susceptible wheats from which inoculum was allowed to disperse onto the test plants. Races 11, 15, 15B2, 32, 113, and 151 of *Puccinia graminis* Pers. f. sp. *tritici* were used for the test.

The severity of stem rust was evaluated according to the modified Cobb Scale (6) just after the plants had tillered and at 8-day intervals thereafter until the plants were in the hard-dough stage of growth. When rust severity was below 1%, the uredia were counted and then converted to a percentage basis by equating 10 uredia per culm to 1% severity (9). The development of the stem rust epidemic was studied by means of the area under the disease progress curve (AUDPC) calculated with the aid of the computer program used by Skovmand et al (9).

Morphological and anatomical characters of the peduncles of the lines were observed in plants after the peduncles had fully elongated following heading. Five peduncles per line, each from a different plant, were collected and placed in formalin acetic acid alcohol for a minimum of 24 hr at room temperature and then in a solution of 10% glycerol and 20% dimethylsulphoxide for 24 hr. Sections 60 μm thick were cut from each peduncle 2.5 cm below the rachis by using a freezing microtome. Sections were mounted in glycerol and stored flat until examined. Measurements were taken by direct observation of the sections or from photomicrographs at ×32 or ×12 magnification, depending on the size of the peduncles. Stomata were counted on five pieces of tissue taken about 3.0 cm below the rachis when peduncles were observed or about 2.0 cm below the point of attachment of the flag leaf when leaf sheaths were observed. The tissues were mounted in water and stomata were counted at ×200 magnification.

The following plant characteristics, previously reported to influence the development of stem rust, were measured in each peduncle: the amount of chlorenchyma tissue subtending the epidermis, the percentage of chlorenchyma tissue in single strands, thickness of epidermis over chlorenchyma strands, the shape of chlorenchyma strands, peduncle contour, and the numbers of stomata on peduncles and leaf sheaths. The relationship between individual anatomical or morphological characters and AUDPC of each wheat line was studied by means of correlation coefficients and Student's *t*-test of significance.

In a confirmatory study (7) made in 1976, the development of stem rust was observed in 127 of the lines that had been studied in 1975; the same techniques and experimental design were used. These 127 lines were selected because they represented the full range of the morphological and anatomical characters as well as AUDPC values. The correlation of AUDPC obtained in the 1976 epidemic was studied in relation to the anatomical and morphological characters of plants grown in 1975. It seemed unnecessary to reevaluate the lines for anatomical and morphological characters because these had proven to be stable over a wide range of environmental conditions (3,8).

RESULTS AND DISCUSSION

The catalog of the 248 lines studied and their anatomical and morphological characters as well as their AUDPC values may be seen in the senior author's field book, which is on deposit at the Department of Plant Pathology, University of Minnesota, and in part in her M.S. thesis, which is on deposit in the library of the University of Minnesota (7). A summary of the data (Table 1) showed that for each character there was a wide range of values among the lines, which allowed us to test its potential association with the development of stem rust epidemics.

Development of the stem rust epidemics in 1975 and 1976, as indicated by AUDPC, was not correlated with any of the observed anatomical or morphological characters of the peduncle or leaf sheath (Table 2). The lack of association of peduncle characters with differences in AUDPC suggests that these characters are not important in stem rust resistance. All of the lines developed infection types, indicating that they were susceptible to the races of the pathogen that were present in the field. Thus, race-specific

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TABLE 1. Ranges and mean values for morphological and anatomical characters of peduncles of 248 wheat lines, and for areas under the disease progress curve (AUDPC) for plants infected with *Puccinia graminis* f. sp. *tritici* at St. Paul, MN, in 1975

Peduncle Character[a]	Range	Mean	Population at mean (%)
Chlorenchyma beneath endermis (%)	34–68	54	68
Chlorenchyma strands (% single)	5–86	51	30
Chlorenchyma strand shape[b]	1–3	...	...
Peduncle contour[c]	1–3	...	...
Epidermis thickness (μ)	15–23	19	61
Peduncle stomata (no./mm^2)	713–1,587	1,233	38
Leaf sheath stomata (no./mm^2)	125–1,020	750	17
AUDPC	1–850	125	19

[a] Characters observed in five plants in each of 248 lines except for AUDPC, which was calculated from disease progress curves from each line in three replications.
[b] 1 = Strand flask-shaped, 3 = strands flat-surfaced, and 2 = a mixture of 1 and 3.
[c] 1 = Peduncle smooth, 2 = slightly ridged, and 3 = prominently ridged.

TABLE 2. Correlation coefficients for the relationship between anatomical and morphological characters of the peduncle and the area under the disease progress curve (AUDPC) for wheat plants infected with *Puccinia graminis* f. sp. *tritici* at St. Paul, MN, in 1975

	AUDPC[b]	
Peduncle characters[a]	1975	1976
Chlorenchyma beneath epidermis (%)	−0.03	0.03
Chlorenchyma strands single (%)	−0.08	0.03
Chlorenchyma strand shape[c]	−0.08	−0.03
Peduncle contour[d]	−0.07	−0.03
Epidermis thickness (μ)	0.05	−0.08
Peduncle stomata (no./mm^2)	0.09	0.01
Leaf sheath stomata (no./mm^2)	0.05	0.12

[a] Characters observed in five plants in each of 248 lines. None of the correlation coefficients were statistically significant ($P = 0.05$).
[b] AUDPC based on three hills in each of 248 lines in 1975 and 127 lines in 1976.
[c] 1 = Strands flask-shaped, 3 = strands flat-surfaced, and 2 = a combination of 1 and 3.
[d] 1 = Peduncle smooth, 2 = slightly ridged, and 3 = prominently ridged.

resistance mechanisms probably were not involved in restricting the development of the epidemics. Furthermore, dry weather limited the severity of the epidemics in both years, so the plant characters associated with resistance should have been able to exert their full effect on the epidemics. Had there been massive development of stem rust, the effects of plant characters might have been overwhelmed.

Our results confirm other reports (2,3,5,7,10) that morphological and anatomical characteristics of the wheat peduncle vary among cultivars. Our results also agree with the conclusion of Mathur (5) that these characters are not closely related to the development of stem rust. Our conclusions differ from those of Hart (3) who thought that the plant characters reduced the severity of stem rust. Perhaps these differences in opinion may be explained by the fact that Hart (3) studied relatively few cultivars with known reactions to *P. graminis* f. sp. *tritici* and did not use statistical procedures to evaluate the relationships. On the other hand, Mathur (5) studied 21 cultivars; we studied several hundred and statistically evaluated the relationship between plant characters and the development of epidemics.

We did not study the effect of plant anatomical and morphological characteristics on individual components of slow rusting. Rather, we chose to relate the plant's characteristics to AUDPC because AUDPC summarizes the effects of all factors that might influence the development of an epidemic. Of the major components of slow rusting, it seems likely that infection frequency and latent period were not affected by the plant's anatomical and morphological characteristics. It is possible, however, that the enlargement of uredia and sporulation by the pathogen were affected by plant structure, as indicated by Hart (3). If this is so, it was not obvious in our material. Perhaps our placement of fast-rusting and slow-rusting plants adjacent to each other prevented observation of the relationship. Further work will be required to clarify this point.

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