Analysis of Symptoms on Spring and Winter Wheat Cultivars Inoculated with Different Isolates of *Septoria nodorum*

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ABSTRACT

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Ten winter and spring wheats that differed in level of resistance were quantitatively inoculated with 14 different cultures of *Septoria nodorum*. Symptoms measured were the number of lesions per square centimeter and the percentage leaf area necrotic on seedlings. The wheats differed in responses to the single isolates of *S. nodorum* from uniformly mild (winter wheats Anderson, Coker 68-8, and Redchief) to uniformly severe (spring wheats Fortuna and Polk). Moderate cultivar × isolate interactions were found in the winter wheats 91-728, Centurk, and Flint and in the spring wheat Olaf. Seedling disease severity agreed with glume blotch severity in the field on all cultivars in some test locations, but not in others. However, the pathogenicity patterns expressed by the 14 isolates of *S. nodorum* were not correlated with geographic origin. Pathogenic interactions were classified as resistant, intermediate, or susceptible. The magnitude of pathogenic interaction within the intermediate class was relatively low and since no isolate was found virulent on the uniformly resistant cultivars, no attempt was made to classify pathogenicity patterns into defined physiologic races.

Additional key words: Triticum aestivum, glume blotch.

Septoria nodorum (Berk.) Berk. (perfect state, *Leptosphaeria nodorum* Müller), the causal agent of glume blotch disease of wheat, has been studied considerably in recent years because of the damage it causes to wheat in several parts of the world (2,3,6,7,10,15). Many studies of resistance in wheat have utilized mixtures of isolates of *S. nodorum* secured from several host sources and geographic locations (3,4,13,14). Some authors have referred to the presence or absence of physiological races or differential host-pathogen interactions among the obviously different populations of *S. nodorum* (11,12,14). The utilization of quantitative inoculation techniques enabled more accurate evaluation of host symptoms in light of an obvious lack of qualitative host response (5,11). In a recent publication Allingham and Jackson (1) presented information on variation in pathogenicity and virulence of 282 isolates of *S. nodorum* secured from the principal wheat-growing areas in northern Florida. The authors concluded that despite differential interactions, the 253 resistance patterns found did not permit conventional race differentiation. Rufty et al (8,9) tested nine isolates of *S. nodorum*, eight from North Carolina and one from Montana, on seedlings of

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four winter wheat cultivars and found significant cultivar × isolate interactions that were indicative of specific resistance, but the magnitude of specificity was not high. The presently reported experiments were designed to test a series of cultures of *S. nodorum* that were known to differ in pathogenicity, measured by the amount of necrosis and number of lesions caused on test cultivars, on a series of wheats that were known to differ in resistance to the pathogen (12). From these experiments we were able to determine whether differential interactions occurred.

MATERIALS AND METHODS

The *S. nodorum* isolates used in this study were single-pycnidium isolates from Alabama (75-25, 75-26, 75-27), Montana (H-28, H-29, 5-43, 6-44), and Virginia (72-5). Spores from a single pycnidium from each original source were used in these experiments. Cultures were grown on yeast-malt agar in petri dishes for 7 days at 20 C under constant light of 20 W cool-white fluorescent lamps (6.6×10^3 ergs/cm^2/sec) (4,5). The plates were flooded with 3–5 ml of sterile water and the cirrhi that contained pycnidiospores were removed by gently rubbing the agar surface with a glass rod. A spore suspension from several agar plates was used to inoculate the seedlings.

Ten wheat cultivars with diverse genetic backgrounds and different levels of resistance to *S. nodorum* were selected for these studies. Six were winter wheats (91-728; Anderson, C.I. 12536; Centurk, C.I. 15075; Coker 68-8; Flint, C.I. 6307; and Redchief, C.I. 12109) and four were spring wheats (Fortuna, C.I. 13596; Manitou, C.I. 13775; Olaf, C.I. 15930; and Polk, C.I. 13773).

Seeding, growing, and inoculation methods were as previously described (5). Glass slides were used as spore traps to estimate the number of pycnidiospores that reached the leaves. The mean spore concentration per isolate was adjusted within the range of 4.4–5.6 $\times 10^7$ pycnidiospores per milliliter, which corresponded to 5.5–6.6 $\times 10^4$ deposited spores per square centimeter of leaf surface. Lesions per square centimeter were counted 8 days after inoculation and area of necrotic seedling tissue was estimated by dividing the leaf into 1-cm segments then assessing the green and the necrotic tissue in each segment 15 days after inoculation. The number of lesions and the percentage of necrosis per square centimeter were calculated for each leaf.

From eight to 20 leaves of each cultivar were inoculated with each isolate of *S. nodorum*. Susceptible cultivar Fortuna was used as a check cultivar in each inoculation set. The mean number of lesions and percentage of necrosis were used in analyzing the differences between cultivars for each isolate, or for analysis of the differences in response to each isolate for each cultivar. The host responses (lesions and/or percentage of necrosis) were adjusted to the response of the susceptible cultivar Fortuna after the data were analyzed by using Duncan's multiple range test. Boundary response classes (R = resistant and S = susceptible) were set by the susceptible cultivars Fortuna and Polk and by the consistently resistant cultivars Anderson, Coker 68-8, and Redchief, with the intermediate response classes floating between the extreme R and S boundaries on the basis of the multiple range test classification.

RESULTS

Number of lesions. Cultivar responses to 14 different isolates of *S. nodorum* as measured by the relative numbers of lesions per square centimeter of leaf tissue compared to the response of the susceptible check cultivar Fortuna are presented in Fig. 1. Plants of cultivars Fortuna and Polk responded similarly by producing high numbers of lesions to all isolates except to isolates 5-43-4, 75-26-7, and 75-27-8. An overall lack of isolate × cultivar interaction was expressed by the resistant winter wheats Anderson, Coker 68-8, and Redchief. The spring wheat cultivars Manitou and Olaf varied in response from resistant to intermediate except in their reaction to isolate 6-44-10 in which they manifested a high number of lesions, corresponding to a susceptible host response. Responses ranging from resistant to intermediate were expressed by the winter wheats 91-728, Centurk, and Flint. However, the cultivar Flint exhibited a high number of lesions when inoculated with isolate 6-44-10 secured from Winoka wheat in southeastern Montana. It is expected that the number of lesions per square centimeter of leaf area, being an early quantitative response parameter, would more accurately reflect the host response than percentage leaf necrosis. However, number of lesions is more difficult and laborious to evaluate than leaf necrosis. The wheat cultivars showed three distinct patterns of response: consistently resistant (Anderson, Coker 68-8, and Redchief), consistently susceptible (Fortuna and Polk), with several exceptions in the case of the cultivar Polk, and variable response in which the number of lesions ranged from resistant to intermediate for the winter wheats 91-728, Centurk, and Flint and the spring wheats, Manitou and Olaf. Plants of the latter two cultivars expressed distinct cultivar × isolate interaction showing a shift from the resistant-intermediate response to a susceptible response to isolate 6-44-10.

Percentage of necrosis. The adjusted cultivar response to the 14 different isolates of *S. nodorum* as measured by the area of leaf necrosis is given in Fig. 2. The winter wheat cultivars Anderson, Coker 68-8, and Redchief were uniformly resistant to all isolates. The relative leaf necrotic area of Anderson was significantly higher than the other two cultivars to isolates 75-27-1 and 75-25-4 secured from Shortana and Blueboy wheat in Huntsville, AL. The spring wheat cultivars Fortuna, Manitou, and Polk exhibited high leaf necrosis to all isolates except, in the case of Manitou, to isolates H28-5 and 75-27-8. Intermediate host responses were expressed by all other wheats, except for the winter cultivar Flint, which varied from intermediate to highly susceptible in response to isolates H28-7, H29-1, 6-44-10, 75-27-1, and 75-25-4.

There is good agreement in cultivar classification into response patterns for the two categories of symptoms studied, adjusted number of lesions per square centimeter, and adjusted percentage of necrosis per square centimeter of seedling leaf tissue.

Field response. Field responses of plants of winter wheat cultivars Anderson and Redchief were variable over several years and locations in USDA International Wheat Septoria Nurseries. These two cultivars, which consistently expressed high resistance at the seedling stage to all isolates (Figs. 1 and 2), were both resistant and susceptible at various locations and years. Redchief was generally susceptible in northwestern Europe and generally resistant in the southeastern United States during the years 1973–1980. Changes in host response from a resistant to a susceptible reaction in consecutive years in field nurseries may be due to changes in pathogenicity patterns of pathogen populations, to environment, or to anomalies of reading.

DISCUSSION

The presence of substantial wheat cultivar × *S. nodorum* isolate interaction on the basis of pathogenicity differences was reported by Allingham and Jackson (1). The authors made no attempt to analyze these differences or to separate the host seedling reactions into discrete response classes. A careful examination of the data presented in the present work reveal clear differences among the isolates of *S. nodorum* and among the host wheat cultivars. Some of the isolates were capable of affecting relatively more host tissue than others (6-44-10 and 75-25-4). Isolates differed among themselves in pathogenicity within one location and between locations (H28-5 and H28-7 on Centurk, 6-44-2 and 6-44-10 on Flint, and 75-27-1 and 75-27-8 on Manitou) (see Fig. 1). Moreover, isolates H28-5, 75-25-4, and 5-43-4, which originated from different geographic regions, expressed similar low levels of pathogenicity on Centurk (Fig. 1). The pathogenic patterns (lesions per square centimeter of leaf) expressed by the 14 isolates of *S. nodorum* were not necessarily correlated with specific geographic locations.

Area of necrosis, despite being more indicative of the damage caused to the plant tissue and, therefore, probably to reduction in grain yield than is the number of lesions, revealed fewer conclusive interactions between cultivar and isolate. Even the most resistant cultivars (Anderson, Coker 68-8, and Redchief) exhibited much more leaf necrosis than the corresponding lesion number counts (Fig. 2).

There were three distinct response classes in the seedling study: lack of cultivar × isolate interaction expressed in uniformly resistant response (Anderson, Coker 68-8, and Redchief); lack of cultivar × isolate interaction expressed in uniformly susceptible response (Fortuna, Polk, and [to some extent] Manitou); and interacting cultivar × isolate response of varying magnitude (91-728, Centurk, Flint, and Olaf). This permits classifying the cultivars on the basis of their response to the varying pathogenicity patterns expressed by the tested *S. nodorum* isolates. The continuous variation in host response of the interacting group (class 3) may suggest that resistance is controlled by the additive action of several genes, while the resistance of the highly resistant cultivars may be governed by major R-genes. Subjecting the cultivars or segregating populations from crosses among the cultivars to *S. nodorum* isolates with known pathogenicity patterns may furnish additional information as to the mode of inheritance and possible breeding strategies.

The magnitude of variation among isolates in the North Carolina studies (8,9) ranged ± 20% of the susceptible median of 51.3% leaf area covered by lesions and for cultivars ±14% of the same mean. In

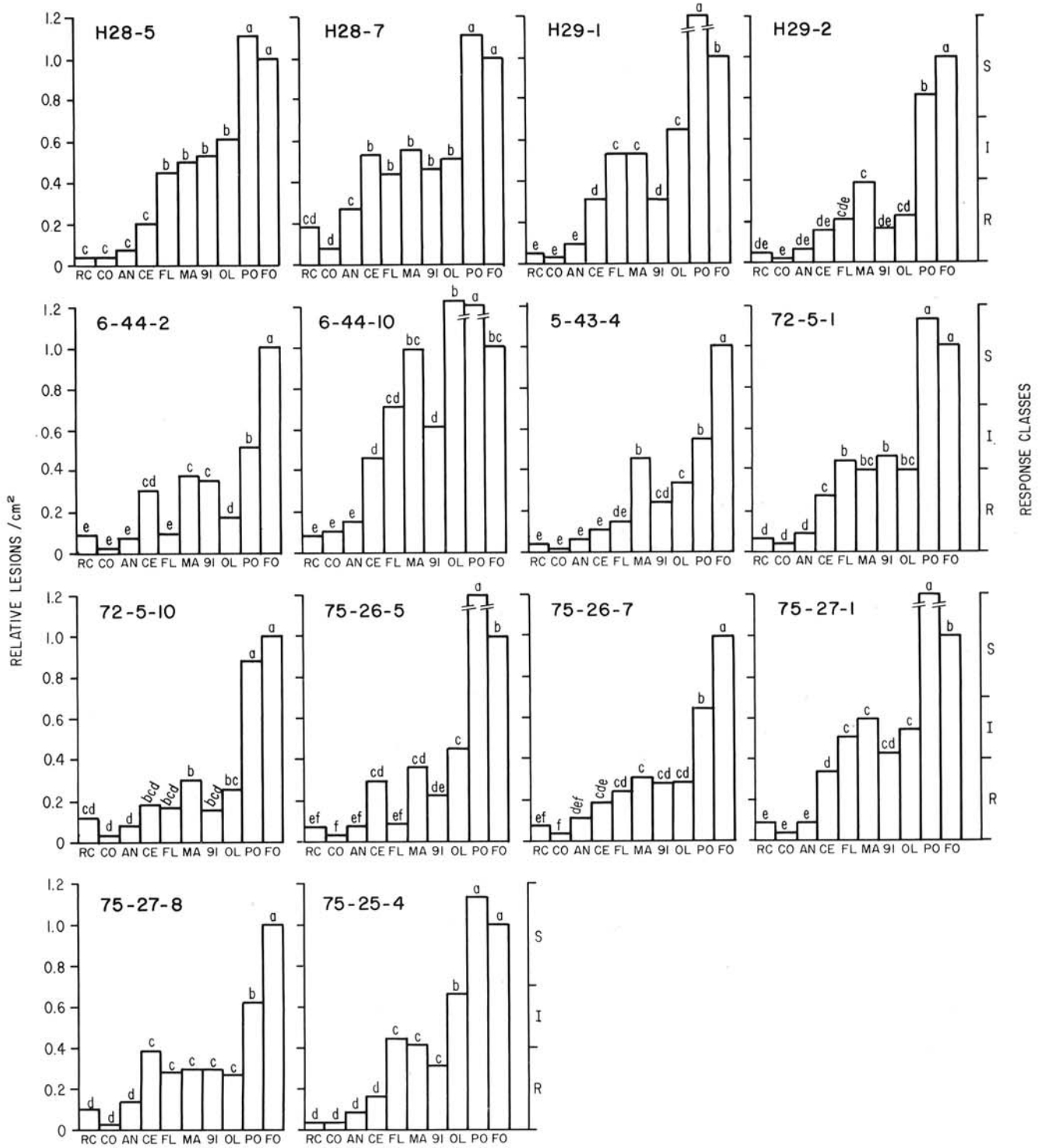

Fig. 1. Number of lesions per square centimeter on seedling wheat leaves inoculated with *Septoria nodorum*. Each histogram represents the reaction of 10 wheat cultivars to one isolate of *S. nodorum*. Isolates are identified by the number near the top left of each histogram. Cultivars: RC = Redchief; CO = Coker 68-8; AN = Anderson; CE = Centurk; FL = Flint; MA = Manitou; 91 = 91-728; OL = Olaf; PO = Polk; FO = Fortuna. Response classes: S = susceptible; I = intermediate; R = resistant. Bars having the same letter at the top are not significantly different, $P = 0.05$, according to Duncan's multiple range test.

the present study, the maximum difference in response for percentage necrosis per square centimeter was as high as 86% for the resistant cultivar Coker 68-8 compared to the susceptible check cultivar Fortuna (Fig. 2). However, due to the uniformly resistant and/or susceptible response of some cultivars to the test isolates of *S. nodorum*, no attempt was made with the current information to classify the pathogenicity patterns into defined physiologic races. Further elucidation of pathogenic variation within and between locations and countries, together with the assessment of frequencies and distribution of specific pathogenicity patterns, is needed. Furthermore, additional differential cultivars, which may possess a different genetic constitution than the cultivars used in these studies, are needed. It is of importance to evaluate the consistency of cultivar response to known isolates of *S. nodorum* at different plant growth stages. Implicit is the need for accumulating cultivar resistance from a number of sources if it is to be durable enough to withstand the pressure exerted by the pathogen variants in the population.

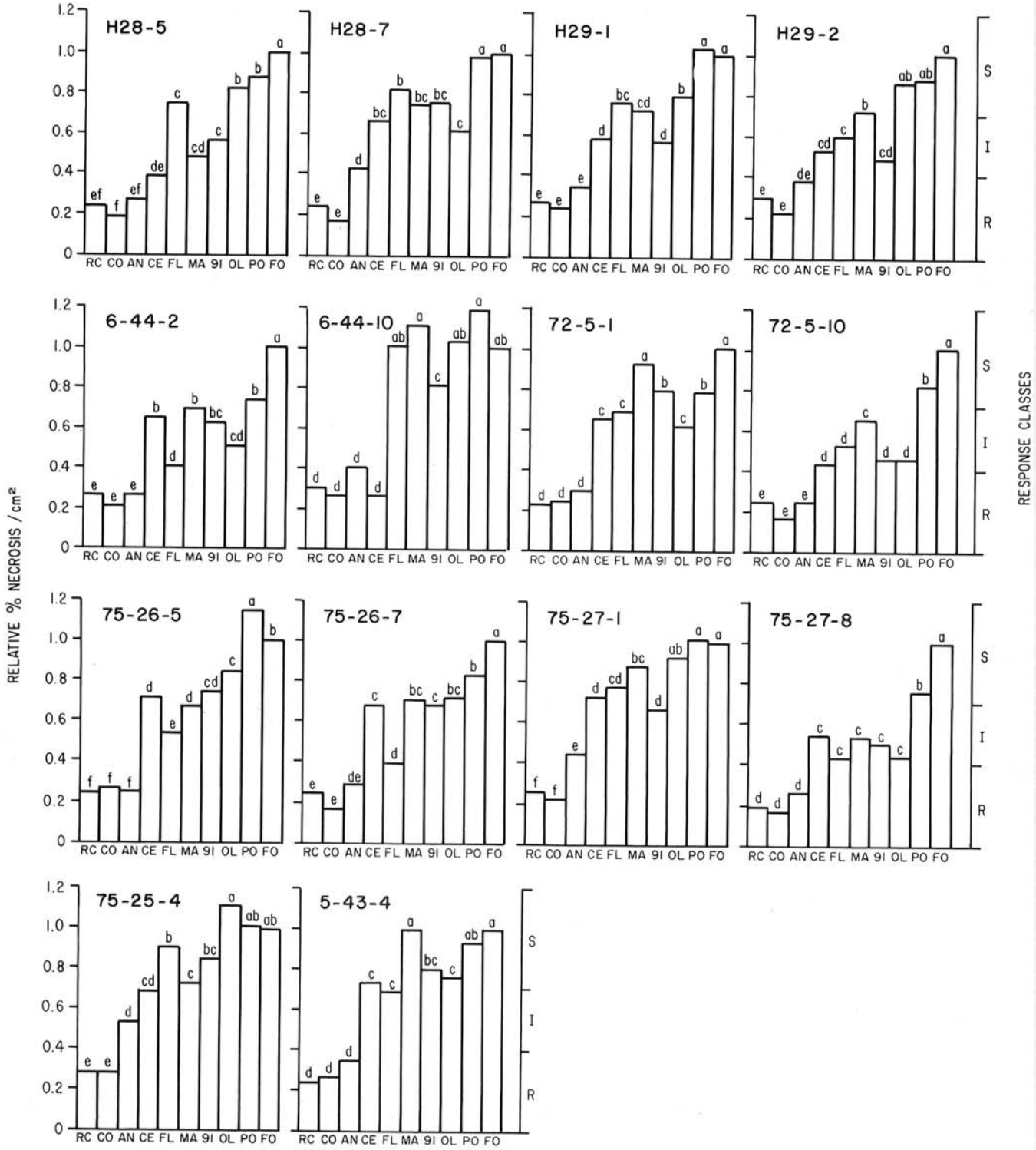

Fig. 2. Percentage necrosis per square centimeter on seedling wheat leaves inoculated with *Septoria nodorum*. Each histogram represents the reaction of 10 wheat cultivars to one isolate of *S. nodorum*. Isolates are identified by the number near the top left of each histogram. Cultivars: RC = Redchief; CO = Coker 68-8; AN = Anderson; CE = Centurk; FL = Flint; MA = Manitou; 91 = 91-728; OL = Olaf; PO = Polk; and FO = Fortuna. Response classes: S = susceptible; I = intermediate; and R = resistant. Bars having the same letter at the top are not significantly different, $P = 0.05$, according to Duncan's multiple range test.

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