Iran Agricultural Research 20:201-210 (2001)

NOTE

PATHOGENIC VARIABILITY OF *PHAEOSPHAERIA NODORUM* (E. MÜLLER) HEDJAROUDE

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(Received: September 14, 1997)

ABSTRACT

Pathogenic variability among four isolates of *Phaeosphaeria nodorum*, causal agent of glume blotch of wheat, was investigated. Aggressiveness of the isolates of the *P. nodorum* was examined by expression of components of partial resistance on six wheat cultivars. All isolates were pathogenic on all wheat cultivars. Significant differences in incubation period, latent period, and lesion type were found among isolates in intact leaf tests. There were significant differences among the six wheat cultivars in incubation, latent and maturation periods, and lesion type in the intact leaf tests. Significant correlation among some components of partial resistance was found. Lesion type was the best component to predict both aggressiveness of isolates and resistance of wheat cultivars. No evidence was found for the existence of races among the isolates of *P. nodorum*. However, based on differences in aggressiveness, different pathotypes could be recognized. Among the wheat cultivars, spring wheat '86ISWMN' 2137 had the highest resistance to the isolates of *P. nodorum*, measured by the components of partial resistance.

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Key Words: Pathogenic variability, *Phaeosphaeria nodorum*.

تحقیقات کشاورزی ایران

(۱۳۸۰) ۲۱۰-۲۰۱:۲۰

تنوع پاتوژنیک *Phaeosphaeria nodorum*

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به ترتیب، مربی دانشکده کشاورزی مراغـه، دانشـگاه تـبریز، مراغـه، جمهـوری اسـلامی ایـران واسـتادبخش علـوم زراعـی و اکولـوژی گیـاهی در دانشـگاه ساسکاچوان، ساسکاتون، کانادا.

چکیده

تنوع پاتوژنیک بین چهار جدایه *Phaeosphaeria nodorum* ، عامل بیماری سـوختگی گلوم گندم مورد بررسی و تحقیق قرار گرفت. تهاجمی بودن جدایه های *P. nodorum* بـه وسیله اجـزای نسبی مقاومت با شش رقم گندم آزمایش شد. تمام جدایه ها روی تمام ارقام گندم مـورد آزمـایش بیمـاریزا بودند. تفاوت های معنی داری برای دوره انکوباسیون، دوره نهفتگی، و رسیدگی و نیز نـوع خسـارت در آزمایش های برگ کامل به دست آمد. همبستگی معنی داری بین بعضی از اجزای نسـبی مقـاومت به دست آمد. نوع خسارت بهترین جزء برای پیش بینی تهاجمی بودن جدایه ها و مقاومت ارقام گنـدم بود. هیچ مدرکی دال بر وجود نژاد یا نژادها در میان جدایه های *P. nodorum* به دسـت نیـامد، لیکـن بر اساس تهاجمی بودن جدایه ها، پاتوتایپ های مختلف شناسایی شدند. در میـان ارقـام گنـدم، رقـم گندم بهاره 'ISWMN۲۱۳۷ ۸۶' بر پایه داده های اجزای نسبی مقاومت، بالاترین مقاومت را در برابر جدایه های *P. nodorum* از خوّد نشان داد.

INTRODUCTION

Phaeosphaeria nodorum (E. Müller) Hedjaroude is a necrotrophic fungus and causes septoria glume blotch on wheat (*Triticum aestivum* L. em Thell.) and other cereals such as barley, rye, and triticale. Presence of *P. nodorum* has been reported from all continents and causes significant damage to wheat in major production areas. Yield losses up to 56% have been reported (14). Very low success has been achieved in breeding for resistance to *P. nodorum* since resistance in wheat cultivars is partial and is quantitatively expressed. In addition, high morphological and pathogenic variability of *P. nodorum* has been reported, even in single spore cultures (11). Therefore, to breed effectively against *P. nodorum* in wheat, the extent of pathogenic variation among isolates of *P. nodorum* and the level of resistance in wheat cultivars should be determined. Some studies have been conducted to investigate pathogenic variability of *P. nodorum* (6, 15). However, knowlege of the extent of pathogenic variability of *P. nodorum* on common wheat cultivars with different levels of resistance to this pathogen is lacking. The objectives of the present study were to determine pathogenic variability of *P. nodorum* on common wheat cultivars with different levels of resistance to the pathogen and whether correlations exist among components of partial resistance to *P. nodorum* in wheat.

MATERIALS AND METHODS

To study pathogenic variability of *P. nodorum*, four isolates of *P. nodorum* and six common wheat cultivars were used. The isolates were single spore cultures derived from infected wheat leaf tissue collected from different regions of Saskatchewan, Canada at Meadow Lake (ML), Porcupine Plain (PP), Saskatoon (SK), and Leipzig (LZ). Six common wheat cultivars Kenyon, Columbus, 86ISWMN 2137, EE8, Atlas 66, and Red Chief were used in these experiments.

Four plants of each cultivar were grown in 15-cm diameter pots containing a 2:1:1 mixture of soil, vermiculite, and peat, respectively, in a walk-in growth room with a 16-h photoperiod (12 fluorescent lights and 16 light bulbs per bench), 22°C/16°C day/night temperature and 60-70% relative humidity. These plants were inoculated when the third leaf had fully extended, about three weeks after planting. Inoculum (with 2×10^6 spores ml^{-1}) was applied to leaves by spraying from different directions with a hand sprayer until near-runoff. The inoculated plants were placed in mist chamber for 48 h at room temperature and then moved back to the growth room bench. Incubation period, and lesion type at 7 d after inoculation were recorded for all cultivars (Fig. 1). Lesion type was rated on a zero to nine scale in which zero and nine represent highly resistant and susceptible cultivars, respectively. After recording the last incubation period, the third leaves of each cultivars were detached, washed, and surface sterilized with 0.6% sodium hypochlorite. Two ml of distilled water were poured on one layer of filter paper in each petri dish and 5 cm of each leaf was cut 10 cm from the leaf base. The leaf segments were put on wet filter paper in 9-cm diameter petri dishes which were sealed with Parafilm™ for 48 h. Latent period was recorded for all cultivars. Data for latent period were adjusted by subtracting the difference between sampling date and incubation period. Maturation period (days between incubation and latent periods) was calculated by subtraction of incubation period from latent period. The number of pycnidia was counted for three random microscope fields on each leaf segment under a binocular microscope. Pycnidial formation was very limited on the resistant cultivars and many zero counts were expected. Since an objective of this study was to measure differences in isolate aggressiveness, pycnidial production was determined only on susceptible cultivars, on which pycnidia developed abundantly.

In this experiment, a split-plot randomized complete block design with six replications was used with cultivars as the main-plot treatments and isolates as the sub-plot treatments. This experiment was repeated with four replications.

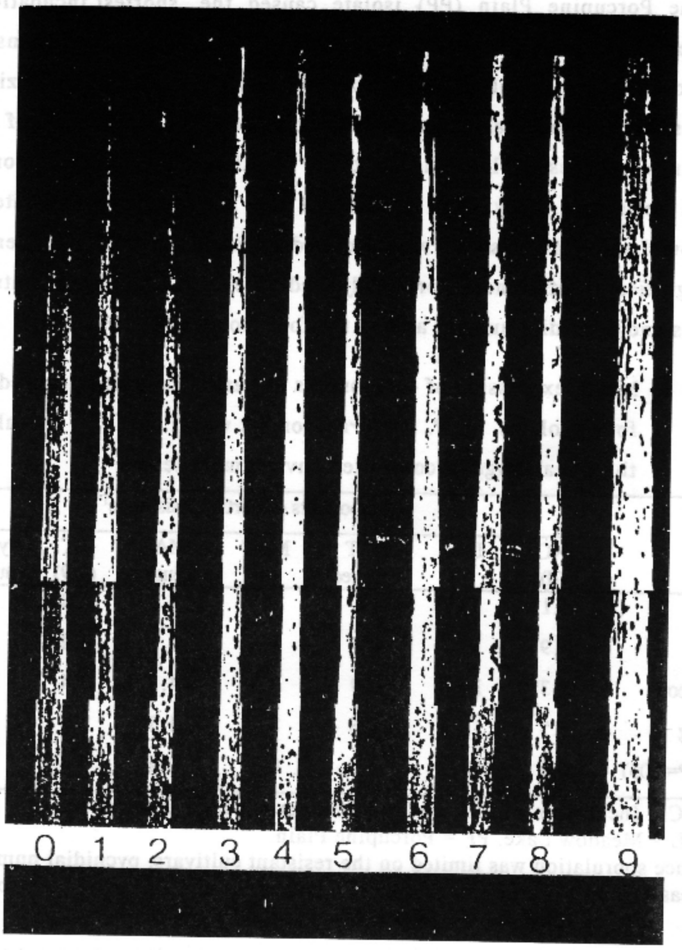

Fig. 1. Rating scale used to describe the lesion type (LT) produced on intact leaves after infection with *P. nodorum*. On this scale, 0 and 9 represent highly resistant and susceptible lesion types, respectively.

RESULTS

Significant differences were found among isolates of *P. nodorum* for incubation period, adjusted latent period, and lesion type (Table 1).

The Porcupine Plain (PP) isolate caused the shortest incubation and adjusted latent periods, and the highest lesion type (LT) and was considered the most aggressive isolate. In general, the Saskatoon (SK) and Leipzig (LZ) isolates caused the least susceptible expression of components of partial resistance. As these isolates did not differ significantly for any component of partial resistance, they were considered the least aggressive isolates. The Meadow Lake (ML) isolate was intermediate in aggressiveness. There were no significant differences for unadjusted latent and adjusted maturation periods and pycnidial number among the four isolates of *P. nodorum*.

Table 1. Mean expression of components of partial resistance caused by the four isolates of *P. nodorum* on six wheat cultivars inoculated at three-leaf stage in controlled environment tests.

	Components of partial resistance†						
Isolate§	INC (d)	LAT (d)	LAT adjusted	MAT (d)	MAT adjusted	LT (0-9)	Pycnidial number¶
ML	5.1	13.3	9.4	8.1	4.2	3.0	34
PP	4.9	13.1	8.9	8.3	4.1	3.4	24
Saskatoon	5.3	13.6	9.9	8.3	4.1	3.4	24
Leipzig	5.3	13.4	9.6	8.1	4.3	2.7	32
LSD (P=0.05)	0.2	0.3	0.5	0.3	0.4	0.5	16

† INC = Incubation period, LAT = latent period, LT = lesion type.
§ ML = Meadow Lake, PP = Porcupine Plain.
¶ Since sporulation was limited on the resistant cultivars, pycnidial number was measured only on the two susceptible cultivars, 'Kenyon' and 'Columbus'.

There were significant differences among the six wheat cultivars for incubation period, latent period (adjusted and unadjusted), maturation period (adjusted and unadjusted), and lesion type (Table 2).

Cultivars 'Kenyon' and 'Columbus' were the most susceptible cultivars to all isolates and showed similar values for each component of partial resistance, except for LT which was significantly higher for 'Kenyon' than for Columbus. Cultivar '86ISWMN 2137' was the most resistant cultivar and had the longest incubation and latent periods (adjusted and unadjusted), the longest maturation period (adjusted) and the lowest LT. Cultivars 'EE8', 'Atlas 66', and 'Red Chief' were also resistant and showed intermediate values for all components of partial resistance except LT. These three winter wheats had similar values for the components of partial resistance except 'Red Chief' for which the incubation period and the adjusted latent period were significantly shorter than 'EE8'. No significant differences for pycnidial number were found between 'Kenyon' and 'Columbus'.

No cultivar-isolate interaction for any component of partial resistance was found in this experiment.

Table 2. Mean expression of components of partial resistance of six wheat cultivars inoculated with four isolates of *P. nodorum* at three-leaf stage in controlled environment tests.

Cultivar	Components of partial resistance†						
	INC (d)	LAT (d)	LAT adjusted	MAT (d)	MAT adjusted	LT (0-9)	Pycnidial number§
'Kenyon'	3.0	12.0	6.0	8.9	3.0	6.8	29
'Columbus'	3.2	12.0	6.1	8.8	2.9	6.1	28
'86ISWMN 2137'	8.2	14.9	14.0	6.7	5.8	0¶	-
'EE8'	5.9	13.9	10.8	8.0	4.9	0.4	-
'Atlas 66'	5.6	13.8	10.3	8.2	4.7	0.6	-
'Red Chief'	5.0	13.5	9.4	8.5	4.4	0.8	-
LSD (P=0.05)	0.7	0.7	1.0	0.9	0.7	0.6	52

† INC = Incubation period, LAT = latent period, LT = lesion type.
§ Since sporulation was limited on the resistant cultivars, pycnidial number was measured only on the two susceptible cultivars, 'Kenyon' and 'Columbus'.
¶ Zero values not included in ANOVA.

DISCUSSION

All isolates of *P. nodorum* were pathogenic on all wheat cultivars tested in this study. No cultivar-isolate interaction was found for any of the components of partial resistance measured in the intact and detached leaf experiments. Lack of a cultivar-isolate interaction is generally interpreted as indicating no physiologic specialization, and therefore no evidence for the existence of physiologic races of *P. nodorum* was found in this study. The results of this study are in agreement with most studies (1, 3, 6, 10, 11, 12), but contrasts with others (4, 7, 13). The apparent lack of races in *P.*

nodorum has consequences for resistance breeding. Lack of races suggests that any cultivar resistant to the population of *P. nodorum* in one region could be used as resistant germplasm in breeding for resistance to *P. nodorum* in another region. However, if races existed, comprehensive host-pathogen studies would be needed before widespread use of a resistant cultivar could be made. Failure to detect physiologic races in this study does not mean that there were no differences among isolates. Differences based on pathogenicity were found and are considered to represent the existence of different pathotypes of *P. nodorum*. Pathotypes are genetically smaller subgroups within a species than races and have a particular pathogenicity character in common (9). Three pathotypes were recognized in this study, isolate PP, isolate ML, and isolates SK and LZ each representing the same pathotype.

Highly significant negative correlations were found for lesion type and incubation period (r =-0.99) and adjusted latent period (r=-0.98). A positive correlation existed between incubation period and adjusted latent period (r = 0.96). These correlations suggest association of components of partial resistance. Association of components of partial resistance to *P. nodorum* has been reported by other workers. Cunfer *et al.* (2) reported a significant association among components of partial resistance including incubation period, latent period, sporulation and necrosis. Since they found more variation for components of partial resistance measured on seedlings than on adult plants in field tests, care should be taken in generalizing results from a seedling test to the adult plants in a field test. Rapilly *et al.* (8) found a significant correlation between incubation period and leaf necrosis area on wheat cultivars in field tests. On the other hand, Jeger *et al.* (5) found that, in general, sporualtion and necrosis were associated on wheat seedlings in greenhouse tests, but desirable (low) levels of these two components were rarely associated in the same host genotype. Meanwhile, they found that other components of partial resistance, including incubation and latent periods, were not consistently associated with host resistance. Association of components of partial resistance within and among intact leaf experiment suggests that one key component, associated with other components of partial resistance, could be chosen as the selection criterion in breeding for resistance to *P. nodorum*. Because of its repeatability and its high association with other components of partial resistance, lesion type rating is recommended as the main component to be used in future experiments. Measuring incubation period on intact leaves, while less repeatable than lesion type rating, could be used in studies of the *P. nodorum*-wheat host-pathogen system.

In this study, cultivar 86ISWMN 2137 showed a high degree of resistance (even more resistance than three winter wheat cultivars EE8, Atlas 66, and Red Chief) to the *P. nodorum* and since this cultivar is a spring wheat cultivar, it could be used as a resistant germplasm in breeding for resistance to *P. nodorum* in spring wheat cultivars.

LITERATURE CITED

1. Allingham, E.A. and L.F. Jackson. 1981. Variation of pathogenicity, virulence and aggressiveness of *Septoria nodorum* in Florida. Phytopathology 71:1080-1085.
2. Cunfer, B.M., D.E. Stooksbury and J.W. Johnson. 1988. Components of partial resistance to *Leptosphaeria nodorum* among seven soft red winter wheats. Euphytica 37:129-140.
3. Eyal, Z., A.L. Scharèn, J.M. Prescott and M.Van Ginkel. 1987. The Septoria diseases of wheat: Concepts and methods of disease management. CIMMYT, Mexico. 52 p.
4. Harrower, K.M. 1977. Specialization of *Leptosphaeria nodorum* to alternative graminaceous hosts. Trans. Br. Mycol. Soc. 68:101-104.
5. Jeger, M.J., D.G. Jones and E. Griffiths. 1983. Components of partial resistance of wheat seedlings to *Septoria nodorum*. Euphytica 32:575-584.
6. Kuwite, C.A. 1993. Expression and genetics of resistance to *Leptosphaeria nodorum* in wheat. Ph.D. Thesis. University of Saskatchewan, Saskatoon, Canada.

7. Newton, A.C. and C.E. Caten. 1991. Characteristics of strains of *Septoria nodorum* adapted to wheat or barley. Plant Pathol. 40:546-553.

8. Rapilly, F., P. Auriau, Y. Laborie and C. Depatureau. 1984. Rechreches sur la resistance partielle du ble tendre a *Septoria nodorum* Berk. Agronomie 4:639-651 (cited by Cunfer *et al*. 1988).

9. Robinson, R.A. 1969. Disease resistance terminology. Rev. Appl. Mycol. 48:593-606.

10. Scharen, A.L. and Z. Eyal. 1983. Analysis of symptoms on spring and winter wheat cultivar inoculated with different isolates of *Septoria nodorum*. Phytopathology 73:143-147.

11. Scharen, A.L. and J.M. Krupinsky. 1970. Cultural and inoculation studies of *Septoria nodorum*, cause of glume blotch of wheat. Phytopathology 60:1480-1485.

12. Scott, P.R. and P.W. Benedikz. 1976. *Septoria*. In: Report of the Plant Breeding Institute, Cambridge, U.K. 114-115.

13. Smedegard-Petersen, V. 1974. *Leptosphaeria nodorum (Septoria nodorum)*, a new pathogen on barley in Denmark, and its physiologic specialization on barley and wheat. Friesia 10:251-264.

14. Wafford, J.D. and R. Whitbread. 1978. Effects of inoculation with *Septoria nodorum* leaf blotch on yield components of spring wheat. Ann. Appl. Biol. 90:323-328.

15. Yang, R. 1985. Variability for pathogen morphology, pathogenicity and host resistance in the wheat/ *Septoria nodorum* host-pathogen system. M.Sc. Thesis. University of Saskatchewan, Saskatoon, Canada.