VARIETAL REACTION OF OATS TO THE SEPTORIA DISEASE UNDER FIELD AND GREENHOUSE CONDITIONS[1]

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Abstract

Varieties of common oats (Avena sativa) show very little resistance to the Septoria disease in field and greenhouse tests. Several selected varieties and strains showed moderate tolerance under field conditions but gave a susceptible reaction when heavily inoculated in the greenhouse, A number of varieties from wild species, especially those in the diploid group, showed a much higher level of resistance. The differences in reaction between these and varieties of common oats was particularly noticeable when the varieties were compared in the greenhouse several weeks after inoculation. Macrospore inoculations in the greenhouse resulted in too severe an infection to permit the detection of small differences in reaction. The use of ascospores as inoculum indicated that this might be a better means of screening varieties in the greenhouse for resistance.

Introduction

The disease of oats caused by the fungus Leptosphaeria avenaria Weber f. sp. avenaria (imperfect stage = Septoria avenae Frank f. sp. avenae) has become, in recent years, a major problem of this crop in Canada. This disease is especially prevalent in Ontario, Quebec and the Atlantic Provinces. Infection by the fungus usually results in severe leaf lesioning and necrosis, stem blackening and kernel blight. In some years extensive lodging occurs which results in an almost complete loss of crop. Invasion of the oat glumes and kernels is also of considerable importance in certain years. In 1954, Derick (2) reported that under natural conditions some varieties showed more tolerance than others to the causal fungus in Eastern Canada but the tolerance was not present in the commonly grown varieties. Several workers in the United States have also reported differences in resistance among varieties (3, 4, 5, 6, 7, 8, 9, 10, 11).

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During the past few years numerous varieties and hybrids have been tested at Ottawa for their varietal reaction to L. avenaria f. sp. avenaria both in the field and greenhouse. This paper summarizes the results obtained since 1956.

Materials and Methods

In 1956, a selected group of varieties and hybrids was grown in field tests at 8 locations throughout Eastern Canada, including Ottawa, In 1957 and 1958 the material under test was grown only at Ottawa and was inoculated artificially with a highly virulent isolate of L. avenaria f. sp. avenaria using a water suspension of macrospores and mycelium. The fungus was grown on oat-leaf agar in plates for 7 days; then the cultures were macerated in a Waring blender in 100 c.c. of water per plate. A further dilution of 1:5 with water was made and finally a few drops of the spreader Tween 20 was added. The inoculum was applied with a knapsack type sprayer and inoculating was done only in the evenings.

Leaf blotch readings were taken twice during the growing season for each entry tested by estimating in percent, the area of plant covered by lesions. Substantial differences in maturity date of the entries made it necessary to take more than one reading. Stem infection readings were taken at maturity by estimating in percent, the amount of stem blackening. In the 1956 test, samples of straw of each entry grown at the 7 outside locations were sent to Ottawa and examined but the leaf blotch notes were recorded by the co-operators at the testing stations,

Testing in the greenhouse was carried out in 2 ways. The material was grown in a greenhouse bed for 3 to 4 weeks with at least 2 replicates included. Several hours before the plants were inoculated, the bed was completely covered with a large polyethylene sheet supported by a wire frame. The air inside was saturated with moisture by using a pneumatic atomizing nozzle placed at one end of the bed. During the winter months, the soil temperature was maintained at 70°F by means of a thermostatically controlled heating cable. The plants were inoculated with a spore-mycelium suspension of a highly virulent isolate as previously described, with the exception that the second dilution of 1:5 with water was not made, A pressure-vacuum sprayer supplying 5-10 lb. pressure was used to inoculate the plants and high humidity was maintained for 48 hours following inoculation, The second method of testing was to grow the test material in greenhouse flats and, in a few cases, greenhouse pots for 3 to 4 weeks and then to place the flats or pots in glass-enclosed chambers in which the humidity and temperature were controlled. The plants were inoculated in the same manner as those grown in the greenhouse bed and the high humidity was maintained for 48 hours.

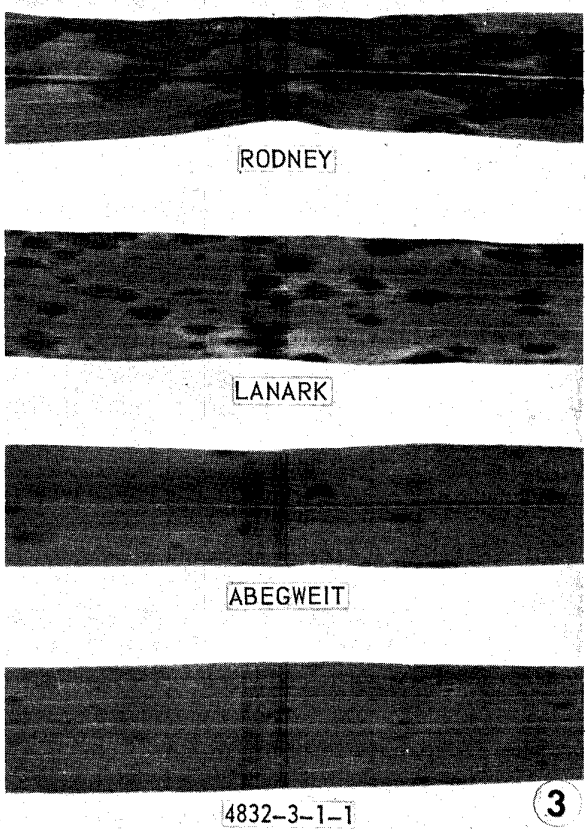

FIG. 1. LESION DEVELOPMENT ON THREE VARIETIES OF OATS APPROXIMATELY ONE MONTH AFTER INOCULATION IN THE GREENHOUSE WITH MACROSPORES OF *SEPTORIA AVENAE* F. SP. *AVENAE*. FROM LEFT TO RIGHT: RODNEY, C.D. 3820 AND ABEGWEIT. FIG. 2. BLACK STEM DEVELOPMENT ON THREE VARIETIES OF OATS AT MATURITY AFTER INOCULATION IN THE GREENHOUSE WITH MACROSPORES OF *SEPTORIA AVENAE* F.SP. *AVENAE*. FROM LEFT TO RIGHT: C.D. 3820, ABEGWEIT AND RODNEY. FIG. 3. LESION DEVELOPMENT ON LEAVES OF FOUR VARIETIES OF OATS INOCULATED WITH ASCOPORES OF *LEPTOSPHAERIA AVENARIA* F. SP. *AVENARIA*. FROM TOP TO BOTTOM: RODNEY, LANARK, ABEGWEIT AND 4832-3 -1-1.

In the greenhouse, disease readings were determined 10 to 14 days following inoculation by estimating the percent infection on the leaves. The fungus does not develop in the greenhouse to any extent on tissues produced after inoculation and therefore, only the inoculated portions of the leaves were considered in the readings. In a few instances, the plants were kept for approximately a month after inoculation and readings taken then were compared with those taken earlier.

A study of infection resulting from inoculation with ascospores was also made, since this spore form has been found to be the principal source of initial infection in the' field (1). The plants were grown in greenhouse flats and pots and before inoculation placed in polyethylene-enclosed chambers in which the air was saturated with moisture. The ascospore inoculum was obtained by placing a number of pots containing overwintered oat stubble, showing typical black stem symptoms, in the chambers. Also, overwintered oat straw was suspended over the flats or pots in the chambers. The test plants and the straw were completely saturated with moisture several times to insure the release of the ascospores from the fruiting bodies and to favsr 'infection and subsequent disease development. Disease reaction ratings were made just prior to heading.

Results

Forty-four selected varieties and hybrids were tested in the field in 1956, 43 in 1957 and 88 in 1958. Those tested included many varieties which had shown some resistance in previous tests in Eastern Canada and in other areas, principally the United States. Some of the entries were tested all three years while others were tested for only one or two years. Highly susceptible varieties were discarded after one year's testing. All varieties showing any indication of tolerance in the field were tested in the greenhouse to determine if the reaction obtained in the field was comparable to that following greenhouse infection by macrospores. A random group of approximately 100 varieties was exposed to ascosporic infection En the greenhouse.

The average leaf-infection reading of all entries in the field in 1956 was 27 percent, in 1957 42 percent and in 1958 46 percent. The 1956 average reading was low because the varieties were tested at 8 locations and the disease incidence was low at some of the locations outside Ottawa. The varieties that showed the best average tolerance to the Septoria disease in the field are shown in Table 1. In all tests the varieties Rodney and Abegweit were used as checks. Rodney wa5 consistently more susceptible than Abegweit. A few varieties of Avena sativa including three Ottawa strains, 4832-3-1-1, 5055-13 and 5055-46 (Russell) showed as good as or better tolerance than Abegweft. These three strains have Abegweit in their

parentage, which may account for their high tolerance. Scots Berlie, an introduction from Scotland, also showed good tolerance but this is a semi-winter type and not suitable for commercial use in Canada,

In 1959 several hundred panicle *selections from each of the most tolerant entries were grown in single rows in a Septoria disease nursery in the field. These were carefully examined and compared with the check varieties, Abegweit and Rodney, in an effort to obtain selections with improved tolerance. The selections of all strains except Scots Berlie were very uniform in reaction and provided little or no improvement over the original strain from which they were obtained.

Several varieties derived from the species A. brevis, A. nudibrevis, A. strigosa, and A. wiestii also showed good tolerance to this fungus and some were considerably better than those from A. sativa (Table 1). However, all the non-cultivated species did not show this tolerance, as evidenced by A. byeantina and all the varieties within a species were not uniformly tolerant, e.g., C.D. 1009, A. strigosa.

Some varieties varied in response from year to year in the field. Apparently these varieties either happened to be in a location unfavorable for disease development or escaped because of maturity differences. There was good agreement between leaf and stem reaction with most varieties. If the leaf reaction was susceptible then black stem would usually be plentiful as well. Some late-maturing varieties showed less stem lesioning than early-maturing varieties. The variety Alexander (Table 1) was an exception in that it showed very little leaf lesioning in 1956 but a high rating for black stem. However, the following years the leaf lesioning was quite high and the black stem symptoms considerably reduced,

Moderate to high infection ratings were obtained on all varieties of A. sativa in the greenhouse using macrospores as inoculum (Table 1). Some of the varieties from the wild species showed more tolerance than the common varieties but the greenhouse readings were much higher than the field ratings. Apparently, with an increase of the spore concentration in the inoculum the disease incidence was also increased. There was a relatively good agreement between field and greenhouse results. The most tolerant varieties in the field were also the most tolerant in the greenhouse.

Greenhouse tests, in which plants were kept for a month or more following inoculation, showed that the more tolerant varieties, especially those from the wild species, developed numerous, small leaf lesions (initially) but these did not enlarge to any extent and there was very little evidence of wilting and dying. In the common varieties, however, the lesions continued to enlarge and many of the infected leaves died. Figure'l shows the disease development on plants of Rodney, C.D. 3820 and Abegweit inoculated approximately one month previously with macrospores of S.

Table 1. Disease ratings in percent for a selected group of oat varieties and hybrid strains which were grown under field and greenhouse conditions and subjected to natural and artificial inoculation with the fungus Leptosphaeria avenaria f. sp. avenaria. This group includes the varieties that showed the most tolerance to this fungus.

Species and Variety	Identification*		Field infection						Greenhouse leaf infection	
			Leaf lesioning			Stem blackening				
			1956	1957	1958	1956	1957	1958	Macro-spores	Asco-spores
A. sativa										
Abegweit	C.A.N.	693	27	35	30	28	30	40	65	42
Rodney	C.A.N.	761	38	50	50	72	70	60	80	57
Scots Berlie	C.A.N.	208	24	25	25	36	20	40	70	30
Wolverine	C.A.N.	106	-	45	35	-	40	40	60	-
Alexander	C.I.	1592	16	45	60	60	30	40	60	50
4832-3-1-1	C.A.N.	871	-	25	25	-	30	30	60	20
5055-13	C.A.N.	845	-	25	25	-	30	30	60	30
5055-46	C.A.N.	844	-	30	30	-	35	40	65	40
A. byzantina	C.D.	6872	-	30	45	-	40	60	75	60
A. brevis										
	C.D.	813	22	-	20	22	-	10	50	10
	C.D.	999	20	-	25	18	-	30	45	-
	C.D.	1001	21	-	25	22	-	30	45	20
	C.D.	1002	24	-	30	24	-	30	40	30
A. nudibrevis	C.D.	1017	20	-	15	18	-	30	40	20
A. strigosa										
	C.D.	1009	28	45	40	36	30	40	70	60
	C.D.	1014	20	20	25	22	20	30	35	30
	C.D.	3820	22	-	25	26	-	30	40	20
Saia	C.D.	4002	-	-	30	-	-	20	40	20
A. wiestii	C.D.	814	28	-	30	26	-	30	50	20

* C.A.N., C.I. and C.D. refer to Canadian Accession Number, Cereal Investigation Number, U.S.D.A. and Cereal Crops Division Number respectively.

avena f. sp. avenae. The lesions on Rodney were large and plentiful with many of the infected leaves dead. Abegweit was approximately the same but fewer dead leaves were evident. The lesions on C.D. 3820, however, were small and there was no evidence of the infected leaves dying. When these inoculated plants were allowed to reach maturity in the greenhouse there was considerable difference in the development of black stem. The tolerant varieties from the wild species showed much less black stem than did the common varieties. The same three varieties mentioned above are shown at maturity in Figure 2. The susceptible variety Rodney showed severe black stem and portions of the stems were badly rotted and lodging was complete. There was also considerable black stem on Abegweit and many of the stems had lodged. However, black stem on C.D. 3820 was not severe and all culms were standing erect.

The infection reaction obtained on a group of varieties inoculated with ascospores in the greenhouse indicated that the same pattern of susceptibility and tolerance existed as with field and greenhouse infection with macrospores but the range in reaction was much broader, especially when compared with macrospore infection in the greenhouse. The response of a few of the varieties to ascospore infection is presented in Table 1. Again, there was good correlation between the different tests with the tolerant varieties showing up well. The type of leaf infection obtained from inoculation with ascospores is illustrated in Figure 3. The varieties Rodney and Lanark were quite susceptible but they reacted differently. Lanark showed numerous, small lesions while Rodney had fewer but much larger lesions. Abegweit was intermediate in reaction and 4832-3-1-1 was the most tolerant. These results suggest that the inoculation of test plants with ascospores in the greenhouse might provide a good means of determining resistance among varieties of common oats and it appears to work equally well with wild species (Table 1).

Discussion

Field and greenhouse testing of oat varieties for resistance to Leptosphaeria avenaria f. sp. avenaria showed that varieties derived from the species A. sativa were quite susceptible. A few varieties and strains had some tolerance in the field but when these were tested in the greenhouse with a heavy macrospore inoculum there was little difference in tolerance between them and the more susceptible varieties.

Some varieties derived from some of the wild species of oats such as A. brevis, A. nudibrevis, A. strigosa, and A. wiestii appear to have considerably more resistance than common oats. This was evident not only in the field but in the greenhouse. However, not all wild species nor all varieties within a species contained the necessary gene or genes for

resistance. The resistance expressed by these varieties was not the absence of disease development but rather a much slower disease development. Individual lesions remained small and did not coalesce to the extent that they did on susceptible varieties. As a result the black stem phase was considerably reduced. Only a limited number of varieties from wild species have been tested and it is possible that with more extensive testing, even better resistance will be found. Among the wild species tested, those showing resistance were diploids. Zillinsky and Derick (12) have shown that resistance to crown rust is also present in these species and that there are several means of transferring the genes responsible for crown rust resistance from diploid to hexaploid oats. This suggests that it should be possible to transfer resistance to L. avenaria f. sp. avenaria in the same way.

Field evaluation would appear to be the best method of locating resistance in the common oat varieties since field tolerance is all that can be expected from this group, However, all entries would have to be tested several years as, invariably, some escape infection each year and if tested only once might appear quite tolerant. The availability of field tolerance in commercial varieties would be of considerable importance, especially in reducing lodging and increasing yields. In Eastern Canada strains **4832-3-1-1**, **5055-13** and **5055-46** (Russell) appear to have considerable field tolerance and this is further indicated by an increase in yield over the more susceptible commercial varieties. Disease reaction among the wild species can be detected either in the field or greenhouse. However, in the greenhouse a true appraisal of this material can only be obtained by taking disease notes approximately a month after inoculation. Disease development on this material shortly after inoculation was similar to, but not as severe as that of the susceptible varieties. Disease development was, for some reason, slowed down on the resistant material and a month following inoculation the differences in disease reaction were most apparent.

The use of ascospores as inoculum in the greenhouse was studied in a preliminary way. It appeared that the range in reaction was much wider with this inoculum than with macrosporcs and these was a good correlation in the response to the two types of inoculum. Clark and Zillinsky (1) have shown that ascospores are the major source of primary inoculum and if resistance against this type of infection could be found, disease development in the field would be greatly reduced, A limiting factor in the use of ascosporee as inoculum is the inability to produce this spare form on artificial media in the laboratory, Ascospores must be obtained from infected oat straw which has overwintered in the field.

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