Comparative tolerance of oat cultivars to septoria leaf blotch and crown rust

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The relative tolerance of 40 oat cultivars, to the septoria and crown rust diseases was determined in field plots in 1980 and 1981. Thousand-kernel weights were obtained for 1) plants artificially inoculated with septoria, 2) plants naturally infected by septoria and crown rust and 3) plants protected from disease by maneb fungicide; from these data tolerance ratios were determined. Based on these ratios, twelve cultivars were significantly more tolerant than the others and six of these were better both years. Most coefficients of correlation for kernel weight ratios for the two years and kernel weight ratios vs yield ratios for one year were significant. In 1980 yield ratios supported conclusions based on kernel weight ratios but the former were generally more variable.

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En 1980 et 1981, on a determine au champ la tolerance relative de 40 cultivars d'avoine envers la septoriose et la rouille couronnée. On a obtenu des rapports de tolerance a partir des données suivantes: poids de mille grains pour 1) des plants inoculés avec septoria, 2) des plants naturellement infectés par septoria et la rouille couronnée et 3) des plants proteges de la maladie a l'aide du fongicide maneb. En se basant sur ces donnees, douze cultivars ont montré une tolerance significativement superieure aux autres, et six d'entre eux ont montré une performance superieure les deux années. La plupart des coefficients de corrélation pour les rapports de poids de grains bases sur deux ans et pour les rapports de poids de grains contre les rapports de rendements bases sur un an etaient significatifs. En 1980. les rapports de rendement supportaient les conclusions basées sur les rapports de poids de grain, mais étaient généralement plus variables que ces derniers.

Tolerance has been described by Caldwell *et al* (1) as the ability of certain susceptible cultivars to withstand a severe disease attack without suffering a substantial loss in yield. Simons (5) has shown that tolerance to crown rust (*Puccinia coronata* Cda.) is present in certain oat (*Avena sativa* L.) cultivars and it is a quantitatively heritable but complex trait (6). Clark and Johnston (2) found that tolerance to the septoria disease (*Septoria* avenae Frank f. sp. avenae) was present also in certain cultivars. Thus tolerant cultivars are a viable alternative to those with specific gene resistance for controlling crown rust and septoria.

A three year study was begun in 1979 to compare the field tolerance of 45 oat cultivars to the septoria disease. Little disease developed that year even in inoculated plots given several periods of supplemental irrigation. However, septoria and crown rust developed extensively the next two years; septoria developed from natural and artificial inoculation while crown rust was initiated by natural inoculum only. The results reported here summarize the data obtained from the two years of tests when both crown rust and septoria occurred.

Materials and methods

A randomized complete block design was employed for the treatments each year. Forty-five cultivars were grown in individual rows in 4 replicates within three blocks in 1980 and 1981 in 3-row plots 3 m long with the first two rows of each plot being Opal wheat and the third row oats. An extra 2 rows of wheat were seeded at the end of each replicate. Thus there were always 2 rows of wheat between each individual oat cultivar to reduce interplot interference (3). Rows were spaced 23 cm apart and seeding was done with a 4-row plot seeder. Each year the plants of each cultivar in one block were protected from foliage diseases with the fungicide maneb applied at 10 day intervals beginning in the 4th week of June at a concentration of 4.4 kg/ha in 935 L/ha of water employing three or four applications. The plants in a second block of the same cultivars were inoculated with macrospores of *S.* avenae f. sp. avenae at heading time by spraying the top leaves and emerged panicles with a spore suspension of approximately 5×10^3 macrospores/ml using a Solo knapsack sprayer. The inoculum was applied in the third week in July by which time most of the late cultivars had developed panicles. At time of inoculation and for a number of days following, several periods of 0.5 to 1 hour duration of overhead irrigation were employed as needed to keep the foliage and ground wet utilizing dew type nozzles. A third or check block of cultivars did not receive any artificial inoculum or fungicide spray.

Disease severities were estimated on the top two leaves and panicles 7-10 days after inoculation.

In this study emphasis was placed on the determination of 1000-kernel weights as it had been shown previously that this kind of data, obtained from small plots, was an effective indicator of tolerance to crown rust (5). Kernel weights were determined each year for the various cultivars using two 1000 seed samples from each replicate. Seed yields were determined in 1980 by harvesting 2.4 m of each row. Yields were not determined in 1981 because of bird damage to parts of some plots. The tolerance data are expressed as ratios of artificially inoculated or naturally inoculated plots to the corresponding fungicide sprayed plots; the ratios were obtained by dividing the kernel weight or yield of each diseased plot either artificially or naturally inoculated by that of the corresponding fungicide sprayed plot. Thus the ratios are directly proportion-

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al to the relative tolerance present, with a ratio of 1.0 indicating complete tolerance or no damage from disease (5).

Results and discussion

In 1980 a moderately severe infection of both crown rust and septoria leaf blotch developed while in 1981 crown rust was so severe that septoria ratings could not be determined on the leaves (Table 1). The artificial inoculation with septoria was done late in the season each year to supplement natural infection and to be sure that most cultivars had headed. Consequently there was little difference between the septoria leaf ratings between the artificially inoculated and the naturally infected plants (Table 1).

Of the forty cultivars included both years 12 showed superior tolerance in one or both of the two years (Table 2) based on significantly higher kernel weight ratios for inoculated plants.

Table 1. Severity of septoria and crown rust (% mean area infected, top 2 leaves) on oat plants grown in field plots at Ottawa in 1980 and 1981.

		Treatments		
Year	Disease	Artificial inoculation with septoria	No treatment	Fungicide[1] spray
1980	Septoria	37.8	31.8	2.4
	Crown Rust	29.9	29.1	0.9
1981	Septoria[2]	—	—	—
	Crown Rust	71.3	72.3	5.3

[1] Three to four foliage applications 10 days apart of maneb fungicide at 4.4 kg a.i./ha in 935 L/ha of water beginning the 4th week of June.
[2] Crown rust so predominant that septoria could not be evaluated.

Table 2. The 1000 kernel weights and tolerance ratios for 40 oat cultivars grown in field plots at Ottawa for 2 years subjected to artificial inoculum of the septoria disease and natural inoculum of crown rust.

	1980				1981			
	Kernel Weight		Ratio[1]		Kernel Weight		Ratio	
Cultivar	Fungicide sp.	Rank	Inoculated	Natural	Fungicide sp.	Rank	Inoculated	Natural
Gemini	42.0a[2]	1	.838 d-l	.649 ef	39.3a	1	.660 e-k	.647 f-l
Athabasca	38.2b	2	.869 c-k	.716 c-f	31.4d-k	17	.890 a	.766 b-h
Manic	38.6bc	3	.793h-m	.700 def	35.7a-e	5	.700 c-j	.690 e-l
Q075.7	36.0bcd	4	.903 a-j	.841 b-e	34.8b-g	7	.720 c-j	.710 d-k
Orbit	35.8bcd	5	.925 a-g	.880 bcd	37.9ab	2	.702 c-j	.673e-l
Sentinal	35.4b-e	6	.826 f-m	.786 b-f	35.8a-d	4	.655 e-k	.708 d-k
OA338	35.4b-e	7	.844 d-l	.812 b-f	34.9b-f	6	.823bc	.713 d-k
Abegweit	34.6c-f	8	.805 g-m	.757 b-f	29.6h-m	28	.746 b-g	.755 b-i
Scott	34.4c-g	9	.915 a-h	.766 b-f	33.1c-j	11	.748 b-g	.776 b-g
Roxton	34.2c-h	10	.874 c-k	.921 bc	36.4abc	3	.782 a-e	.743 b-k
Hudson	34.2c-h	11	.765 klm	.830 b-f	30.1g-m	25	.757 a-g	.696 d-l
Oxford	34.0c-i	12	.859 d-k	.936 b	31.9c-j	13	.750 b-g	.780 b-g
Dorval	33.9c-i	13	.952 a-d	.901 bcd	31.8c-j	15	.774 a-f	.806 b-e
Fidler	33.7c-j	14	.952 a-d	.822 b-f	30.8f-l	23	.749 b-g	.869 bc
Laurent	33.5d-k	15	.943 a-e	.801 b-f	26.6k-n	36	.858 ab	.845bcd
Dula	32.4e-l	16	.780 j-m	.733 b-f	30.0h-m	26	.632 g-k	.612 i-l
Elgin	32.1 f-m	17	.887 b-k	.847 b-e	33.7b-i	9	.664 d-j	.685 e-l
Foothill	32.0f-m	18	.779j-m	.631 f	33.2c-j	10	.640f-k	.599 kl
Saladin II	31.7f-m	19	.722 lm	.703 def	31.0 f-k	20	.597 ijk	.552 l
Lanark	31.5f-n	20	.983 abc	1.183a	30.9f-k	21	.741 b-h	.771 b-h
Alma	31.5f-n	21	1.006ab	.765 b-h	29.2i-m	30	.783 a-e	.790 b-f
Turbo	31.3g-o	22	.784 i-m	.760 b-f	31.8c-j	14	.583 jk	.601 jkl
Saladin I	31.2g-o	23	.706 m	.748 b-f	31.3d-k	18	.530 k	.551 l
Lamar	31.1 h-o	24	.886 b-k	.814 b-f	30.8f-l	22	.712 c-j	.681 e-l
Menomine	30.9i-o	25	.803 g-m	.746 b-f	28.8j-m	32	.638 f-k	.640 g-l
Garry	30.6j-p	26	.812 g-m	.785 b-f	30.7g-m	24	.687 c-j	.648 f-l
CI 8175	30.5k-p	27	.840 d-l	.828 b-f	34.2b-h	8	.707 c-j	.675 e-l
Random	30.2l-p	28	.884 b-k	.801 b-f	31.8c-j	16	.710c-j	.639 g-l

Table 2. Continued

Cultivar	1980 Kernel Weight Fungicide sp.	1980 Kernel Weight Rank	1980 Ratio' Inoculated	1980 Ratio' Natural	1981 Kernel Weight Fungicide sp.	1981 Kernel Weight Rank	1981 Ratio Inoculated	1981 Ratio Natural
Dal	30.0 l-p	29	.900 b-j	.806 b-f	31.1 e-k	19	.682 d-j	.655 f-l
Sioux	29.8 l-q	30	.844 d-l	.763 b-f	28.7 j-m	33	.694 c-j	.662 e-l
Lang	29.8 l-q	31	.910 a-h	.927 b	32.5 c-j	12	.723 b-i	.748 b-j
Leanda	29.1 l-q	32	.706 m	.780 b-f	29.2 i-m	31	.606 h-k	.616 i-l
Hinoat	28.4 m-r	33	.910 a-i	.835 b-f	25.9 mn	39	.771 a-f	.883 b
Jaycee	28.2 n-r	34	.833 d-l	.800 b-f	26.7 k-n	35	.800 a-d	.793 b-f
Kelsey	27.2 o-s	35	.815 g-m	.787 b-f	29.6 h-m	27	.714 c-j	.725 c-k
stout	26.9 p-s	36	.894 b-j	.800 b-f	29.3 i-m	29	,681 d-j	.673 e-l
Gopher	26.6 q-s	37	.827 e-m	.763 b-f	28.7 j-m	34	.590 ijk	.623 h-l
Clintland	26.4 r-s	38	.909 a-g	.799 b-f	25.8 mn	39	.783 a-e	.765 b-h
Clintland 60	25.9 s	39	1.020 a	.902 bcd	24.0 n	40	.883 a	1.030 a
Ottee	25.5 s	40	.863 c-k	.921 bc	26.1 lmn	37	.770 a-f	.757 b-i
Mean	31.8		.859	.809	31.1		.716	.714

1 Ratios obtained by dividing the kernel weights of inoculated or naturallly infected plants by Corresponding weights of plants kept free of disease with maneb fungicide.
2 Data in columns followed by the same letter are not significantly different (Duncan's Multiple Range Test P = 0.05).

Within this group the cultivars Alma, Clintland, Clintland 60, Dorval, Hinoat, and Laurent had significantly better tolerance both years. These cultivars were quite susceptible to the two diseases with the exception that Clintland 60 has slightly less crown rust both years. Coefficients of correlation between certain kernel weight ratios for the 40 cultivars were significant (Table3), with the exception of the one between naturally infected plants in 1980 and 1981. Therefore the data for the two years were reasonably consistent. The highly significant correlation between the kernel weight ratios from naturally and artificially inoculated plants in 1980, a year when the septoria disease developed quite well, suggests that tolerance to both septoria and crown rust was similar. The very high correlation between the same data for 1981 was expected since crown rust was very severe on both uninoculated and inoculated plants.

Correlations between kernel weight and yield ratios obtained for the 45 cultivars grown in 1980 were highly significant with coefficients ranging from 0.53 to 0.66. Thus ratios for the kernel weights and yields for that year were in good agreement and both indicated that tolerance was present in certain cultivars. However, when the two types of ratios were analyzed statistically it was found that those for yield had quite high coefficients of variation (C.V.) (Table4) and would not be

Table 3. Coefficients of correlation between certain kernel weight ratios' of 40 cultivars of oats grown for 2-yr in replicated single row plots.

Categories of ratios correlated	r
1980 inoculated vs. 1980 naturally infected	0.423""
1980 inoculated vs. 1981 inoculated	0.351*
1980 naturally infected vs. 1981 naturally infected	0.232
1981 inoculated plants vs. 1981 naturally infected	0.705**

** and * Significant at P = 0.01 and P = 0.05 respectively.
1 Ratios obtained by dividing the 1000 kernel weights of inoculated or naturally infected plants by corresponding 1000 kernel weights of plants kept free of disease with maneb fungicide.

Table 4. Mean yield and kernel weight ratios' for 45 cultivars of oats grown in 1980 in replicated single row plots comparing plants inoculated with *S.* avenae f. sp. avenae with plants naturallv infected.

Variable	Septoria inoculation Ratio	Septoria inoculation S.E.	Septoria inoculation C.V.	Natural inoculation Ratio	Natural inoculation S.E.	Natural inoculation C.V.
Yield	0.616	.072	23.5	0.629	.088	28.1
k. weight	0.852	.041	9.6	0.799	.046	11.6

1 Ratios obtained by dividing yields and 1000 kernel weights of inoculated or naturally infected plants by corresponding yields and 1000 kernel weights of plants kept free of disease with maneb fungicide.

overly reliable due to the large experimental error. The ratios for kernel weights, on the other hand, had reesonable C.V.'s and consequently were more reliable than the yield data. F values for the kernel weight and yield ratios ranged from 1.9 to 4.4 and all were significant at P = 0.01. These conclusions agree with those of Simons and Browning (4) and Simons (5).

These studies have shown that a number of oat cultivars are more tolerant to crown rust and septoria than others and that several consistently showed the trait in successive years. The good tolerance of Clintland corresponds with the results of Simons (4) in his study of tolerance with specific races of crown rust. These studies also show that kernel weights are more useful for measuring tolerance than yields.

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