Optimum Disease Potential for Evaluating Resistance to *Stenocarpella maydis* Ear Rot in Corn Hybrids

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ABSTRACT

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Field trials were carried out at four localities in South Africa to evaluate 35 corn cultivars for resistance to ear rot caused by *Stenocarpella maydis*. Trials at each locality were split to include inoculated plants and plants infected by natural inoculum. Differences in hybrid disease resistance reactions were recorded, but ranking of genotypes over trial sites was poorly correlated. Regression analyses ($Y = AX^b$) were used to determine the relationship between disease potential of a trial site (X) and observed disease incidence (Y) within a genotype. Disease potential was quantified as the mean disease incidence over all hybrids in a trial. Genotypes could be divided into three categories: 1) linearly related to disease potential, 2) high susceptibility despite a low disease potential, and 3) various degrees of resistance despite increasing disease potentials. This served to explain the absence of constant rankings of hybrids and the often conflicting results when genotypes screened at different localities were compared for disease resistance. Confidence limits fitted to regression lines showed that screening of hybrids within a disease potential of ±0.6% to ±50.6% was acceptable for determining differences between highly resistant and susceptible hybrids, but the range for distinguishing moderately resistant (intermediate) hybrids from resistant and susceptible hybrids was limited to 4.4 and 26.3% and 1.9 and 40.9%, respectively. Beyond these points, disease reactions converged, suggesting that at very high or very low potentials, the use of cultivars in disease control is limited.

Stenocarpella maydis (Berk.) Sutton (syn. *Diplodia maydis* (Berk.) Sacc.) is the most prevalent ear rot pathogen of South African corn (*Zea mays* L.), causing reductions in grain quality and yield (2,13) and diplodiosis in sheep and cattle (11). Local corn hybrids vary in their response to *S. maydis* ear rot infections (3–5,9). However, inconsistent results have been obtained in different localities and seasons with both natural and inoculated infections (3–5,10). This variation has prevented reliable identification of resistance and susceptibility in corn hybrids and makes it difficult to determine if severity of *S. maydis* ear rot is genetically controlled or, rather, is the result of climatic conditions or inoculum potential at a specific time.

This study was carried out to determine maize hybrid reactions to *S. maydis* ear rot in inoculated and naturally infected field trials. The role of seasonal and geographic variation in the expression of resistance was quantified, and limits for optimum screening for resistance were set.

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MATERIALS AND METHODS

Field trials were planted at Potchefstroom and Greytown during the 1990–1991 season and at two additional sites, Petit and Delmas, during 1991–1992. Localities were selected to represent the range of climatic and geographic variation of the major corn production area. The 35 corn hybrid entries (Table 1) for each season were planted in fields previously cropped to corn. The fields were deeply ploughed to reduce the natural source of inoculum (7). Two 20-m rows of each cultivar were planted 1.2 m apart at Potchefstroom, and four 10-m rows of each cultivar were planted 0.75 m apart at the other localities. Experiments were planted in a randomized block design replicated three times. Fertilization, insect and weed control, and irrigation were applied at each locality as required.

Inoculum of *S. maydis* was prepared using an isolate from infected corn and was maintained in the Summer Grain Centre culture collection. Jars (500 ml) were filled with corn kernels (400 ml), and tap water was added to fill the jars. Kernels were soaked for 24 hr, after which the water was decanted and 30 ml of modified Fries Bosal medium (1) was added. Jars were autoclaved for 30 min

Table 1. Calculated parameters[a] for the relationship between *Stenocarpella maydis* ear rot potential and incidence in corn hybrids

Hybrids	*A* parameter	*B* parameter	R^2
A1257	0.66	0.83	84.0
A1616	0.09	1.04	89.3
A1849	−1.30	1.29	90.4
A210	1.49	0.75	92.6
CRN3414	0.34	0.94	94.0
CRN4502	0.95	0.84	82.9
HL8	−2.55	1.48	71.6
PAN473	−0.64	1.12	86.8
PAN6363	−1.41	1.27	90.1
PAN6364	0.80	0.61	45.1
PAN6479	−0.20	0.93	85.2
PAN6480	−1.83	1.25	72.4
PAN6481	−1.48	1.35	96.6
PAN6528	0.42	0.97	88.6
PAN6549	−1.57	1.33	98.5
PAN6552	−0.76	1.15	72.0
PAN6564	−0.57	1.06	64.9
PAN6578	−1.26	1.21	87.6
RO410	0.32	0.94	92.3
RO411	−0.11	1.00	96.6
RO413	−0.44	1.13	91.6
RO430	−0.25	1.13	92.2
RS5206	−0.69	0.95	76.8
RS5232	−1.79	1.44	67.4
SNK2147	−0.57	1.13	89.7
SNK2340	0.79	0.91	81.1
SNK2665	−1.17	1.21	95.7
SNK2770	0.05	1.04	94.6
SNK2771	−0.76	1.12	90.7
SNK2776	−0.28	1.14	90.8
SNK2888	0.54	0.85	83.2
SNK2950	−0.53	1.24	94.8
TX24	−1.27	1.34	92.9
TX552	0.37	0.88	86.7
TX56	−2.25	1.60	91.9

[a] For the function $Y = AX^b$, where $X =$ *S. maydis* ear rot incidence over all hybrids associated with a specific locality and inoculation and $Y =$ mean disease incidence within each hybrid associated with a specific locality and inoculation.

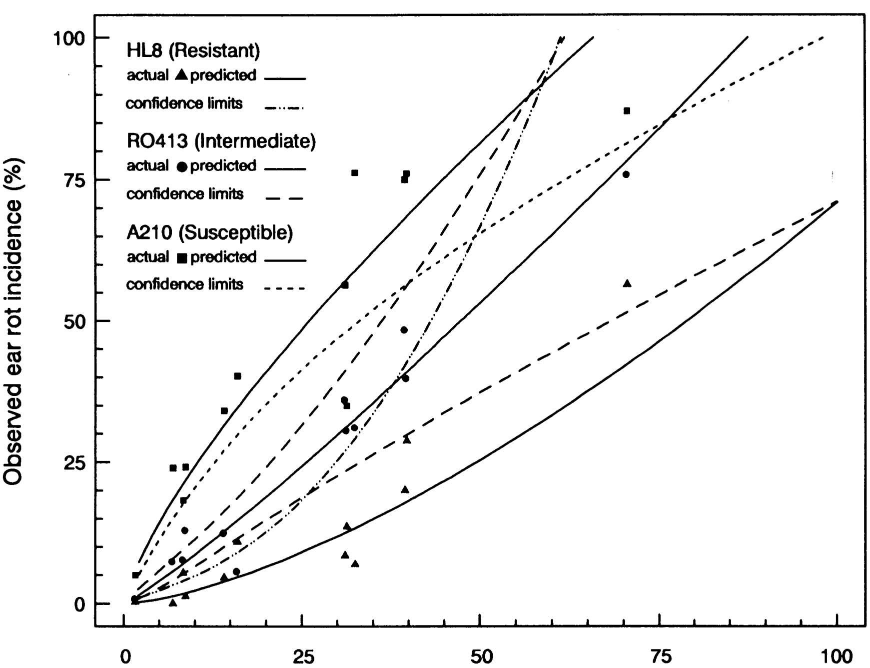

Fig. 1. Relationship between *Stenocarpella maydis* ear rot potential and observed ear rot incidence in resistant, intermediate, and susceptible corn cultivars. Confidence limits indicate minimum and maximum disease potentials for screening corn hybrids for resistance.

at 120 C on two consecutive days. Each jar was inoculated with a 1 cm^2 block of actively growing mycelium of *S. maydis* cultured on potato-dextrose agar. Jars containing inoculated kernels were incubated at 28 C for 60 days. Colonized kernels were removed from the jars, air-dried for 5 days, and milled to a fine meal, which was stored in a cool room (±6 C) prior to use.

Plants were inoculated with *S. maydis* by placing 5 g of inoculum into the apical whorl approximately 2 wk prior to anthesis. All plants in one row of each cultivar were inoculated at Potchefstroom and all in two rows at the other localities. Remaining rows served as uninoculated controls. Trials were harvested at kernel moistures below 18%, and the percentage *S. maydis* infected ears was visually determined. Analysis of variance was carried out on the percentage of *S. maydis* infected ears of inoculated and uninoculated corn hybrid treatments for each season and locality. Spearman rank correlations were carried out over localities and seasons to determine the consistency of corn hybrid reactions.

RESULTS

Significant differences between corn hybrids were recorded at each locality and season (*data not shown*). Corn hybrid resistance reactions over localities, season, and naturally infected and inoculated treatments were, however, inconsistent. Ranking correlations ranged from $r_s = 0.15$ to 0.84, with only 12 of a possible 66 (i.e., six localities/seasons × two inoculation treatments) significantly greater than $r = 0.5$. Data for each hybrid were used in a regression analysis, with the model $Y = AX^b$, where $Y =$ mean ear rot incidence within each hybrid and $X =$ the ear rot disease potential, defined as the mean *S. maydis* ear rot incidence over all hybrids associated with a specific season, locality, or inoculation treatment. Ear rot disease potentials ranged from 1.6% (uninoculated hybrids at Potchefstroom in 1992) to 70.5% (inoculated hybrids at Greytown in 1991). Three types of relationship were recorded between ear rot potential and observed ear rot incidence (Fig. 1). These relationships were defined by the *b* parameter. Where $b = \pm 1$ (e.g., hybrid RO413), a linear relationship between *S. maydis* ear rot potential and observed ear rot incidence within a corn hybrid was indicated; where $b = >1$ (e.g., hybrid HL8), initial resistance to the disease was indicated despite increasing disease potential; and where $b = <1$ (e.g., hybrid A210), susceptibility to the disease was indicated despite low disease potential. The *S. maydis* ear rot incidence of a hybrid may be predicted at any disease potential by applying the calculated *A* and *b* parameters to the model (Table 1).

Fitting of confidence limits to regression lines for the most resistant and susceptible hybrids (14) gave an indication of maximum and minimum disease potential at which cultivar reactions differed significantly. The confidence limits of the most resistant and most susceptible hybrids converged at ear rot potentials of 0.6 and 50.6%. Similarly, a comparison of the most linearly related hybrid with the most resistant and most susceptible hybrids set the limits at which significant differences could be determined at ear rot potentials of 4.4 and 26.3% and 1.9 and 40.9%, respectively.

DISCUSSION

Significant differences in corn hybrid reactions to *S. maydis* ear rot were recorded within localities and seasons. However, hybrids did not rank consistently over localities and seasons except at localities with similar disease potentials. These data support reports by Du Toit and Nordier (3–5) of inconsistent hybrid reactions in screening trials with naturally infected corn. Results suggest that genetic effects on the phenotype are overshadowed by environmental effects, including climatic conditions and inoculum potential. A comparison of mean disease incidences at a single disease potential, therefore, does not adequately reflect resistance of a hybrid to *S. maydis* ear rot. Consequently, results cannot be extrapolated to other disease potentials. Similar observations have been recorded for ergot on pearl millet (15) and grain sorghum (12). All corn hybrids evaluated were more or less susceptible to *S. maydis* ear rot, depending on disease potential. The primary differences between hybrids were the relationships between disease potential, observed disease incidence, and the rate of resistance breakdown.

Confidence limits fitted to regression lines showed the limits at which cultivar differences can be determined. The variable hybrid reactions obtained by Du Toit and Nordier (3–5) can therefore be ascribed to extremely low incidences of ear rots resulting from natural infection, i.e., ranging from 0.8 to 3.0% disease potential. In screening trials carried out by Du Toit and Nordier (3–5), the trial means (disease potentials) were lower than the minimum disease potentials required for the reliable distinction between resistant, moderately resistant (intermediate), and susceptible hybrids. In this study, confidence limits indicate that for optimum distinction between resistant, intermediate, and susceptible hybrids, it is necessary to ensure a disease potential of 17–20%. This optimum disease potential may be achieved by artificial inoculation or by using a wide range of experimental sites. It should be noted that the optimum will also vary according to the corn genotypes used to determine disease potentials. This may, however, be eliminated by the introduction of standard hybrids for determining disease potential.

The maximum disease potential (50.6%) for comparing the most resistant and susceptible hybrids is the maximum disease potential at which resistant corn hybrids may play a significant role in control of *S. maydis* ear rot. Should the disease potential of a specific locality be greater than this maximum, the use of such alternate control measures as ploughing under infected stubble (7,8) and rotating crops (6) needs to be considered.

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