FINAL REPORT 2018/19

DETAILS

Project number		P05000045 (000369)
Project title		Screening maize hybrids for resistance to Diplodia ear rot
Project manager		BC Flett
Co-worker(s)	Internal	F Mashinini, B Janse van Rensburg, M Mahlobo, A Tantasi
	External	Pannar Seed Co; Pioneer Seed Co, Monsanto Seed Co, Prof Neal McLaren
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Final abstract report

Field trials were carried out at four localities in South Africa over 6 seasons (2012/13 to 2017/18) to evaluate 138 medium to long season and 30 short season maize 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. The range of predicted disease at a potential of 20 % in medium to long season hybrids ranged from 2.413 % (LS8542) to 85.697 % (DKC74-74BR) and for short season hybrids from 12.053 % (KKS8216BR) to 151.263 % (IMP50-10B).

Keywords:
Diplodia ear rot; *S. maydis*; maize; disease potentials.

INTRODUCTION

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 (De Wet, 1989; Rheeder et. al., 1990) and diplodiosis in sheep and cattle (Marasas, 1977). Local corn hybrids vary in their response to *S. maydis* ear rot infections (Du Toit and Nordier,1989-1991; Gevers, 1988). However, inconsistent results have been obtained in different localities and seasons with both natural and inoculated infections (Du Toit and Nordier,1989-1991; Klapproth and Hawk, 1991). This variation has prevented reliable identification of resistance and susceptibility in maize 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 hybrids were compared at the 20 % disease potential and rate of breakdown was determined.

MATERIALS AND METHODS

Field trials of the medium to long growing season trials were planted at Potchefstroom, Petit, Delmas and Greytown during the 2012/13 to 2017/18 seasons. Similarly, short season trials were planted at Potchefstroom, Delmas and Greytown. Localities were selected to represent the range of climatic and geographic variation of the major maize production areas. The maize hybrid entries (Tables 1 and 2) for each season were planted in fields previously cropped to maize. The fields were deeply ploughed to reduce the natural source of inoculum (Flett and Wehner, 1991). 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 maize and was maintained in the Grain Crops Institute culture collection. Jars (500 ml) were filled with maize 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 was added. Jars were autoclaved for 30 min 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^o 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^o C) prior to use.

Plants were inoculated with *S. maydis* by placing 5 g of inoculum into the apical whorl approximately 2 weeks 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. Due to inconsistencies in rankings as shown previously by Flett and McLaren (1994) regression analyses using $Y=Ax^b$ were used. The maize cultivars were compared at a disease potential of 20% which was found by Flett and McLaren (1994) to be the optimum potential to compare maize hybrid resistance reactions.

RESULTS

Significant differences between maize hybrids were recorded at each locality and season (data not shown). Maize hybrid resistance reactions (Pearsons ranking correlations) over localities, season, and naturally infected and inoculated treatments were inconsistent as found by Flett and McLaren (1994). 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. As previously determined by Flett and McLaren (1994) three types of relationship were recorded between ear rot potential and observed ear rot incidence. These relationships were defined by the b parameter. Where b = +/-1(e.g., hybrid PAN 6R-510R), a linear relationship between *S. maydis* ear rot potential and observed ear rot incidence within a maize hybrid was indicated; where b > 1 (e.g., hybrid PAN 6B-410B), initial resistance to the disease was indicated despite increasing disease potential; and where b < 1 (e.g., hybrid SC 402), susceptibility to the disease was indicated despite low disease potential (Table 1). Similarly, the same principle applies to the short growing season maize cultivars (Table 2). 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). Flett and McLaren (1994) determined the optimum disease potential to screen and compare hybrids was 20 %. In tables 1 and 2 the actual hybrid reaction at a potential of 20 % is indicated which enables hybrids to be compared objectively. The most resistant medium to long season hybrid was LS 8542 (2.413 %) and most susceptible medium to long season hybrid was DKC 74-74BR (85.697 %) (Table 1). The most resistant short season hybrid was KKS8216BR (12.053 %) and most susceptible was IMP50-10B (151.263) (Table 2).

Table 1:. Medium to long season hybrid reactions to *Stenocarpella maydis* ear rots with number of potentials (n), R^2 for model fit, A and b parameters for the relationship between *S. maydis* ear rot potential and incidence in maize hybrids, calculated *S. maydis* incidence at a potential of 20 % and the resistance breakdown point.

Cultivar	**n**	**R-sq**	**A-parm**	**b-Parm**	**20% onset**	**Breakdown point**
3X23B144WYB	8	0.953	0.373	1.244	24.60	1.01
3X28B174WYB	8	0.825	0.366	1.229	25.89	0.95
BG3292	8	0.977	0.221	1.223	39.87	0.61
BG3592R	6	1.000	0.809	0.855	42.60	0.40
BG5285	33	0.865	0.606	1.138	21.58	1.05
BG5485B	9	0.799	1.213	0.925	20.72	0.89
BG5685R	4	0.927	0.774	1.064	21.24	1.00
BG5785BR	25	0.866	1.305	0.870	23.07	0.75
BG6308B	6	0.992	0.352	1.332	20.75	1.28
DKC64-54BR	8	0.982	0.382	1.346	18.93	1.42
DKC68-56R	6	0.807	2.793	0.668	19.01	0.70
DKC68-58BR	14	0.794	2.476	0.783	14.42	1.09
DKC71-42	6	0.893	0.073	1.443	48.80	0.59
DKC71-44B	14	0.684	0.429	1.098	33.07	0.66
DKC73-70BGEN	19	0.543	1.557	0.892	17.50	1.02
DKC73-74BR	8	0.915	0.467	1.149	26.28	0.87
DKC73-74BRGEN	25	0.893	0.963	0.987	21.61	0.91
DKC74-26R	6	0.983	0.558	1.230	18.35	1.34
DKC74-74BR	6	0.687	0.722	0.746	85.70	0.17
DKC75-65BR	8	0.902	0.978	1.019	19.35	1.05
DKC76-61B	14	0.968	0.345	1.316	21.85	1.20
DKC77-77BR	33	0.952	0.612	1.172	19.60	1.20
DKC77-85B	11	0.673	1.205	0.888	23.69	0.75
DKC77-85BGEN	12	0.879	1.450	0.869	20.50	0.85
DKC78-17B	25	0.752	0.810	0.969	27.36	0.71
DKC78-35R	8	0.473	2.677	0.618	25.91	0.48
DKC78-45BRGEN	31	0.483	1.557	0.767	27.88	0.55
DKC78-79BR	33	0.921	0.920	0.988	22.56	0.88
DKC78-87B	17	0.722	1.253	0.845	26.50	0.64
DKC80-12BGEN	7	0.856	1.409	0.832	24.22	0.69
DKC80-40BRGEN	33	0.868	0.527	1.167	22.57	1.03
IMP51-22B	31	0.794	1.035	0.921	24.88	0.74

Cultivar	n	R-sq	A-parm	b-Parm	20% onset	Breakdown point
IMP51-92R	13	0.845	1.647	0.860	18.27	0.94
IMP52-11	8	0.844	0.480	1.031	37.27	0.55
IMP52-11B	19	0.521	1.465	0.716	38.59	0.37
IMP52-11R	25	0.872	0.488	1.166	24.13	0.97
IMP52-12	24	0.504	2.501	0.630	27.07	0.47
IMP52-12R	17	0.574	1.287	0.702	49.90	0.28
IMP53-13	8	0.744	1.197	1.009	16.30	1.24
IMP53-49B	25	0.888	2.013	0.851	14.85	1.15
KKS4412B	8	0.875	0.960	1.036	18.74	1.11
KKS4581BR	31	0.82888	1.74521	0.92913	13.80	1.35
KKS8301	16	0.695	1.564	0.786	25.57	0.62
KKS8301B	7	0.86667	0.1263	1.45803	32.26	0.90
KKS8326B	25	0.808	0.690	1.132	19.58	1.16
KKS8330B	8	0.87636	2.54449	0.78426	13.86	1.13
KKS8403R	14	0.967	4.391	0.731	7.95	1.84
KKS8408R	12	0.969	1.425	0.925	17.37	1.07
KKS8410BR	33	0.88994	0.49391	1.25129	19.26	1.30
LG3607Y	10	0.75104	4.59345	0.70368	8.09	1.74
LS8518	31	0.8594	1.33181	0.9857	15.62	1.26
LS8524R	12	0.798	0.133	1.719	18.47	1.86
LS8526	21	0.954	1.453	1.002	13.69	1.46
LS8528R	6	0.75577	0.01131	2.39155	22.80	2.10
LS8529	8	0.54682	2.819	0.6662	18.94	0.70
LS8533R	33	0.844	1.548	0.954	14.60	1.31
LS8535B	8	0.80346	0.6501	1.25781	15.24	1.65
LS8536B	33	0.887	0.980	1.089	15.94	1.37
LS8537	9	0.99693	0.37217	1.27089	22.99	1.11
LS8539B	33	0.83079	0.90491	1.12683	15.60	1.44
LS8541BR	14	0.99366	0.43091	1.24376	21.88	1.14
LS8542	8	0.61708	12.85141	0.50206	2.41	4.16
P1615R	12	0.60615	1.00933	0.97605	21.32	0.92
P1659W	8	0.97046	1.62079	0.98449	12.84	1.53
P1745R	8	0.84639	4.82028	0.67572	8.21	1.65
P1973B	8	0.94026	1.51752	0.87358	19.14	0.91
P1973Y	8	0.589	0.760	1.123	18.39	1.22
P2137B	15	0.67163	1.08823	0.69437	66.19	0.21
P2319B	8	0.998	0.066	1.686	29.78	1.13
P2369WB	6	0.911	0.268	1.336	25.23	1.06
P2369WY	8	0.96949	1.76687	0.9066	14.53	1.25
P2370B	8	0.97258	0.65389	1.17528	18.36	1.28
P2432R	33	0.79739	1.13556	0.99856	17.69	1.13
P2553WY	8	0.99326	0.76749	1.05048	22.28	0.94

Cultivar	n	R-sq	A-parm	b-Parm	20% onset	Breakdown point
P2653WB	23	0.73688	1.43204	0.9256	17.26	1.07
P2653WBR	17	0.51518	1.59298	0.80601	23.08	0.70
P2707WYR	8	0.990	0.314	1.279	25.76	0.99
P2823WB	8	0.46528	0.99202	1.03618	18.15	1.14
P2823WBR	8	0.993	0.903	1.079	17.66	1.22
P2842W	4	0.83771	0.1502	1.3376	38.74	0.69
P2864WYR	8	0.992	1.567	0.960	14.18	1.35
P2880WYR	8	0.958	0.221	1.314	30.79	0.85
P2961W	12	0.73152	1.21967	0.95371	18.78	1.02
P2961WB	8	0.90059	1.18101	0.79814	34.64	0.46
P2961WBR	9	0.87081	1.67437	0.81637	20.87	0.78
P2961WYR	8	0.870	0.723	0.963	31.41	0.61
PAN4A-111	17	0.93784	0.11541	1.54734	27.98	1.11
PAN4A-172	14	0.92634	0.09838	1.48806	35.57	0.84
PAN4B-311B	15	0.96879	0.19037	1.40492	27.47	1.02
PAN4B-312CB	8	0.85544	0.88281	1.11774	16.31	1.37
PAN4P-228	6	0.79523	0.20875	1.69834	14.68	2.31
PAN4R-511R	9	0.9232	0.25542	1.37766	23.69	1.16
PAN5A-182	17	0.88978	2.15132	0.86972	12.98	1.34
PAN5A-291	6	0.98896	0.09578	1.58419	29.13	1.09
PAN5Q-649R	8	0.73144	2.79583	0.84529	10.25	1.65
PAN5Q-751BR	8	0.87638	0.9059	1.04151	19.52	1.07
PAN5R-591R	8	0.97594	0.09849	1.48392	35.90	0.83
PAN5R-785BR	8	0.99676	0.05921	1.70484	30.42	1.12
PAN5R-791BR	17	0.88443	0.87626	0.95608	26.35	0.73
PAN5R-795BR	6	0.935	1.225	0.934	19.89	0.94
PAN5R-851CBGT	6	0.87618	0.26278	1.37698	23.25	1.18
PAN6B-410B	8	0.99715	0.00109	2.78174	34.10	1.63
PAN6B-465B	8	0.24178	2.40232	0.52439	56.91	0.18
PAN6P-110	25	0.79954	0.42299	1.18024	26.24	0.90
PAN6Q-245	25	0.82056	1.36259	0.86015	22.72	0.76
PAN6Q-308B	8	0.49027	1.45152	0.76356	31.04	0.49
PAN6Q-345CB	5	0.76812	1.10158	0.96745	20.02	0.97
PAN6Q-408CB	25	0.94449	0.31167	1.34129	22.26	1.21
PAN6Q-445B	8	0.53099	2.18183	0.72568	21.18	0.69
PAN6Q-508R	8	0.6601	0.2899	1.23031	31.23	0.79
PAN6Q-708BR	8	0.4509	1.36492	0.72178	41.24	0.35
PAN6Q-845CBGT	8	0.79981	0.64534	1.05341	26.04	0.81
PAN6Q-865BR	8	0.96696	0.16855	1.13851	66.37	0.34
PAN6R-510R	8	0.38618	0.72958	0.99988	27.42	0.73
PAN6R-665R	8	0.979	0.675	1.157	18.70	1.24

Cultivar	n	R-sq	A-parm	b-Parm	20% onset	Breakdown point
PAN6R-680R	17	0.89748	0.87746	1.04807	19.75	1.06
PAN6R-710BR	8	0.9984	0.01063	2.05903	38.93	1.06
PAN6R-845CBGT	11	0.91793	0.40841	1.18661	26.56	0.89
PAN6R-880CBGT	15	0.84478	0.60665	1.13088	22.00	1.03
Phb30D09BR	10	0.86461	0.70029	1.10036	21.04	1.05
Phb30DO9BR	6	0.71407	1.98071	0.66785	31.89	0.42
Phb31M09	25	0.696	1.102	0.945	21.52	0.88
Phb32W72B	16	0.51856	0.67637	1.02604	27.13	0.76
Phb33H52B	25	0.79273	0.79512	0.89498	36.72	0.49
Phb33H54BR	23	0.75776	0.29939	1.19675	33.48	0.71
PHB33H54YR	6	0.99455	0.50946	1.3221	16.05	1.65
SC402	6	0.98524	9.43414	0.49807	4.52	2.20
SC411	6	0.97967	1.05018	1.06889	15.75	1.36
SC419	6	0.98667	1.29261	0.97447	16.62	1.17
SC506	25	0.86955	3.38929	0.80347	9.11	1.76
SC512	6	0.84398	0.73654	1.14041	18.08	1.26
SC533	8	0.49983	1.54837	0.90564	16.86	1.07
SC608	19	0.55862	1.54943	0.92822	15.73	1.18
SC719	8	0.79993	0.03461	2.03747	22.67	1.80
US9711	8	0.86763	2.29313	0.73265	19.22	0.76
US9777	8	0.9903	0.53816	1.27503	17.04	1.50
VP8301B	8	0.99201	1.24166	0.96033	18.07	1.06
VP8405B	11	0.54067	1.61084	0.6549	46.82	0.28

Table 2. Short season hybrid reactions to *Stenocarpella maydis* ear rots with number of potentials (n), R^2 for model fit, A and b parameters for the relationship between *S. maydis* ear rot potential and incidence in maize hybrids, calculated *S. maydis* incidence at a potential of 20 % and the resistance breakdown point.

Cultivar	n	R-sq	A parameter	b parameter	Onset 20%	Rate of breakdown
BG3292	20	0.690	0.967	0.780	48.69	0.32
BG3492B	18	0.636	0.778	0.955	30.00	0.64
BG3592R	18	0.810	1.517	0.685	43.10	0.32
BG3792BR	16	0.851	0.898	0.835	41.11	0.41
DKC61-90	16	0.788	1.161	0.969	18.89	1.03
DKC61-94BR	16	0.930	1.128	0.937	21.49	0.87
DKC62-80BRGEN	18	0.902	0.552	1.145	22.96	1.00
DKC62-84R	12	0.976	0.963	1.015	19.85	1.02
DKC64-54BR	6	0.972	2.036	0.868	13.92	1.25
DKC64-78BRGEN	18	0.981	0.812	1.080	19.44	1.11

Cultivar	n	R-sq	A parameter	b parameter	Onset 20%	Rate of breakdown
DKC65-52BR	6	0.973	1.681	0.950	13.56	1.40
IMP50-10B	10	0.542	1.509	0.515	151.26	0.07
IMP50-10BR	12	0.519	1.424	0.650	58.36	0.22
IMP50-10R	20	0.724	1.576	0.707	36.28	0.39
IMP50-90BR	14	0.975	0.665	1.025	27.64	0.74
KKS8214R	8	0.963	1.434	1.044	12.49	1.67
KKS8216BR	16	0.939	2.081	0.909	12.05	1.51
KKS8326B	12	0.980	0.447	1.396	15.23	1.83
KKS8328B	6	0.908	1.641	0.731	30.64	0.48
KKS8330B	6	0.949	1.002	1.007	19.54	1.03
LG3607Y	10	0.973	1.169	1.066	14.35	1.49
P1517W	6	0.878	0.142	1.316	42.90	0.61
P1745R	6	0.995	0.073	1.745	24.88	1.40
PAN3D-736BR	18	0.974	1.260	1.033	14.54	1.42
PAN3P-502R	16	0.922	0.846	1.102	17.62	1.25
PAN3Q-240	18	0.949	0.957	1.037	18.74	1.11
PAN3Q-740BR	12	0.992	0.816	1.135	16.75	1.36
PAN4B-312CB	6	0.969	0.316	1.475	16.66	1.77
PAN6126	20	0.957	1.238	1.031	14.85	1.39
Phb32D96B	16	0.958	0.947	0.965	23.56	0.82

DISCUSSION

Significant differences in maize 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 (1989 - 1991) of inconsistent hybrid reactions in screening trials with naturally infected maize. 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 (Thakur et. al., 1982) and grain sorghum (McLaren, 1992). All maize 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 (1989-1991) 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 (1989-1991), 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 a previous study (Flett and McLaren, 1994), found that confidence limits indicate that for optimum distinction between resistant, intermediate, and susceptible hybrids, it was necessary to ensure a disease potential of 17-20%. This optimum dis ease potential was achieved by artificial inoculation or by using a wide range of experimental sites. Therefore, in this study the predicted *S. maydis* ear rot were determined at 20 %, where for the medium to long grower hybrids ranged from 2.413 % to 85.697 % with the hybrid LS 8542 being the most resistant hybrid and DKC74-74BR the most susceptible hybrid over all seasons studied. In the study where the short season hybrids were screened predicted *S. maydis* ear rots ranged from 12.053 to 151.263. With KKS8216BR being the most resistant hybrid and IMP50-10B being the most susceptible hybrid. Under conditions of high disease potentials, the use of alternate control measures such as ploughing under of infected stubble (Flett and Wehner, 1991; Flett et al., 1992) and rotating crops (Flett, 1991) need to be considered together with resistant hybrids.

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