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Evaluation and response of selected maize genotypes to *Stenocarpella maydis* in Maseno farm, Maseno (Kenya)

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Abstract

Maize ear rot disease is caused by *Stenocarpella maydis* and other ear rot fungus that work in a complex relationship. The disease lowers the quality of the maize cob and grains. Before this study, there was no documented report on the susceptibility of the 9 selected genotypes namely; EH10, EH14, EH15, P3253, H614D, EH13, H516, H515 and EHI6 to *S. maydis*, therefore information gained on the response of these genotypes to *S. maydis* would be helpful not only in determining resistance of the 9 genotypes but also provide useful information in the continuous evaluation of germplasm for ear rot resistance. Investigations were conducted on the genotypes that were planted between September - December 2014 and February - July 2015 in the Maseno University farm and analysis conducted at the botany laboratory located within geographical coordinates; 0 1'0" S, 34 36'0'N at an altitude of 1503 meters above sea level. The experimental design was Alpha lattice, replicated thrice with nine hybrids. The mean severity scores level for the 9 hybrids was 1.98. EH10, EH14, EH15, and P3253 hybrids were resistant to *S maydis* H614D, EH13, H516, H515, EHI6 hybrids susceptible to the *S. maydis* ear rot fungus. *S. maydis* was also found to be the main ear rot causing fungus in Maseno University farm constituting (8-9%) while *Nigrospora* caused highest severity score of 3.

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Introduction

Maize ear rot disease is one of the factors among others that contribute to low maize productivity in Kenya with high annual losses attributed to maize ear disease running into millions of shillings. The fungal pathogen *Stenocarpella maydis* [=*Diplopodia maydis*] causes ear rot of maize (*Zea mays*). It is also associated with stalk rot, seed rot and seedling blight diseases of maize (Christensen *et al* 1967, Vincelli, 2003). The husks of ears which are infected early appear bleached or straw-colored, in contrast to green healthy ears. Infections occurring within 2 weeks after silking cause the entire ear to be gray-brown, shrunken, very lightweight and completely rotted. Lightweight ears stand upright, with the inner husks stuck tightly together to the ear by white mycelia growth. Ears infected later in the season usually show no external evidence of disease (Flett *et al*, 2001). When the husks are opened a white mold is seen growing between the kernels. All or part of an ear may be rotted. In later infections, the white mold may be visible between the arrows of kernels (Dorrance *et al*, 1998). Ears sometimes appear healthy until after shelling, when the brown germs and dead kernels become evident. Infection usually begins either at the base of the ear progressing toward the tip or at an exposed ear tip, but can also advance from the stalk through the shank and into the ear (Sutton and Weterston, 1966).

Speck-sized, black fruiting bodies (pycnidia) of *S maydis* are often found scattered on the husks and sides of the kernels as well as floral bracts and cob tissues .The pycnidia are filled with thousands of microscopic spores that may be carried considered distances by the wind to initiate new infections. Rotted ears have reduced nutritive value and reduced palatability to hogs (Flett *et al*, 2001). Dry weather followed by abnormally wet weather just before and after silking favors ear infections. Ears are most susceptible from silking to about three weeks later.

Hybrids with poor husk coverage or thin pericarps are often very susceptible. Some isolates of S. *maydis* may induce vivipary (Premature germination of kernels on the ear) (Dhanraj, 1966).

S. maydis is reported to work with other fungal pathogens such as; *Penicillium* spp., *Trichoderma* spp. *Nigrospora* spp, *Gibberella* spp., *Fusarium* spp., *Stenocarpella* spp., and *Aspergillus* spp among others, in a complex relationship that result in the ear rot disease symptoms (Flett *et al.* 1992; Mac Donald and Chapman, 1997).. *S. maydis* is not the only member of the genus *Stenocarpella* able cause ear rot, a close species *Stenocarpella macroscopora* has been reported in the United States to cause a similar ear rot during warm humid weather (Walker, 1969; Vincelli, 2003).

Before this study, there was no documented report on the susceptibility of the 9 selected maize genotypes namely; EH10, EH14, EH15, P3253, H614D, EH13, H516, H515 and EHI6, therefore information gained on the response of these genotypes to *S. maydis* would be helpful not only in determining resistance of 9 genotypes to this pathogen but also provide information useful in the continuous evaluation of germplasm for ear rot resistance.

Materials and methods

Description of area of study

This study was carried out at Maseno University farm and in the Botany Laboratory at Maseno University. Maseno University lies within the geographical coordinates 0 1'0" S, 34 36'0'N at an altitude is 1503 meters above sea level.

Evaluation of Hybrids to S. maydis

Evaluation of Hybrids to *S. maydis* in field experiments was conducted during short rains season of 2014 and long rains season of 2015 at Maseno University farm, after which Planting materials was performed. A total of 9 hybrids (treatments) including popular commercial hybrids were obtained from Kenya Seed Company (KSC) and Maseno University (inbred lines).

Experimental design

The experiment were incomplete block Alpha (0, 1) lattice (Patterson and Williams, 1976) to take care of soil invariability and were replicated thrice, the sample area carried 27 blocks and each block carried 28 plants.

Randomization was done using computer software Field Book (Banziger and Vivek, 2007). Inoculation of the host by the pathogen was conducted using standard methods.

Agronomic practices

Land was tilled and harrowed before planting. Using marked twine and hoes planting holes were dug and planting was done at the August, 2014 and the second crop in April, 2015. Seeds were planted in plots measuring 4m x 1m at spacing of 90cm between rows and 60 cm within row sand replicated 3 times. Di-ammonium phosphate (18–46-0) fertilizer was applied at rate of 128 Kg/hectare to facilitate maize development. Two seeds were planted per hole and thinned to one plant after emergence. Management practices required during planting of maize such as irrigation, weeding etc were carried out as required.

Results

There are 3 groups of the maize hybrids responding differently to the *S. maydis* inoculum. The EH15, EH14, EH16 group; EH10, P3253 group; and EH13, EH16 group of hybrid which responded similarly to inoculation by *S. maydis* fungus. The (EH15, EH14, EH16), shows the least effects from the inoculum based on severity, failure in filling, incidences, and yield. H614D is distinct in its response to the inoculation by *S. maydis*. It experiences the highest mean effects. Although it has been suggested that hybrids would be important to the management of *Stenocapella* ear rots, corn hybrids vary in their susceptibility (Vincelli, 2003).

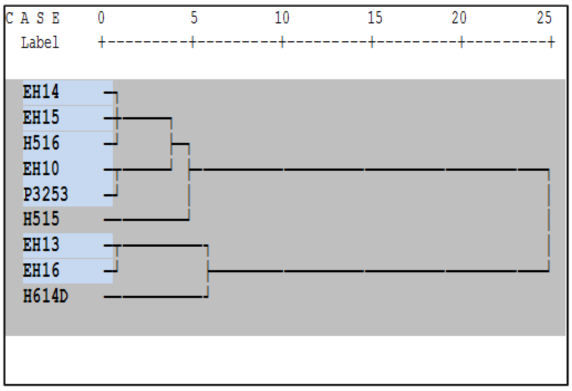

Fig. 1: A dendogram showing 3 clusters of the 9 hybrid maize varieties assessed.

A dendogram drawn (Fig. 1) shows 3 clusters based on the responses of the 9 hybrid against *S.maydis*. The 3 clusters of maize hybrids responded differently to the *S. maydis* inoculums were visible as (Fig 1). EH15, EH14, EH16 comprised group 1, EH10, P3253 group 2 and EH13, EH16 group 3 of hybrid responses to inoculation by *S. maydis*. EH15, EH14 and EH16 exhibited the least effects from the inoculum based on severity, failure in filling, incidences, and yield (Fig 1). H614D is distinct in its response to the inoculation by *S. maydis* and appeared to experience the highest mean effects.

Table 1. Mean values for grain yield, *S. maydis* severity scores and other agronomic characters measured on maize hybrid evaluated at Maseno during the short rains of 2015.

.HYBRID	GYD (tons/ha)	PLT STD (%)	SEVERITY SCORE	DAY TO SILKING
EH10	8.75	76.18	1.36	75.0
EH14	8.09	80.96	1.56	74.5
EH15	7.32	82.14	1.70	74.5
EH13	7.15	85.71	2.04	73.5
H614D	3.69	91.68	1.50	74.5
H516	5.78	78.57	1.39	74.0
H515	6.77	75.00	1.93	74.5
P3253	6.22	73.82	1.94	73.5
EH16	5.89	85.71	1.28	74.0
Mean	6.63	81.09	1.63	74.22
Standard Deviation	1.48	5.88	0.28	0.51

Key: PLT STD (Plant stand), GYD (Grain Yield).

During the short rains of 2015, the mean yield was 6.63 with EH10 and EH15 giving the highest yields of 8.75 and 8.09 tones/ha (Table 1). The plant stand after inoculation with *Stenocarpella* was highest in H614D (91.68%) and lowest in P3253 (73.82%). The mean severity score was 1.63 with the EH10, EH14, H641D, H516, and EH16 being resistant while the rest of the hybrids being susceptible to *Stenocarpella* infections. The plant stand was of the highest variation among the aspects of hybrids checked; with severity score having a variation for the severity score. A lower standard variation for the severity score offers limited opportunities for selection for purposes of breeding for *Stenocarpella* ear rot resistance. This agrees with earlier findings (Vincelli, 2003) that there is generally unreliable prediction of varietal performance in the presence of the disease, while all hybrids tested thus far are susceptible to some degree. Up to 5 out of the 9 varieties tested during the short rain season showed high susceptibility, while 4 varieties showed severity score below the mean severity score of 1.63 (Table 1).

Some relatively resistant varieties e.g. EH16 gave relatively lower yields (5.89 tones/ha) and relatively lower percentage plant stand (85.71%). This suggests that ear rots although they reduce the yields in maize they could also be interacting with other factors in the environment including the temporal as well as environmental or edaphic factors as earlier reported (Olantinwo *et al*, (2004).

Table 2. Mean values for grain yield, *Stenocarpella* severity scores and other agronomic characters measured on maize hybrid evaluated at Maseno during the long rains of 2015.

HYBRID	GYD (tons/ha)	PLT STD (%)	SEVERITY SCORE	DAY TO SILKING
EH10	10.5	90.26	1.8	72.0
EH14	10.2	88.96	1.9	73.5
EH15	9.25	82.00	1.7	74.0
EH13	9.4	85.71	2.0	71.5
H614D	4.5	91.67	3.0	73.0
H516	7.36	80.57	2.8	72.0
H515	8.72	79.00	2.9	73.5
P3253	8.22	80.21	1.85	74.0
EH16	7.85	89.00	2.9	74.0
Mean	8.44	85.26	2.32	73.06
Standard Deviation	1.81	4.89	0.56	0.98

Key: PLT STD (Plant stand), GYD (Grain Yield).

The combined mean value for the severity (table 2 of *Stenocarpella* innoculum and other agronomic characters of the various hybrids tested during the long rains of 2015. The yield ranged from 4.5 tones/ha to 10.5 tons/ha. The plant stand ranged from 79% to 91.67%, while the severity of the *Stenocarpella* infection on the ear was from 1.7-3.0.

The days to silking ranged from 71.5 days to 74.0 days. H614 hybrid gave the lowest yield while the highest yield was given by EH10 hybrid. The highest severity score was observed in H614D, EH10, EH14, EHI3 and P3253 showed high susceptibility, with the rest of the hybrids showed high resistance.

Table 3. Combined mean values for grain yield, *Stenocarpella* severity scores and other agronomic characters measured on maize hybrid evaluated at Maseno during the long and short rains of 2015.

HYBRID	GYD (tons/ha)	PLT STD (%)	SEVERITY SCORE	DAY TO SILKING
EH10	9.63	83.22	1.58	73.5
EH14	9.15	84.96	1.73	74.0
EH15	8.29	82.07	1.70	74.5
EH13	8.28	85.71	2.02	72.5
H614D	4.10	91.68	2.25	73.5
H516	6.57	79.57	2.10	73.0
H515	7.75	77	2.42	74.0
P3253	7.22	77.02	1.90	73.5
EH16	6.87	87.36	2.09	74.0
Mean	7.54	83.17	1.98	73.61
Standard Deviation	1.64	4.87	0.27	0.60

Key: PLT STD (Plant stand), GYD (Grain Yield).

The table 3 above shows combined means mean value for the severity of *S. maydis* inoculum and other agronomic characters of the various hybrids tested. The yield ranged from 6.57 tones/ha to 9.63 tons/ha. The plant stand ranged from 77% to 91.68%, while the severity of the *S. maydis* infection on the ear was from 1.58-2.09. The day to silking ranged from 72.5 days to 74.0 days.EH10 gave the highest yield, while the lowest yield was observed in H614D (4.10 tonnes/ha). H614D also gave the highest plant stand of 91.68%.The days to silking ranged from 72.5 days (EH13) to a maximum of 74.5 days (EH15).

Table 4. Showing the analysis of infection among hybrids, two seasons.

Source of Variation	SS	df	MS	F	P-value	F crit
Hybrids	124.15	8	15.52	3.74	0.0028	2.21
Seasons	1.19	1	1.19	0.29	0.5962	4.11
Interaction	2.15	8	0.27	0.065	0.9998	2.21
Within	149.33	36	4.19			
Total	276.81	53				

An analysis of the means of infection after inoculation by *S. maydis* during the long and short rains of 2015 (Table 4), indicated that there was no significant interaction between the hybrids and seasons on infection. A significant difference in the infection among the hybrids was observed, while no significant variation in level of infection between the varying seasons was observed (Table 4).

Discussions

There was a general increase in mean severity scores in long rains as compared to the severity scores during the short rains (Table 2). This trend was observed alongside the other agronomic aspects checked. This agrees with other studies (Vincelli 2003, Walker 1969) that have implicated wet weather during silking for it enhances severity. The hybrid varieties (H516 and EH16) which were originally resistant during the short rains have been rendered susceptible during the long rain season. For these two varieties, their response suggests a possible interaction between the genetic aspects of resistance and the weather conditions. This therefore would be an aspect for consideration during the selection for resistance to *S. maydis* ear rots. In (Table 4), plant stand does not correspond to high yields as is the case of hybrid H614D with a high plant stand (91.68%) yet relatively lower yield (4.10 tones/ha). The plant stand can therefore not be used for indirect selection for yield. There is no significant interaction between the hybrid and the season on the severity scores (Table 4). There seem to be a contribution of other factors that lead to severity of ear rot attack. These could be attributed to them inoculum load that must be sufficient to achieve a certain severity level. Inoculum load could be further influenced by the local agricultural practices. Lack of significant interaction could also imply that severity of various ear rots could increase irrespective of the season or hybrid used.

Conclusions

It has become clear from these studies that the mean severity scores of the 9 hybrids studied is 1.98. While the hybrids EH10, EH14, EH15 and P3253 have proved to be resistant to *S. maydis,* the hybrids H614D, EH13, H516, H515, and EHI6 have shown susceptibility *S. maydis*. In Maseno farm the main ear rot pathogen is *S. maydis* at 8-9% while the fungus *Nigrospora* causes highest severity score of 3.

Recommendations for future studies

1. There is a need to understand why *Nigrospora* spp. showed the highest severity score.
2. All the hybrids tested during this study need to be tested for susceptibility to other ear rot pathogens.
3. There a need for susceptibility tests to be replicated over longer periods to monitor and evaluate responses of the 9 maize genotypes to *S. maydis*.

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