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Incidences and severity of maize ear rot disease in Western Kenya

George T. Opande*[1], Mathews Dida[2], Phillip Onyango[1], Christine Wesonga[1]

[1]*Department of Botany, SPHS, Maseno University, Maseno Kenya*

[2]*Department of Horticulture, School of Agriculture, Maseno University, Maseno Kenya*

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Abstract

Maize ear rot disease is caused by a complex relationship involving the fungal pathogens; *Stenocarpella* spp., *Penicillium* spp., *Trichoderma* spp. *Nigrospora* spp, *Gibberella* spp., *Fusarium* spp., *Stenocarpella* spp., and *Aspergillus* spp. These pathogens are reported to jointly lower the quality of the maize crop and produce mycotoxins, which are toxic to both livestock and human beings. Before this study, there was insufficient documented information pertaining to incidences and severity of ear rot causing pathogens occurring in 4 counties (Western Kenya) namely; Kisumu, Siaya, Homabay and Migori, therefore this study was initiated to determine the incidences and severity of the ear rot symptoms. Studies were carried out in 12 Divisions in 4 counties of Western Kenya namely; Kisumu, Homabay, Siaya and Migori in successive long and short rain seasons of September to December 2014 and February to July of 2015 respectively using a Stratified Random Sampling design (SRSD), with the divisions as sampling units and the farmers' fields as sampling fields. Maize ear rots were prevalent in all the 12 divisions studied. Their prevalence being only higher during the February to July 2015 than in the September to December 2014.

* **Corresponding Author:** George T. Opande ✉ opandeg@gmail.com

Introduction

Kenya has 47 counties in total, where maize (*Zea mays* L.) forms the staple carbohydrate sources for over 90 percent of the population in Kenya (Laboso, 1996) and is grown almost in all agro ecological zones of the world. It is the most important food crop in Kenya with national production of 2.4 million tons in a total area of 1.6 million hectares (Gebrekidan *et al.*, 1992). The production of maize is constraint by a number of factors including poor soil, fertility, rainfall and diseases among others. Common maize diseases in Kenya include leaf spot, leaf blights, maize streak virus (MSV), stalk and ear (cob) rots. Maize cob rots are caused by fungal complex including *Stenocapella* spp., *Nigrospora* spp., *Gibberella* spp., *Fusarium* spp. and *Aspergillus* spp. (Flett, 1992; Mac Donald and Chapman, 1997).

Increased incidences of *Stenocarpella maydis* [=*Diplodia maydis*] ear rot is related to changes in tillage practices where high incidences of *Stenocarpella* spp. ear rot occur under conservation tillage systems. More pycnidia are produced and survived on maize stubble on the soil surface than on stubble buried in the soil (Flett and Wehner, 2001). Infection is enhanced by dry weather prior to silking followed by wet conditions at and just after silking, maize ears are more susceptible to this disease during the first 2 days after silking. High disease incidences do not normally occur over wide areas but rather occur in isolated fields (Flett and Wehner, 2001).

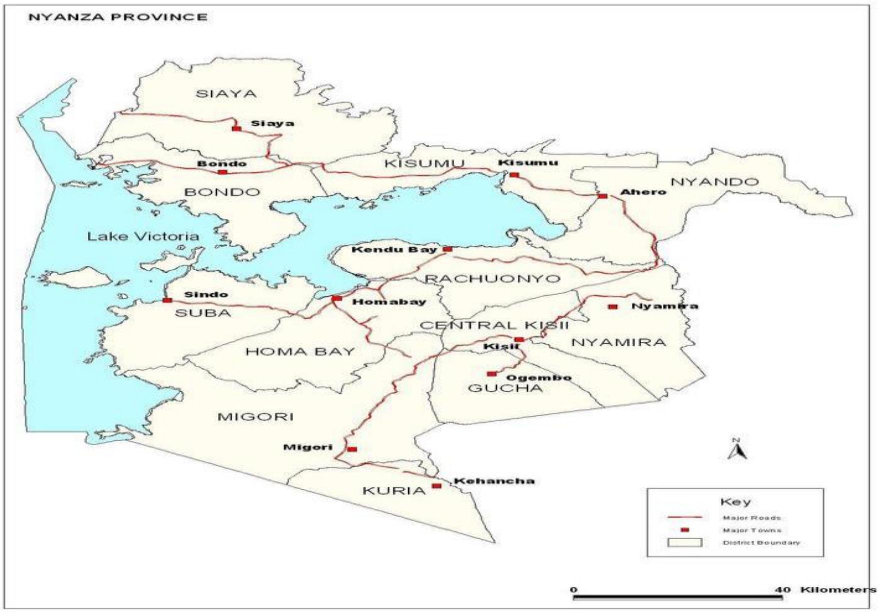
Maize ear rots are important because heavy infestations directly result in grain spoilage, significantly reducing both the yield and quality of the crop. The infested grains are light in weight and ears are discolored with shriveled grains. Yields from individual farms are generally low with majority of small holder farmers obtaining less than 1 to 4 tons per hectare (Ajanga, 1999). The annual losses due to ear rot are estimated to be 18 percent (Ajanga, 1999). Cob rot fungi produce mycotoxins, which have been linked with a number of mycotoxicoses and carcinomas of humans and domestic animals including esophageal cytological abnormalities in humans, pulmonary edema, and hydrothorax in swine, intoxication and paralysis in cattle (Rabie *et al.*, 1993; Julian *et al.*, 1995; Marasas *et al.*, 1998; Castelo *et al.*, 1998).

Even though in Kenya farmers have experienced an annual loss due to ear rots, not withstanding that many countries have recognized maize ear rots as a disease of concern, no quantifiable information was readily available about the incidences and severity of the disease before this study. Therefore this study was initiated to show relative incidences and severity of this disease in the western Kenya region represented by 4 counties namely; Migori, Kisumu, Siaya, Homabay and Homabay counties, in view of the fact that information obtained during these studies would be better utilized to sensitize farmers on the importance of ear rots and associated risks.

Materials and methods

The Study Area

The study area covered 4 counties located in W. Kenya where maize is grown, as shown in fig. 1 and Table 1 showing the 4 counties and the 12 divisions in which sampling was done. The counties selected included; Kisumu, Homabay, Migori and Kisumu and Siaya counties, where 5 farms with plants exhibiting ear rot symptoms were randomly selected from 2 divisions per county and infected cobs with distinct ear rot symptoms counted during both the short and long rain seasons (table 1). Altitude zone (MM) earlier defined (Hassan, 1998) to form a belt around Lake Victoria from its borders at an altitude ranging between 1110 meters and 1500 meters above sea level. This zone corresponds largely with the Lower Midland (LM) temperature belt (Jaetzold and Schmidt, 1982). The rainfall amount and pattern within this study zone are modified by altitude and topographyic factors: The first rainy season starts in February/March and the second in August /September. At lower elevation, in particular at the shore of Lake Victoria, the rainfall is less and the second season is less reliable. Mean annual temperature, calculated from March till August was 22^{o}c, while the mean minimum and maximum temperature range was between 15.4^{o}C and 29.9^{o}C respectively with an average annual rainfall of 1250mm



(Source: Opande 2017)

Fig. 1. Showing map of study area indicating the 4 counties and 12 divisions The 4 counties where study was carried out (table 1) consisted of a moist mid.

Table 1. Counties, Divisions, and number of participating farmers during survey.

County	Division	No farmers
Kisumu	Maseno	5
	Kombewa	5
Homabay	Kasipul	5
	Kabondo	5
Siaya	Sakwa	5
	Imbo	5
Homabay	Rangwe	5
	Asego	5
Migori	Awendo	5
	Rongo	5
Siaya	Madiany	5
	Asembo	5

Surveys for incidences of ear rot

Surveys were conducted in the 4 counties (W. Kenya) following a method earlier described (Marley and Abar, 1999), the number of maize plants sampled was 100 per farmer within 12 divisions i.e. 2 divisions per county; using the farmers field as the experimental plot where the maize plants were sampled. Sampling was done using the stratified random sampling design (SRSD). The samples were stratified i.e. each county divided into divisions representing a stratum, after which sampling was done in the 12 divisions located within the 4 counties where five farmers were selected for each of the 12 division. The sampling fields in each division were made in an X design and samples randomly collected along the X sample design and a field sampled 100 times.

Disease incidence

Disease incidence was measure as the number of plants showing the ear rot symptoms out of the 100 plants collected within the experimental plot/ farmers' field.

Results

The mean percentage incidences of ear rots in the studied twelve during the long and short rains in the 12 divisions i.e. Msn (Maseno division), Kbwa (Kombewa Division), Kpl (Kasipul Division), Kbdo (Kabondo division), Skw (Sakwa), Imb (Imbo), Rgw (Rangwe), Asg (Asego), Awdo (Awendo), Rngo (Rongo), Asmb (Asembo) and Mdny (Madiany). indicated that the disease incidences were higher in divisions where the crop was grown during the long rain seasons (Fig 2).

Adjacent divisions e.g. Asmb (Asembo) and Mdny (Madiany) as well as Kbdo (Kabondo) and Skw (Sakwa) had similar mean percentage incidences with their mean percentage incidences being relatively higher than the rest of the divisions (Fig 1).

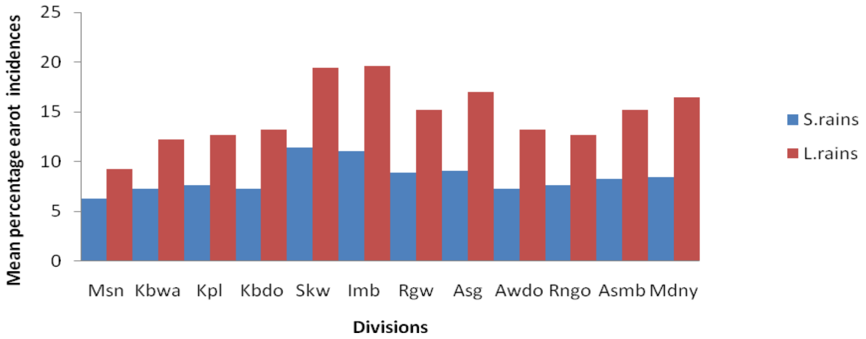


Fig. 2. Distribution of ear rots incidences in short and long rains of 2009 in Nyanza.

Table 2. Ear rot incidences in the short rains.

Source of Variation	SS	Df	MS	F	F crit
Between Groups	133.38	11	12.13	7.5	1.99
Within Groups	77.60	48	1.62		
Total	210.983	59			

Table 3. Ear rot incidences in the long rains.

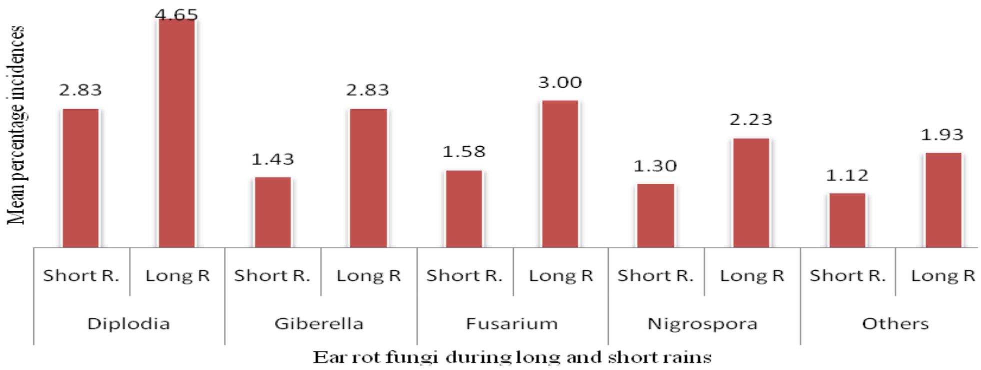
Source of variation	SS	df	MS	F	F crit
Between Groups	522.85	11	47.53	12.35	1.99
Within Groups	184.80	48	3.85		
Total	707.65	59			

While an analysis of the mean percent incidences in the 12 divisions studied during the long rains indicated that there was a significant variation in the mean percentage of incidences throughout the 12 divisions in which the study was carried out during the short rains (Table 3).

An analysis of mean incidences in the 12 divisions studied during the short rains (table 2), indicated that there was a significant variation in the mean percent incidences in the 12 divisions in which the study was carried out during the short rains period. higher during the rainy seasons, and the fungal pathogens; *Stenocarpella* spp.

When the incidences of various ear rot causing fungi in the 12 divisions studied over the short rains and long rains were compared (Fig. 2).

The incidences of various ear rot causing fungi were high for *Fusarium* spp. and *Gibberella* spp. that had the highest incidences (Fig 2).



Key: Short R. (Short rains), Long R. (Long rains).

Fig. 2. Mean percentage incidences of various ear rots in Nyanza during long and short rains.

The mean percentage of incidences when compared for the various ear rot pathogens. i.e. *Stenocarpella* spp., *Gibberella* spp, *Fusarium* spp., *Nigrospora* spp. and others including *Aspergillus* spp and *Penicillium* spp, *Trichoderma* spp. (Table 4), showed that there were no significant interaction between the type of the ear rot and the percentage mean incidences of the ear rots. A significant difference between mean percentage incidences of various ear rots was observed while mean percentage of incidences of various ear rots in various divisions were not significant (Table 4).

Table 4. Mean percentage Ear rot incidences in 12 divisions within the 4 counties of study.

Source of Variation	SS	Df	MS	F	F crit
Ear rots	71.78	4	17.94	15.89	2.53
Divisions	23.85	11	2.17	1.92	1.95
Interaction	9.86	44	0.22	0.20	1.58
Within(Error)	67.78	60	1.13		
Total	173.27	119			

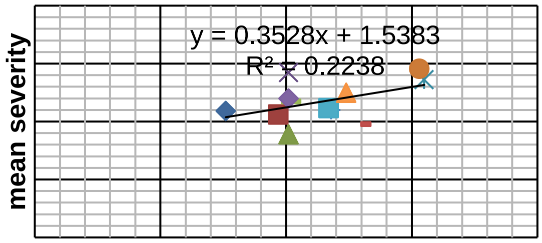


Fig. 3. Correlation between severity and incidences in the short and long rainy seasons.

A regression analysis of mean incidence of ear rots and mean severity of the ear rots in the 12 divisions of studied in the 4 counties showed a positive non-significant correlation as was observed between the mean percentage incidence and the mean severity (Fig. 3). In consideration of the mean severity of ear rot in the 12 divisions (Table 5) for Step (*Stenocarpella* spp.), Gib (*Gibberella* spp.), Fus (*Fusarium* spp.), Nig (*Nigrospora* spp.) and Oth (Other fungi) for study site in Msn (Maseno division), Kbw (Kombewa Division), Kpl (Kasipul Division), Kbdo (Kabondo division), Skw (Sakwa), Imb (Imbo), Rgw (Rangwe), Asg (Asego), Awdo (Awendo), Rngo (Rongo), Asmb (Asembo) and Mdny (Madiany), the severity levels ranged from 1.1 in Kpl (Kasipul) for Nig (*Nigrospora* spp.) to 3.6 in Asmb (Asembo) for *Gibberella* spp.(table 5). It was noticeable that in 11 out of the 12 divisions studied the mean severity ranged from 2.1 to 2.9 of all the ear rots. The mean severity for each ear rot within the 12 divisions ranged between 2 to 2.7 (Table 5).

Table 5. Mean severity of ear rots in 12 divisions studied during the short rains.

	Msn	Kbw	Kpl	Kbdo	Skw	Imb	Rgw	Asg	Awdo	Rngo	Asmb	Mdny	Mean
Step	1.6	1.6	2.2	3.6	3.8	3.4	2.6	2.4	2.2	2.8	2.8	3.4	2.7
Gib	2.5	2.9	1.8	2.8	3	3.5	2.4	2.5	3	2.4	3.6	3	2.8
Fus	1.9	1.6	1.4	2.3	2.4	2.8	2.2	1.3	2.6	2.2	1.6	1.8	2.0
Nig	1.9	1.8	1.1	3	2.6	3	1.8	1.6	2.3	2.3	1.3	1.8	2.0
Oth	3	3.2	2.4	2.4	1.8	1.4	1.8	2	1.24	1.4	2	2	2.0
Mean	2.2	2.1	1.8	2.8	2.7	2.9	2.2	2.0	2.3	2.4	2.2	2.5	2.0

Table 6. Mean severity during long rains in the 12 divisions studied.

	Msn	Kbwa	Kpl	Kbdo	Skw	Imb	Rgw	Asg	Awdo	Rngo	Asmb	Mdny	Mean
Step	1.4	1.75	2	3.4	3	3.6	2.4	2.6	2	2.6	3	3.2	2.6
Gib	2.3	2.6	1.8	2.6	3.2	3.6	2.2	2.5	3.2	2.6	3.2	3.4	2.8
Fus	2	1.4	1.5	2.6	2.6	3	2.2	1.4	2.8	2.4	1.8	2.2	2.2
Nig	2.1	1.6	1.3	3.1	2.8	3.2	2.6	1.8	2.1	3	1.2	1.7	2.2
Oth	3	2.8	2.2	2.6	2	1.6	1.7	1.4	2	2.2	1.8	2.4	2.0
Mean	2.2	2.0	1.8	2.9	2.7	3	2.2	1.9	2.4	2.6	2.2	2.6	2.3

The mean severity in each of the ear rots ranged between 2.0 and 2.8 as seen for all the 12 divisions (table 6), the mean severity for; Step (*Stenocarpella* spp.), Gib (*Gibberella* spp), Fus (*Fusarium* spp)., Nig (*Nigrospora*) and Oth (Other fungi) showed that in; Msn (Maseno division), Kbwa (Kombewa Division), Kpl (Kasipul Division), Kbdo (Kabondo division).

Skw (Sakwa), Imb (Imbo), Rgw (Rangwe), Asg (Asego), Awdo (Awendo), Rngo (Rongo), Asmb (Asembo) and Mdny (Madiany) the mean severity in each of the divisions ranged from 1.8 to 3 (Table 6).

Table 7. Mean severity of ear rots during short and long rains in the 12 divisions.

Source of Variation	SS	df	MS	F	F crit
Ear rots	10.70	4	2.67	56.73	2.53
sites	13.27	11	1.21	25.58	1.95
Interaction	23.71	44	0.54	11.43	1.58
Within	2.83	60	0.05		
Total	50.50	119			

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

When an analysis was done for the mean severity of ear rots during the short and long rains (table 7), there was a significant interaction between the ear rot types and site on severity.

The mean severity of ear rot infection had a significant variance among the divisions studied and showed a significant variation in the mean severity among the ear rots studied.

Discussions

This study has shown a general presence of maize ear rots in the 4 divisions of western Kenya, a case that is well in agreement with reports by Fajemisin *et al*, 1985 that most maize grown in Kenya is susceptible to the ear rot fungus. The presence of ear rot disease in the 4 counties where this study was conducted has further affirmed that yield losses in maize production systems are partly attributable to the ear rots as earlier observed in other parts of Kenya by Ajanga, 1999. The disease incidences as observed could still rise as currently there are few known maize varieties known to be resistant in the market, and farmers are not aware of the maize varieties that repeatedly suffer high levels of ear rot (Vincelli, 2003).The prevalence of corn ear rots in these 4 counties could be attributed partly to multiple yearly cropping cycles that allow the ear rot causing pathogens to build up large proportions in a similar case as was observed by Dragich *et al* in 2014.

Similar mean percentage incidences observed in adjacent divisions of Asembo and Madiany as well as Kabondo and Sakwa (fig 1) may be attributable to the fact that ear rot incidences are associated with the tillage practices with similar weather conditions as major factors in adjacent areas. A significant variation in mean incidences both in the short and long rain seasons (Table 2 and 3) would suggest further that the weather conditions could be contributing factor to the ear rot incidences as earlier seen by Ajanga (1999).

In other parts of Kenya. An occurrence of various ear rot causing fungus i.e. *Stenocarpella* spp., *Gibberella* spp., *Nigrospora* spp, *Fusarium* spp and other minor ear rot pathogens (Fig. 2) supports the earlier reports (Flett, 1992) that maize ear rots may be a complex of various fungi some of which include the *Fusarium* spp, *Stenocarpella* spp and *Aspergillus* spp. *Stenocarpella* spp that showed the highest incidence (Fig. 2) though unusual *Stenocarpella* spp has been ranked among the top three important maize diseases.

Although in Kenya there is no quantifiable information readily available about the incident and severity of the diseases in the 4 counties where this study was conducted. It is evidently clear that this study has gone a long way to show the existence of the pathogens and therefore a need for concern. *Gibberella* spp. ear rot causing fungus was the second most prevalent fungus (Fig. 2) and this agrees with earlier reports by other workers of its prevalence in other counties of western Kenya where this study was not conducted.

Although earlier reports by Adejumo *et al* (2007) had shown that *Fusarium moiliforme* was the most widespread disease attacking maize in Kenya, this study has shown that it is the third prevalent fungus (Fig. 2), in the 4 counties where this study was conducted, a variation from earlier reports by workers such as Dhanraj (1966). The fact that *Fusarium* spp. can be recovered from highly decomposed debris after two years of burial (Adejumo *et al*, 2007) implies limited chances of the total eradication of the fungus inoculums in western Kenya in the current farming circumstances where there is high land pressure and high cropping index. A Complex of several species of fungi causing ear rots rather than a single species makes it difficult to assess loss of ears in western Kenya due to a single fungal pathogen alone a similar case as was seen by Nwigwe (1974).

There was a general trend of increase of incidences of ear rots during the rainy season, this agrees with the observation that monocyclic diseases are not expected to be affected by climate change although moisture (rain, dew, high humidity) plays a significant factor in the incidences and epidemics caused by these fungi; high moisture promotes infection and spore release and germination in many fungal species. (Olantinwo, 2004).

The lack of a significant interaction between the ear rot type and the site (Table 4). This suggests the possibility of other factors that influence the ear rot incidences in the 12 divisions studied. Relationship exists between incidence and amount of maize stable affected by environmental conditions and the rate of relationship also varies with localities.

Crop rotation would be implicated for instances where pathogens are host specific *S. maydis* is significantly reduced in 24 months or 2 cropping seasons without a host crop being planted (Flett *et al*, 2001).

A correlation analysis (Fig.3) shows a positive correlation between severity and incidence. Although of plant disease intensity still remains a problem, and since measures of incidence are more easily acquired, a qualitative relationship e.g. in Fig.3 would greatly facilitate the evaluation of disease intensity when accurate assessment of disease severity aren't available or possible. The relationship between incidence and severity (Fig.3) shows a weak correlation implying an existence of a third factor that contributes largely to this correlation.

Conclusions and recommendations

Maize ear rots are prevalent in all the 12 divisions studied, with the main ear rot causing fungi being *Stenocarpella* spp., *Gibberella* spp., *Fusarium* spp. and *Nigrospora* spp. The prevalence is higher during the long rains. There is no significant association between the incidence and the severity of the ear rots. We wish to recommend that;

1. Cultural practices that increase the inoculum load should be avoided through extension services to the framers.
2. Maize hybrid varieties that are not susceptible to ear rots should be identified and recommended to the farmers.
3. The survey for severity and prevalence should be replicated more over longer periods to monitor epidemiology of the ear rots because this study was only conducted over two seasons namely the long and short rainy seasons.
4. The factors of co-occurrence of the studied ear rots should be probed further.

This study was only limited to 4 counties in western Kenya, yet in Kenya there are more than 47 counties so there is need to replicate this study in other counties in different parts of Kenya.

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