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## Incidence and Severity of Maize Ear Rots and Factors Responsible for Their Occurrence in Uganda

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**Abstract:** Eleven major maize growing districts of Uganda were surveyed for three consecutive seasons between 2002 and 2003 to establish maize ear rot incidence and severity. *Sternocarpella maydis* and *Fusarium* species particularly *F. graminearum* and *F. verticillioides* were the identified maize ear rot causing fungi. Incidence of *S. maydis* ranged from 2.5 to 32.5% while that of *Fusarium* sp. was in the range of 1.9 and 15.3%. In districts of higher altitude (above 1,800 m above sea level) *F. graminearum* dominated in all seasons while in districts with an altitude between 900 and 1,500 m above sea level, *S. maydis* was the major cause of ear rots. This observation was attributed to differences in temperature, altitude and rainfall. There was a strong positive correlation ( $p = 0.001$ ) between incidence and severity for *S. maydis* and a weak one for *Fusarium* sp. because the latter would rarely infect the entire cob unlike the former. All farmers expressed concern about the quality of maize due to ear rots and sort out infected grain after harvest. However, varied uses of infected grain were noted. For example, in Kapchorwa district 82% of the respondents indicated that the infected grain is used for making local brew because the moulds give it a good taste and aroma, while in Kamuli and Masaka districts, 36% use it as animal feed ingredient. This indicates that people and animals could be ingesting mycotoxins unknowingly thus the need for sensitization programmes.

**Key words:** Ear rots, mycotoxins, incidence and severity, grain quality

### INTRODUCTION

Maize ear rots are widespread and occur worldwide wherever maize is grown (Shurtleff, 1980; Kedera *et al.*, 1994; Mutitu *et al.*, 2003). The rots are caused by several pathogens belonging to two main genera; *Fusarium* and *Sternocarpella* (Ullstrup, 1977). Symptoms of some of these ear rots can visually be identified during crop growth and development. For instance, symptoms of *Sternocarpella maydis* during early development result in yellowing and drying of infected ear bracts on green maize plant. White mycelial growth generally begins at the ear base and may infect the entire ear (Flett *et al.*, 1998). A transverse section through an infected ear will expose pycnidia at the kernel bases. On the other hand, symptoms of *Fusarium* species are difficult to tell when the crop is still growing until the husks are removed and a white-pink cottony mould on kernels or pink kernel discoloration is seen. However, in some instances, these fungi infect kernels without any visible symptoms (Shurtleff, 1980).

Ear rot pathogens of maize overwinter to a greater or lesser extent on host residues (Nyvall and Kommedahl, 1970; Kommedahl and Windels, 1981). Minimum tillage promotes *Sternocarpella* ear rot and stalk rot however; *Fusarium* ear rot is not affected by tillage practices (Flett and Wehner, 1991). Whereas many countries have recognized maize ear rots as a disease of concern, in Uganda, no quantifiable information is readily available about the problem. This study was therefore initiated to establish the magnitude of ear rots in major maize growing districts of Uganda and this would help decide whether the problem deserves research attention in view of the limited resources.

### MATERIALS AND METHODS

**Study sites:** Three consecutive surveys were conducted between 2002 and 2003, that is, during the first season and second season of 2002 and first season of 2003 to establish the incidence and severity of *Sternocarpella* and *Fusarium* maize ear rot fungal species. The survey

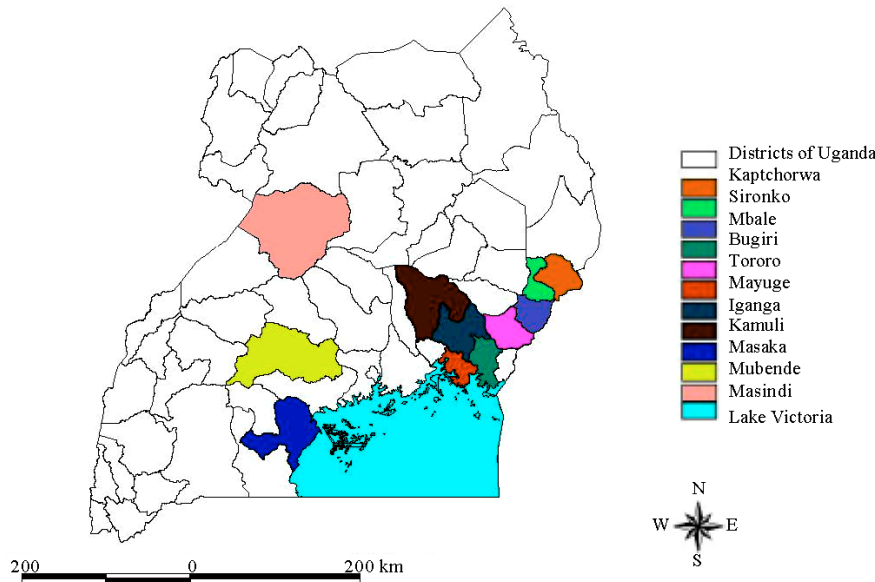


Fig. 1: Map of Uganda showing districts of study

covered eleven major maize growing districts of Uganda (Kikafunda-Twine *et al.*, 2001) namely; Kamuli, Iganga, Mayuge, Bugiri, Tororo, Mbale, Sironko, Kapchorwa, Masindi, Masaka and Mubende (Fig. 1). Sironko, Mbale and Kapchorwa are high altitude districts (above 1800 m above sea level) while the others are low altitude districts (between 900 and 1,500 m above sea level).

**Sampling maize for ear rot incidence and severity:** A minimum of ten fields was sampled per district during each survey and stops would be made every 20 km on a road system across each district according to Sseruwu (2003). However, during the second season of 2002 only four districts were surveyed and in each district thirty fields were sampled. In all instances, surveys were made when the crop was nearing harvesting.

**Determination of ear rot incidence, severity and associated factors:** In each field, ear rot incidence was determined by counting the number of infected ears of a random sample of 100 plants in four different positions according to Mutitu *et al.* (2003). Severity was scored using a 0-5 scale where, 0 = 0% infection (no infection), 1 = 1-10%, 2 = 11-25%, 3 = 26-50%, 4 = 51-75% and 5 = 76-100% infection (Jeffers, 2002). The maize ear rot pathogens were identified and differentiated using an illustrated compendium of maize diseases compiled by Warren (2000). In addition, in order to establish the factors associated with the occurrence of the ear rots,

extra information was sought from a total of 360 farmers, on the variety being grown, use of infected ears, possible causes of rots, cropping system and the seasons when ear rots are severe.

## RESULTS

**Ear rot incidence and severity:** Survey results for ear rots in pre-harvest maize in some major maize growing districts of Uganda indicate that the diseases exist in all the districts surveyed. Incidence and severity varied from 1.9-32.5 and 1.0-4.6, respectively (Table 1). This clearly shows that ear rots cause a significant impact on maize production in Uganda. The rots were more severe during the first season of 2002 than in 2003 season as reflected by the incidence and severity scores (Table 1). Rots due to *S. maydis* were more common in all districts than those caused by *Fusarium* sp. *Fusarium* sp. were dominated by two species; *F. graminearum*, exhibiting a pink coloration and the other was *F. verticillioides* exhibiting pericarp etching and kernel popping.

During the first season of 2002, Mubende district registered the highest incidence of *S. maydis* (32.5%) followed by Mayuge with 29.3% and in the third position were two districts Iganga and Kamuli with 25.3% each. Kapchorwa had the least *S. maydis* incidence with 10.3% (Table 1). On the other hand, Kapchorwa registered the highest incidence of 15.3% for ear rots due to *Fusarium* sp. and this was followed by Sironko with 10.2%, while Kamuli district had the least (1.9%).

**Table 1: Mean incidence and severity of maize ear rots in Uganda during the first season of 2002 and 2003**

Districts	First season 2002				First season 2003			
	<i>Sternocarpella maydis</i>		<i>Fusarium</i> species		<i>Sternocarpella maydis</i>		<i>Fusarium</i> species	
	Incidence (%)	Severity	Incidence (%)	Severity	Incidence (%)	Severity	Incidence (%)	Severity
Masindi	23.2	3.7	9.8	2.5	7.6	1.7	3.7	1.0
Masaka	10.7	2.1	10.0	2.9	2.5	1.2	5.2	1.2
Mubende	32.5	4.6	7.7	2.2	3.9	1.3	3.7	1.0
Kapchorwa	10.3	2.9	15.3	3.3	7.8	1.6	7.1	1.2
Tororo	21.3	4.0	3.8	1.2	5.1	1.4	3.3	1.0
Mbale	11.6	2.5	2.3	1.0	3.2	1.4	3.6	1.0
Kamuli	25.3	4.2	1.9	1.0	7.7	1.8	3.7	1.0
Sironko	12.4	2.5	10.2	1.9	5.3	1.3	5.5	1.3
Iganga	25.3	4.0	8.3	1.7	7.0	1.5	3.6	1.0
Mayuge	29.3	4.4	7.7	2.6	9.0	2.0	3.9	1.0
Bugiri*	-	-	-	-	9.5	1.9	3.8	1.1
Mean	20.4	3.5	7.7	1.5	6.2	1.5	4.3	1.1
LSD	2.0	2.0	2.0	2.0	2.0	0.8	2.0	0.6

\*: Bugiri district was not surveyed during the first season of 2002

**Table 2: Mean incidence and severity of maize ear rots in four selected districts of Uganda during the second season of 2002**

Districts	<i>Sternocarpella maydis</i>		<i>Fusarium</i> species	
	Incidence (%)	Severity	Incidence (%)	Severity
Kamuli	21.9	3.0	11.9	2.0
Iganga	19.0	2.4	12.6	1.8
Mayuge	12.1	2.0	12.0	1.5
Masindi	11.5	1.8	8.5	1.4
Mean	16.1	2.3	11.3	1.7
LSD	3.7	0.9	2.8	0.4

**Table 3: Pearson correlation matrix showing relationships between incidence and severity of *Sternocarpella maydis* and *Fusarium* species during the second season of 2002**

Parameters	Sm <sup>1</sup> incidence	Fs incidence	Fs severity
Fs incidence	-0.217		
Fs severity	-0.246	0.339*	
Sm <sup>1</sup> severity	0.940***	-0.177	-0.211

Sm<sup>1</sup> = *Sternocarpella maydis*; Fs = *Fusarium* species; \*: Correlation was significant at p = 0.05; \*\*\*: Correlation was significant at p = 0.001

**Table 4: Pearson correlation matrix showing relationships between incidence and severity of *Sternocarpella maydis* and *Fusarium* species during the first season of 2003**

Parameters	Sm <sup>1</sup> incidence	Fs incidence	Fs severity
Fs incidence	-0.054		
Fs severity	-0.057	0.265*	
Sm <sup>1</sup> severity	0.982***	-0.051	-0.0490

Sm<sup>1</sup> = *Sternocarpella maydis*; Fs = *Fusarium* species; \*: Correlation was significant at p = 0.05; \*\*\*: Correlation was significant at p = 0.001

**Table 5: Utilization of ear rot infected maize grain by farmers in selected districts of Uganda**

Districts	Discarding grain (%)	Using grain		Total No. of respondents
		for animal feeds (%)	for local brewing (%)	
Kapchorwa	13	5	82	40
Mbale	50	20	30	30
Sironko	41	2	57	30
Mayuge	56	24	20	50
Iganga	53	30	17	50
Kamuli	39	36	25	50
Masindi	52	8	40	50
Mubende	45	26	29	30
Masaka	57	36	7	30

Significant differences (p = 0.05) in *S. maydis* incidence were observed among the studied districts. Incidence of *S. maydis* ear rots recorded during the second season of 2002, ranged from 21.9% in Kamuli to 11.5% in Masindi, while that for *Fusarium* sp. ranged from 12.6% in Iganga to 8.5% in Masindi. Similarly, Kamuli district had the highest *S. maydis* (3.0) and *Fusarium* species (2.0) severity while Masindi had the lowest *S. maydis* (1.8) and *Fusarium* sp. (1.4) severity (Table 2).

During the second season of 2002 and first season of 2003, there was a strong positive and highly significant (p = 0.001) correlation between *S. maydis* incidence and severity scores while that of *Fusarium* sp. was also positive but not highly significant (p = 0.05) (Table 3, 4).

**Farmer information related to maize ear rots:**

Information obtained from farmers revealed that the maize varieties grown in the districts surveyed are several ranging from local to improved types. All farmers interviewed indicated that they were aware of the maize ear rot problem and how it compromised grain quality. It was established that maize ear rot incidence and severity were affected by several factors among which were the variety of maize grown by farmers and the quantity of rain received in a growing season. A good number of farmers indicated that Zimbabwe varieties (SC 627 and SC 625) were not good because of high susceptibility to ear rots. Some farmers resolved never to grow these two varieties again even if the seed is given to them free of charge. Farmers also reported that some local varieties especially those whose ears are open when maize reaches physiological maturity are susceptible to ear rots. Although farmers indicated that too much rain and type of variety were some of the reasons responsible for the

observed ear rots, they could not establish the seasons when rots are severe neither could they relate the disease incidence to different cropping systems.

**Farmer utilization of ear rot infected grain:** Farmers reported that in order to circumvent the quality of grain infected by ear rot fungi, sorting of either cobs or grain is done before sowing, sale or consumption. However, after sorting, farmers indicated that infected grain is used for various purposes ranging from animal feeds to making local brew. For instance, in Kapchorwa and Sironko, which are nearby districts, 82 and 57% of the respondents interviewed respectively indicated that infected grain is locally used for making brew (Table 5). Although this practice was reported in all districts it was less common in some, like Masaka (7%). Farmers who use infected grain for brewing indicated that moulds give a good taste and aroma to the brew thus highly preferred by local consumers. Use of infected grain as animal feed ingredient was also reported in all districts (Table 5). Masaka and Kamuli had the highest percentage of respondents using grain in animal feeds (36%) followed by Iganga (30%) while only 2% use it in Sironko district.

Despite the use of infected grain for brewing and animal feed manufacture, however, majority of the respondents indicated discarding it. For example, in Mbale, Mayuge, Iganga, Masindi and Masaka districts 50% or more of the farmers do not use the infected grain which is a good practice.

## DISCUSSION

The study only covered three growing seasons and perhaps to have got a clear picture about ear rots since they are dependent on environmental conditions (Macdonald and Chapman, 1997), it would have required a slightly longer period. This in part may explain why incidence and severity scores obtained were relatively low. However, in another related study under the project that supported this study (data not shown), losses of more than 30% due to these ear rots were recorded and this is bound to affect both quantity and quality of the maize produced in Uganda.

Results from the survey show that the ear rots are of economic importance and there is need to initiate programmes to address them. In addition, given the nature of farming practices carried out by farmers in Uganda, it is easy to perpetuate the causal pathogens. In some areas farmers repeatedly grow maize in one field, season after season. Continuous cropping with little or no fallow period in Uganda is attributed to factors like growing human population which is exerting pressure on land and

limited economic power to open new land (Doss *et al.*, 2002). Worse still, there are occasions when maize stover is left on the soil surface throughout cropping season for the new crop (Bigirwa *et al.*, 1999). There is therefore little chance to break the disease cycle. Fungi like those belonging to *Fusarium* species are known to survive and sporulate on plant debris and in the soil, thus providing source of inoculum for the new crop (deNazareno *et al.*, 1992).

In the districts of higher elevations like Kapchorwa, Mbale and Sironko which are 1,800 m above sea level (Rwabwoogo, 2002), ear rots due to *Fusarium* species dominated with the most common one in these cooler areas being *F. graminearum*. A similar situation with regard to climatic conditions of high rainfall and cool temperatures was found in Zambia and South Africa (Marasas *et al.*, 1997).

Although a large number of fungi are associated with ear rots, findings from this study confirm that *S. maydis* and *Fusarium* sp. were predominant. This corroborates with findings of Julian *et al.* (1995) in Latin America. All these fungi have been implicated in animal and human disorders including oesophageal cancers and infertility and kidney disorders (Marasas, 1996). Diplodiatxin and diplodiol produced by *Sternocarpella* sp. have been associated with oesophageal cancers and neurological disorders (CAST, 1989).

In other related studies (Bigirwa *et al.*, 2006; Kaaya *et al.*, 2006), aflatoxins among other mycotoxins were analyzed in maize from some of these districts and the levels as high as 50 ppb were established. Thus, the significance and magnitude of other mycotoxins especially fumonisins produced by *Fusarium verticillioides* (Kaaya, 2005), in Ugandan maize need to be established given the fact that people prefer to use infected grain for local brew on the pretext that it gives good aroma and taste. It is possible that people and animals could be ingesting substantial quantities of these toxins. For example, Kenji (2003) reported that Busaa, a local brew made from malted maize grains and sold in Kenya was found to be contaminated with more than 50 ppb levels of aflatoxin B<sub>1</sub>. Aflatoxins especially aflatoxin B<sub>1</sub>, have been associated with acute illness resulting in death, liver cancer, immune system suppression as well as binding of important micronutrients in both humans and animals in developing countries (Williams *et al.*, 2004; Jiang *et al.*, 2005). In light of this, it is important that the public is made aware of the dangers of utilizing fungal infected maize grain for brewing and as ingredient in animal feeds. This calls for public awareness and sensitization.

In an attempt to maintain quality, some farmers sort their maize by removing infected ears or grain. While this might be to some extent easy for *S. maydis* and *F. graminearum* because the infected kernels are shriveled and discoloured, it becomes more difficult for the asymptomatic infections such as those caused by *F. verticillioides* and *F. subglutinans*. These are the types of infection which further pose serious problems of mycotoxins since they are ingested unknowingly. Bigirwa *et al.* (2006) analysed asymptomatic maize grain and found that some had been contaminated by aflatoxins. In Kenya, several deaths due to mycotoxin poisoning have been reported because of people consuming asymptomatic maize grain (Okioma and Nyamongo, 2005).

Ear rots particularly those caused by *Fusarium* species are said to be seed-borne and seed transmitted (Mutitu *et al.*, 2003). This is made worse by those causing asymptomatic infections which poses problems to seed health (McGee, 1988). The pathogens may cause seedling blights (Shurtleff, 1980) and farmers who sow seed saved from previous crops may thus aggravate the problem of infection (Macdonald and Chapman, 1997).

Findings from this study clearly show that ear rots due to *Sternocarpella* and *Fusarium* are a problem and need to be addressed. There are various ways in which this can be handled. (i): advise farmers to grow varieties which are not susceptible, (ii): researchers need to incorporate breeding for ear rot resistance in their programmes to enable them identify sources of resistance to improve materials already on market and those in the pipeline and (iii): joint efforts are required among health workers, extension staff and local authorities to sensitize the public on how to maintain grain quality through proper post-harvest handling. Farmers need to be cautioned about the dangers of consuming fungal contaminated maize. Attention on quality will not only reduce health risks but will also result in increased trade and income since, according to Rates (2003) some countries in the East and Southern Africa region are beginning to set acceptable limits of mycotoxins in maize produce and animal feeds.

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