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A Survey of Sorghum Covered Kernel Smut Disease Infection in Western Kenya

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Abstract: ***Covered kernel smut is a seed borne panicle disease caused by the fungus Sporisoriumsorghi which is classified within the Ustilaginales, class Basidiomycetes.An extensive survey was conducted across six counties (Busia,Siaya,Vihiga,Kisumu,Homa-Bay and Migori) in western Kenya during the long rain season of March- August 2018 when sorghum was at physiological maturity in order to: (i) determine occurrence and distribution of the covered kernel smut disease (CKSD) in western Kenya (ii) identify possible sources of resistance to the CKSD in farmers' fields and (iii) determine the cropping systems under which sorghum is grown in the region. A total of 100 farmers' sorghum fields were surveyed in the six counties. Average incidence (%) of the disease was obtained from a sample of 20 plants selected in a 4by 4msquare plot area using simple random sampling technique from each farm visited. Sorghum was grown either as sole or as intercrop with common beans, groundnut, cowpeas and mung beans, with cowpeas intercrops dominating across the farms. Disease incidence was relatively higher on the shorter and early maturing varieties (Nyadundo 1 and 2, C26 and MUK27) compared to the taller ones (T53B, MUK154, N68, T30B, IS3092) suggesting a potential relationship between sorghum variety and the disease incidence based on the height or maturity period of the sorghum. Further discussions with farmers and observations made indicated that the CKSD was present only during anthesis and grain filling stage and virtually absent at the seedling stage. The higher disease incidence on the shorter varieties resulted into more than 90% of the sorghum panicle being infested hencethe urgent needto put in place control measures to curb spread of the disease. Farmers were advised to use improved cultural practices such as burning to destroying the infected crop residues, Chemical method of seed dressing using relevant fungicides and using clean planting materials as quick remedies. However, long term alternatives include breeding for tolerance to the CKSD which our sorghum breeding program has started to pursue. It is expected that some of the sources of resistance identified in this study will be used to introgression disease resistance into the farmer preferred susceptible varieties.***

1. Introduction

Covered kernel smut is a seed borne panicle disease caused by the fungus *Sporisoriumsorghi*which is classified within the Ustilaginales, class Basidiomycetes (Perez, 2002). The disease occurs in every sorghum growing region with different agro-ecology globally and causes severe yield losses when conditions are favorable for infection and proper control measures are not utilized (Yilmaand Brhane, 1979; Dogget, 1988; Singh, 1998; Ngugi and King, 2002; Wilson, 2011)According to Sisay et al (2012) spore germination varies morphologically under the optimum temperatures from 20-30degrees Celsius andthespore retains viability for four years when kept in dry conditions. According to Frederisken and Odvody (2000), it causes greater grain yield losses than any other disease in the tropical regions. Although the pathogen was suggested to be specific to the genus *Sorghum*, the weed *Cynodondactylon* was recognized as an alternative host for the pathogen *(*Marley *et al.*, 2002). The disease is only apparent after heading where the individual ovules are replaced by smut fruiting bodies that vary in size, generally the smut sori are smooth, oval, conical or cylindrical in shape and vary in size from those small enough to be concealed by the glumes to that one cm long, but vary in color from white to grey or brown (Howard *et al.*,2005and Ashok et al., 2011). According to Sisay*et al* (2012) annual yield losses due to covered kernel smut in Africa reaches 10% with localized losses of 60% or more. The incidence of covered kernel smut varies from place to place. In the year 2012, these authors reported more than 50% disease incidence in Ethiopia. In Kenya, covered kernel smut is also significant with yield losses of 42-43 % (CBI, 2013). However, in western Kenya, the disease has been a new phenomenon and little is known about its occurrence and distribution. Moreover some new sorghum varieties that were introduced in western Kenya by Rongo University in 2017 were infected by the disease (www.ccrp.org).According to Silaev (2005)and Sisay et al., (2012) the fungus *Sporisoriumsorghi* can grow and develop at 10-32ºC. The soil optimum temperature conducive for the disease development is 18-25ºC and infection is established in warmer, wet soils with humidity of 15-20%. More importantly, periods of delayed seed germination are optimal for the contamination of plants. According to Ashok *et al.* (2011) the disease infection usually takes place before the seedlings emerge out therefore the conditions suited for delayed germination of seeds greatly favor infection. According to Silaev(2005) and Sisay*et al.*, (2012) spore germination varies morphologically under the optimum temperature from 20-30ºC, and the spores retain viability for up to four years when kept in dry conditions. Covered kernel smut can survive in the soil and crop residues. Ashok et al., (2011) stipulated that, Host variety, soil temperature, soil moisture content and depth of sowing are also known to affect the degree of infection. High temperatures after sowing have been reported to reduce smut incidence on the seedlings. Others authors (Sisay*et al.*, 2011; Wilson, 2011) have showed that high temperature and low soil moisture encourage seed germination and discourage smut mycelium invasion of the germinated coleoptiles of the host plant. According to these authors, low temperature, high moisture content of the soil and deeper planting of sorghum initiate high infection level.

Covered kernel smut can be controlled by chemical, biological, breeding for resistance and cultural methods. Chemical method includes the use of fungicides which assist in reducing the incidence and severity of the disease on the sorghum but does not completely control the disease.

Economical and complete protection from covered kernel smut can be achieved with proper seed treatment (Howard *et al*., 2005). The disease can easily and effectively controlled by treating the seed with a protective fungicide. Seed treatment also prevents introducing the kernel smut fungus into uninfected fields (Silaev, 2005 and Thakur et al., 2007).However farmers can hardly afford the fungicides due to high costs. If systemic seed dressings is not feasible, cultural methods can be employed such as soaking the seeds in water for 4 hours, then drying the seeds, first in the shade and then in the sun. This procedure kills germinating smut spores without impairing seed viability (IPM, 2008).Biologically the fungus has been controlled by the use of leaf extracts of botanicalAbeyi plant (*Maesalanceolata*) and fermented cattle urine. Fresh leavesof the plant are ground into pieces to form paste by adding water this was tried in Ethiopia. (Adane and Gatam,2000).However, many farmers consider such procedures to be laborious and unpractical due to labor and time constraints during planting season. Many authors working with small holder farmers in sub-Saharan Africa have acknowledged the heterogeneity, diversity and complexities that characterize smallholder farming environments such as variation in farming resources endowment, access to extension services, education levels and knowledge base (Tittonell *et* al., 2010; Giller et al., 2011; Nyangweso et al., 2018). Therefore a factor like labour constraint or resource limitation within a farm can significantly hinder use of chemical, cultural or biological control measure. The most cost effective, farmer and environmentally friendly strategy to control head smut is through the incorporation of resistance genes. This study is aimed at providing baseline information on the occurrence and distribution of sorghum covered kernel smut disease in western Kenya and to identify potential sources of resistance for future breeding and variety development.

2. Materials and Methods

Study Area

The survey covered six counties located in western Kenya along the shore of lake Victoria where sorghum is grown in substantial quantity by smallholder farmers. The counties were Busia, Siaya, Kisumu, Vihiga, HomaBay and Migori. (Figure 1). These counties were also selected because a good number of farmers in these counties had been given improved sorghum seed which were being promoted by Rongo University Sorghum Project.

According to FAO. (2018), the agro-ecological zones (AEZ) found in western Kenya are majorly the lower midlands (LM) and the upper midlands (UM). In the Lower midland zone the altitude ranges from 800to 1500m. Temperatures are warm with an annual mean ranging from21 to 24 degrees Centigrade.Parts of Busia, Homabay, Migori, Kisumu and Siaya fall in this zone.In the upper midland zone, the altitude range is from 1300 to 1900m with annual mean temperature ranging from 18 to 21degree centigrade. It includes parts of Homabay, Kisumu, Migori and Vihigacounties.

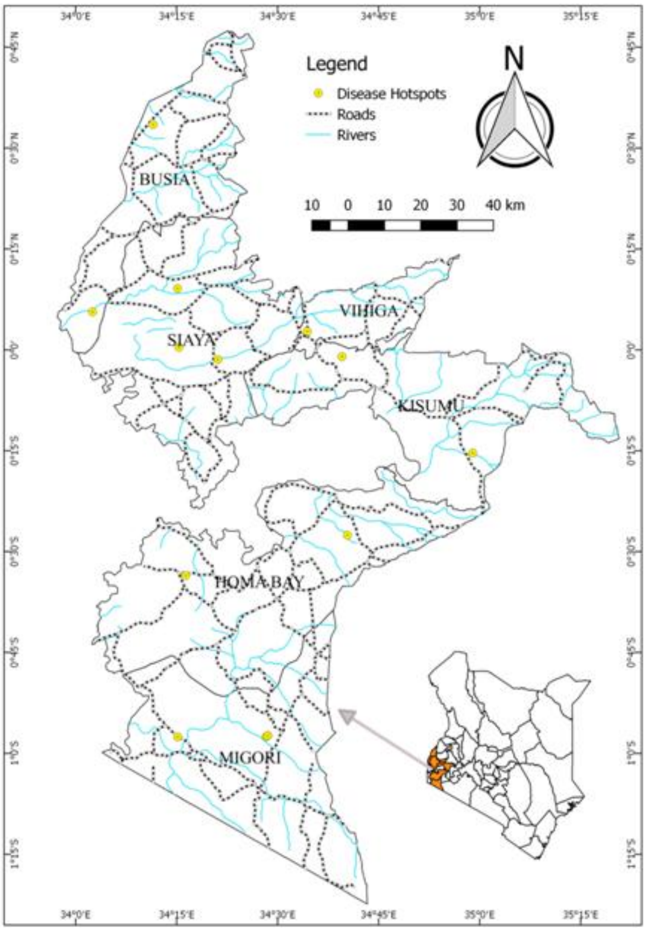

Figure 1: Map of western Kenya showing the distribution of sorghum Covered Kernel smut disease hot spots

Plant Materials

Plant Material	Source	Colour
NYADUNDO 1	Rongo University	Red
NYADUNDO 2	Rongo University	Red
RUC26	Rongo University	Cream
MUK27	Makerere University	Brown
MUK60	Rongo University	Red
RUT53B	Rongo University	Brown
RUN68	Rongo University	Brown
RUT30B	Rongo University	Brown
RUE117B	Rongo University	Brown
MUK154	Makerere University	Red
IS3092	Kalro Katumani	Brown
N4	Rongo University	Red
JOWI	Farmer	Red
OCHUTI	Farmer	Red
SERENA	Kenya Seed Company	Cream
SEREDO	Kenya Seed Company	Cream

3. Field Survey

The survey was conducted during the March-June 2018growing season when sorghum was at physiological maturity. The fields visited were farmers who were growing the new improved sorghum seed given by either Rongo University, Farmer Research Networks NGO (FRN) or by other farmers who had earlier received the seed. A total of 100 farmers' sorghum fields were visited. Disease symptoms were critically observed from a random sample of 20 plants in each field measuring 4m by 4msquare area and the disease incidence obtained by counting the number of symptomatic plants observed and expressing this as a percentage of the total number of plants examined as demonstrated by James (1974) and Chaube and Punder (2005) using the formula

$$DiseaseIncidence\ per\ variety = \frac{Total\ number\ of\ diseased\ plants}{Number\ of\ plants\ examined} X100$$

During the visit the local varieties grown by the farmers and commonly grown commercial varieties were also examined for disease incidence using similar methodology. Other important parameters recorded during the survey included; size of the farm, sorghum variety grown, cropping system within the farm (whether sole cropped or intercropped), the presence or absence of other diseases.

Data Collection and Analysis

The main instruments used for data collection included, GPS coordinate software, questionnaire and observation. The questionnaire was designed using Open Data Kit (ODK) and data collected using a smart phone (Samsung A 35). Data was analyzed using GRASS GIS version 7, Ms –Excel and SPSS Version 20.

4. Results and Discussion

4.1 Cropping Systems within the Sorhum Farming Communities

The results of the survey indicated that in virtually all the sorghum farms visited within the six counties, 95% of the sorghum varieties grown were either improved varieties given to farmers either by Rongo University and FRN NGO or local varieties. This was an indication that the new sorghum varieties were recognized by the farmers and had started gaining popularity within the counties. These varieties were either grown as sole crop or intercrop in equal measure (50%). It was also observed that sorghum was intercropped mainly with common beans, cowpeas, maize, mung bean or groundnuts with cow peas intercrop dominating followed closely by common bean intercrops. Farmers explained that cow peas intercrops were dominant because it helps them to completely cover the soil therefore reducing moisture loss, lowering demand for weeding and also it acted as a trap crop for *Striga* weed which is highly prevalent in the western region and has been completely devastating their cereal crop production. Those who intercropped with beans explained that bean matured faster than other legumes and hence provided them with early season food before the cereals and other crops were ready. The farmers also reported that bean yields were low in the 2018 season due to hailstones and several diseases such as bean fly that devastated the crop. Only few people intercropped with groundnuts as many farmers prefer growing this crop in pure stand during the short rain seasons, as a rotation with maize. Mung bean was mostly common with farmers who were in the drier parts of the lake region such as in HomaBay county because of its adaptation to the drought.

Table 1: Showing the number of farmers and different cropping systems practiced.

Croping System (Sole /Intercrop)	*Number of Farmers*
SORGHUM+COWPEAS	26
SORGHUM+COMMON BEANS	13
SORGHUM+MUNG BEAN	4
SORGHUM+MAIZE	7
SORGHUM+GROUNDNUTS	2
SORGHUM ALONE	48

4.2 Occurrence and Distribution of Sorghum Covered Kernel Smut Disease

The overall prevalence of covered kernel smut disease was generally high which suggests that the disease is of economic importance in the region. In general disease symptoms were observed in all the local varieties (Jowi, Nahadavo, and Ochuti), existing commercial varieties (Serena & Seredo) and in majority of the improved ones grown by the farmers. Disease incidence was relatively higher on the shorter and early maturing varieties (Nyadundo 1 and 2, C26 and MUK27) compared to the taller ones (T53B, MUK154, N68, T30B, IS3092) (Fig 2). This observation suggests a potential relationship between sorghum variety and the disease incidence based on the height or maturity period of the sorghum. However all the tall improved varieties exhibited no disease symptom hence were considered tolerant to the disease in the long season of 2018. The most seriously affected varieties across the six counties included Nyadundo 1 and 2, and C26 with disease incidence > 50% (Fig 2).Further discussions with farmers and observations made from previous visits indicated that the CKSD was present only during anthesis and grain filling stage and virtually absent at the seedling stage.

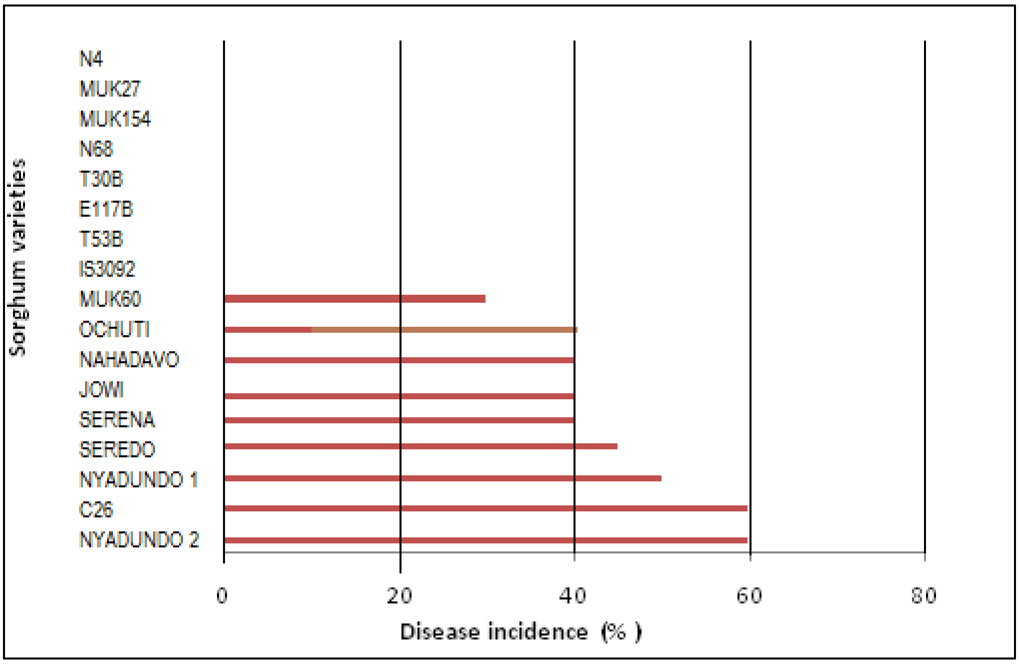

Figure 2 (a): Percent incidence (%) of Covered kernel smut disease in selected sorghum

Figure 2 (b): Sorghum panicles infested with covered kernel smut disease.

5. Conclusion

Sorghum was grown both as sole and in intercrops with different legumes and cereals including common beans, cowpeas, maize, mung bean or groundnuts with cow peas. The incidence and distribution of sorghum covered kernel smut disease was generally high in the six counties and more prevalent on the improved short varieties compared to the tall ones. All the local varieties and the common commercial varieties (Serena and Seredo) were also infested with the disease. This study identified four potential sources of resistance to the CKSD which will be used for future breeding work.

6. Recommendation

We recommend urgent dressing of sorghum seeds with appropriate fungicide in order to reduce disease infestation and spread. Farmers need to be advised on proper disposal of the infested plant material outside the farm preferably by burning. Farmers in prevalent areas to adopt resistant sorghum materials (MUK27, T53B, N68, T30B, E117B, MUK157, IS3092 andN4). As a long term strategy, we recommend genetic improvements of the current varieties to incorporate disease resistance within the current susceptible farmer preferred sorghum materials for future use.

7. Acknowledgement

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