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Assessment of Uganda's Farmers' Perception and Knowledge on Maize Cob Rots towards Breeding for Resistance

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Abstract: *Stenocarpella maydis* and *Fusarium graminearum* maize cob rots are two most devastating cob rots in maize which causes yield losses and reduce grain quality as a result of mycotoxins which is produced from this fungus. Developing varieties resistant to cob rots is a practical and economic strategy that provides cheaper protection against yield loss and poor grain quality. There is still low adoption of improved varieties partly because of limited incorporation of farmer preferred standards. Therefore farmers' preferences and perceptions should be captured early in a breeding program to enhance the adoption of released varieties. A focus group discussion (FGD) participatory approach was used in four districts of Uganda to assess farmers' perceptions on maize cob rots and to investigate the possibilities of breeding for farmer-preferred cob rot resistant varieties. Semi- structured questionnaires were administered to selected seed merchants to consolidate and verify farmers' reporting on seed varieties. Results ofinvestigationsuggested that absolute cob rot resistance was associated with undesirable traits such as small seededness, late maturing and low yields. Yield and earliness were the most preferred farmer agronomic traits, with a farmer-preference mean derived score of 4.5 and 3.75 respectively from the total of 5. In this regard, selection for farmer-preferred cob rot resistance varieties should strike a balance between yield and or earliness with cob rot resistance.

Keywords: Cob rot resistance; Survey, Maize, Uganda.

1. Introduction

Maize is the most important cereal in the tropics and sub-Saharan Africa. It was estimated that the demand for maize in the sub-Saharan Africa will increase by 93% by the year 2020 [1]. The productivity of maize from the farmers' fields has been characterised as being low averaging 1.2 t ha^{-1} compared to yield from research which is in excess of 10 t ha^{-1} [1]. The low yields experienced have been attributed to both biotic and abiotic stresses. Among the biotic constraints, diseases still rank highly as the major maize production constraint. Maize cob rots are important diseases which cause yield losses and reduce grain quality as a result of mycotoxins produced [2, 3]. The major cob rot pathogens in sub-Saharan Africa and world-over belong to fungi of the genera *Fusarium*, *Stenocarpella, Aspergillus Penicillium Nigrospora* and *Macrospora.* [4]. *Stenocarpella maydis* and *Fusarium species* particularly *F. graminearum* and *F. moniliforme* are the most predominant cob rot pathogens [5, 6]. The most important factors that promote proliferation of cob rots include; use of susceptible varieties and poor post harvest handling practices such as maize storage in high moisture and aerobic conditions [7].

To reduce the incidence of cob rots, a number of strategies have been suggested including spraying with fungicides but, this is expensive and in most cases not economically feasible in the small scale farming condition. Developing cob rot resistant varieties is an alternative strategy that is practical and economically feasible. However, low adoption of improved varieties by the farmers however may undermine adoption of such improved traits [8]. One way to address this challenge is to engage farmers early during varietal development, which also creates awareness of the problem [9]. Understanding farmer preference can assist in designing an effective breeding strategy for cob rot resistance and other important traits. Indeed, the acceptability of improved agricultural technologies by farmers depends on how well farmers' constraints and trait preferences have been addressed [10].

Participatory rural appraisals (PRAs) have been used to solicit farmer view points on various agricultural resource management options necessary to ensure household food security and improvement in their welfare [11]. Among them, focus group discussions have been developed to tap indigenous knowledge of farmers, investigating their production constraints and preferences in varieties they grow. This approach provides a fast and practical way of getting in touch with the target population under investigation [11]. It is utilized when a single subject is being

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examined in depth and where interaction of respondents may stimulate a richer response or new valuable thoughts [11, 12]. In order to understand farmers' perceptions and knowledge on maize cob rots, a study was conducted in four districts in Uganda.

The aim of this study was to assess farmers' perceptions and knowledge on occurrence and control of *Stenocarpella maydis* and *Fusarium graminearum* maize cob rots. The specific objectives were to investigate farmers' perceptions of *S. maydis* and *F. graminearum* cob rot problem in maize production, and evaluate the possibility of breeding new cob rot resistant maize varieties with farmer-preferred traits.

2. Materials and Methods

The study was conducted in four major maize growing districts of Iganga, Kapchorwa, Kayunga and Masindi (Figure 1) in Uganda. Two sub-counties per district were selected for the survey which was conducted between March to April 2010 giving a total of 8 sites (Table 1). These districts were chosen purposely because they were among the major maize production areas. A total of 152 respondents (Table 1) identified with the help of extension workers were interviewed.

Focus group discussions were used to solicit information from farmers. Before each group discussion exercise, the objectives and procedures of the exercise were explained to the farmers by the extension staff and the farmers were encouraged to use the local language, as it was easier for them to understand and respond. A member of the research team, most versed with the local language, facilitated the group discussion. The Focus group discussions involved both male and female participants in all cases. Issues pertaining to maize production, with specific emphasis on *S. maydis* and *F. graminearum* cob rots were explored. Farmers were shown samples of maize infected with these cob rots. Other disease symptoms displayed to farmers were maize leaf symptoms for maize streak virus and turcicum leaf blight. Farmers were asked to rate cob rot and selected biotic maize production constraints. For each FGD meeting, rating for cob rots and other biotic stresses was prepared using a scale of 1 (High) to 4 (Non-existence) Farmers' ways of handling infected grains were discussed and noted. Their perceptions on causes of cob rots and maize preferred traits were listed and ranked at each site.

To capture information on varieties, farmers listed varieties grown, old and abandoned varieties and their associated traits (cob drooping, erect cob and husk cover) in terms of cob rot resistance. In this study, a variety was classified as susceptible if yield losses of more than 30% were realized in a cob rot epidemic season (from the farmers understanding, at least 3 out of every 10 x 50 kg bags produced was infected grain). The association of traits to cob rot resistance was then determined on varieties with consistent reaction to cob rots in all sites visited. This was done by doing variety counts for each associated trait (cob drooping, erect cob and husk cover) to find out if either resistance or susceptibility is more likely associated with a particular trait. When addressing the questions of abandoned varieties, the group relied mostly on the older farmers for more information. Preferential ranking of farmers choices was done using the pairwise ranking method. Farmers also highlighted ways used to manage cob rots. Key informants were subsequently interviewed to get more details and clarification on certain aspects of the information gathered.

Five selected seed merchants who were named as the source for improved varieties were interviewed using a semi structured questionnaire to verify accuracy of farmer reporting. The companies interviewed were Mount Elgon, Victoria Seed, Farmers Inputs Care Center (FICA), Nalweyo Seed Company (NASECO) and East African Seed. The seed sellers' questionnaire was administered to a breeder, a seed technologist or other person directly involved in seed production at the company. Issues covered ranged from maize production constraints, cob rot management and maize preferred traits.

To verify the farmers' information, varieties perceived to exhibit variations to cob rot reaction across districts including Katulika (which was perceived to be resistant) and a resistant check line (WL118-10) was evaluated during the period Septmber- December in 2010 at the National Crop Resource Research institute at Namulonge (0º 32′ N, 32º 35′ E). The field was laid as a randomized complete block design with 2 replications and the cobs were evaluated for disease severity at harvest. The cobs were toothpick inoculated at 20 days after mid silking (R3 stage) Severity for *F. graminearum* was rated using the scale 1 = 1–3%, 2 = 3–10%, 3= 11–25%, 4 = 26–50%, 5 = 51–75%, and 6 = 76–100% [13]. For *S. maydis* the scale was 1=0-25 %; 2= 26- 50 %, 3=51-75 %, 4= 76-99 % and 5= 100 % (completely rotten) [5].

Mean derived scores were used to rank the farmers preferences [14]. The Fisher-one sign sample test was employed to evaluate each trait (Erect cob and open tip; Erect cob and closed tip and Early drooping) on whether associated varieties are more likely to be resistant or susceptible or have equal chances of either been resistant or susceptible (equally likely).

3. Results

Farmers' perception on prevalence and causes of cob rots. Cob rot was viewed as a serious concern in at least one sub-county per district with the exception of Masindi. Incidences of *S. maydis* and *F. graminearum* was rated using the scale 1 = 0–3%, 2 = 3–10%, 3= 11–25%, 4 = 26–50%, 5 = 51–75%, and 6 = 76–100% in Masindi (Table 2). Incidence/Severity of *F. graminearum* was high in Kapchorwa while for *S. maydis* it was high in at least one sub-county of Iganga, Kapchorwa and Kayunga. Across districts high rainfall was considered as the main predeposing factor to cob rot disease with a mean derived score (MDS) score of 4.75 followed by pest damage with a score of 2.13 (Table 3). The least was drought with a score of 0.13.

Farmers views on cob rot infected grains and their usage. While the farmers across districts agreed that cob rot reduce yield, only few were aware that consuming cob rot infected grains could cause health hazards, such as cancer in humans and diploidiosis in animals due to produced mycotoxins. In Kapchorwa, only 5% of the farmers were aware of the mycotoxins produced by infected cob rot grains. The rest indicated that they opted either to feed animals, brew beer (local name: warage) and ground the maize into maize flour for human consumption. Farmers in Iganga and Masindi unanimously got rid of infected grains. They were however, not aware of the specific health hazards caused by infected grain but agreed that it's not good for consumption. Fifty percent of the farmers who participated in Kayunga mentioned that they got rid of the grains while the rest either mixed it with good grain and sold or left it in the field to decompose.

Maize varietal reactions to cob rots. A total of 15 (Table 4) and 12 (Table 5) varieties were reported as being grown and old or abandoned respectively by the farmers across the four districts. Only two varieties currently grown, PH4 and H624 were not rated for cob rot susceptibility as farmers indicated that they were still new and under assessment. Varieties that were reported to droop were perceived to be resistant in all environments by farmers. There were mixed views with respect to erect cobs and closed tip varieties with respect to cob rots. The perception of the reaction to cob rots for some varieties varied in different sites (Table 6). Farmers were still growing some varieties that are perceived as susceptible such as, Longe 5 that was reported to be susceptible in Iganga, (Kiyunga sub-county), Masindi (Kiriyandango sub-county), and Kayunga (both Nazigo and Galilaya sub-counties). Farmers mentioned high-yield as the reason for growing the variety while hoping that cob rot would not be rampant in that particular season. With another variety, Longe 4, farmers pointed out early maturing as the reason for growing the variety in Kiyunga and Pakanyi sub-counties of Iganga and Masindi respectively. On the other hand, there were varieties which were reported to be old or abandoned and low yielding even though they were resistant to cob rots i.e. Munandi, Katumani, Ndere and Kawanda composite (Table 5). Field experimental results confirmed Katulika as resistant to both *Stenocarpella maydis* and *Fusarium graminearum*. The Longe series of varieties ranged from 'moderate resistance to susceptibility' and from 'resistant to moderate resistance' for *Stenocarpella maydis* and *Fusarium graminearum* respectively (Table 7). The association of the traits to cob rot resistance using Fisher-one sample sign test (Table 8), showed that at 95% confidence interval (CI), a sampled variety that droops early was likely to be resistant to cob rots and an open tip variety was more likely to be susceptible. In addition, at 95% CI, an erect cob and closed tip variety had an equal chance of either being resistant or susceptible.

Preferred traits/ characteristics. A summary of farmer preferred traits or characteristics for selection across the districts in comparison to the seed merchants' assessment revealed similarities with the top two criteria (Table 9). High yield followed by earliness were recorded as the top two preferred traits by farmers and seed merchants. While seed merchants considered disease resistance as the third, farmers considered drought tolerance as their third most important trait of interest.

Management strategies of cob rots by farmers and seed merchants. Farmers in all four study districts exclusively mentioned different strategies for managing cob rots. The strategies included harvesting at the right time, dusting cobs with dry ash while in the field, termite control, early harvesting and breaking off tips before storage. Seed companies pointed out the selection of closed tip inbred lines in hybrid varietal formation was important to reduce cob rots. The common ways of managing cob rots between seed sellers and seed companies were crop rotation, chemical control and use of resistant varieties.

4. Discussion

Capturing farmer perceptions and knowledge, and incorporating them early in the plant breeding program can enhance the rate of adoption of newly released varieties. Understanding the famers' perceptions about the causes of diseases is pivotal in designing the best approaches to combat diseases. Too much rainfall late in the growing season, when cobs have set was ranked as the number one cause of cob rots by the farmers in all districts except for Kayunga where it was ranked second. Overall it had a much higher mean derived score of 4.73 followed by pest damage with 2.13. These data show that farmers are aware that moisture contributes to the development of cob rot diseases. In other studies, increased exposure of mature maize cobs to water or rainfall in the field increases chances of cob rot disease incidence and severity if the pathogen is present [15]. Harvesting cobs immediately after they mature could reduce incidence of cob rots but complications associated with post harvest storage poses a challenge [16]. In addition, early maturity was one of the traits mentioned by farmers and seed companies as being desirable. Such varieties are likely to mature before the end of the rains and therefore prone to cob rot infection. This further emphasizes the importance of cob rot resistance breeding.

Differences in the way farmers perceived reaction of maize varieties to cob rots in different districts with the Longe series of maize varieties, Longe 1, 4, 5 and 6H (Table 6) was due to differences in environments where they were grown. However, the fact that two varieties; Katulika (still grown) and Munandi (abandoned) were viewed by the farmers in two different districts, Iganga and Kayunga, to be resistant to cob rots suggests that inherent genetic resistance across environments to cob rots may exist in some germplasm. The assessment on associated cob rot resistance traits (Table 8), as perceived by the farmers, shows that erect and closed tip varieties may not be used as an indirect selection tool for resistance to cob rots. Early drooping was perceived by the farmers as a trait which correlates to cob rot resistance. This may have been influenced by drooping cob ability to keep the cob dry, by easily draining excess moisture and thereby reducing pathogen infection. The resistance to cob rots as shown by a variety, Katulika, with open tips suggests that resistance may also be due to other causes rather than husk inhibition through

the silk channel. Two resistance mechanisms for cob rot exists: i) as a result of inhibition for the pathogen to pass through the silks and ii) the resistance of the kernels to the spread of disease [17].

Overall, farmers across the sites and seed merchants preferred high yielding varieties, closely followed by earliness as the most important traits (Table 9). However, the overall comparison between farmers' and seed merchants' criteria displayed some differences. While seed merchants ranked pest/ disease resistance as third ranked selection criteria, farmers ranked it as fifth with drought and palatability at position three and four respectively. Other studies have highlighted lack of correlation between farmers and breeders varietal trait preferences as a reason for low varietal adoption [14].

Breeding for varieties that should be adoptable by farmers is essential. In this situation, evaluation of possible cob-rot resistant varieties must take into consideration, traits for yield and earliness. In addition, the relationship between resistance and undesirable traits such as small seeded cobs, low yields and late maturity had been shown by the cob-rot resistant varieties that farmers have abandoned (Munandi, Ndere and Katumani). These associations corroborate other reports which showed that their may be a practical limit to the amount of resistance to cob rots in desirable varieties due to complicated genetics and/or linkage to undesirable agronomic traits [18, 19]. Therefore, there may be need to strike a balance between selection for other desirable traits and for cob rot resistance. It should be noted however, that the farmers' low ranking for some traits such as disease and pest resistance might mean that the National Crop Resources Research Institute (NaCRRI) in Uganda, has done good work in releasing varieties that are resistant to most pests and diseases, so that the farmers do not notice these as a great concern. The other reason could be ignorance of crop diseases and their effects by farmers which is prevalent in many parts of Africa [20]. This could as well be observed from the farmers' lack of awareness in this study, on the effects of mycotoxin produced by cob rots as it has also been reported by other studies [6, 21]; . The fact that most farmers are still not aware of the effects of mycotoxins shows that there is need to intensify a health awareness about mycotoxins produced by maize cob rot diseases. No market penalties, cause farmers to put less importance on cob rots as they should. The poor maize market system has probably led to maize farmers to have less consideration on marketability as an important characteristic to consider when selecting a variety to grow [22]. The market in Uganda was liberalized and farmers usually sell the excess produce to middlemen at their farms and at nearby trading center or urban market at low prices [22]. There are no established classification standards for selling maize and what should be paid for it, and that situation continues through the present.

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Tables and Figure

Figure-1. Map of Uganda showing districts of study for the focus group discussion survey conducted during the period March to April 2010

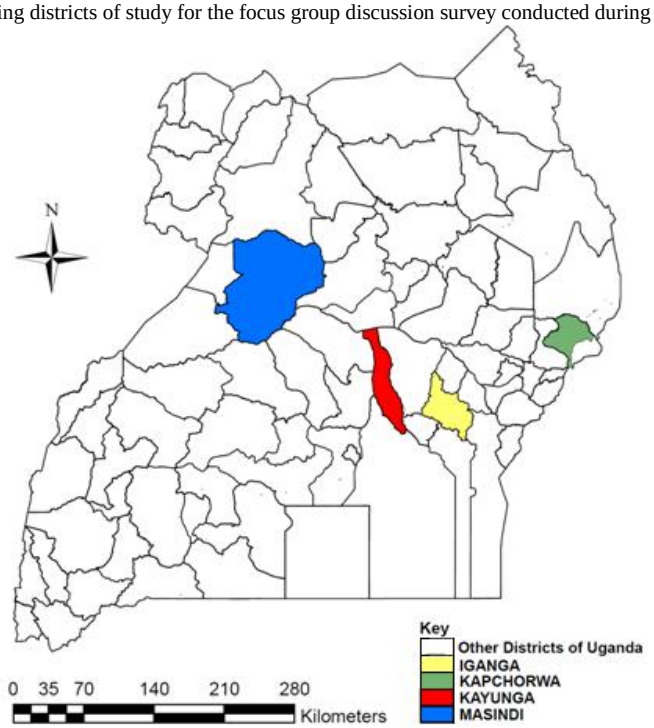

Table-1. Number of participants across districts who took part in focus group discussions during the period March-April 2010

District	Sub-county	Male	Female	Total
Iganga	Bukanga	7	13	20
Iganga	Kiyunga	10	7	17
Kapchorwa	Kaptanya	7	12	19
Kapchorwa	Tegres	11	9	20
Kayunga	Galilaya	12	8	20
Kayunga	Nazigo	10	10	20
Masindi	Kiriyandango	7	10	17
Masindi	Pakanyi	9	10	19
Total		73	79	152

Table-2. Cob rot and other common biological stresses as rated by farmers across four districts in Uganda, March-April 2010

Constraints	Iganga		Kapchorwa		Kayunga		Masindi	
	A	B	C	D	E	F	G	H
Striga	1	1	4	3	4	4	4	4
Stem Borer	3	2	2	1	1	1	1	1
Birds	1	1	3	1	1	1	1	1
Livestocks	3	3	3	1	3	1	1	3
Termites	1	1	1	2	1	1	1	1
Maize streak virus	3	2	1	3	3		1	1
Tursicum leaf bright	3	3	3	3	3	1	3	3
Gray leaf Sport	3	3	3	3	3	1	3	3
Cob rots								
Stenocarpella maydis	1	1	2	1	1	1	2	2
Fusarium graminearum	3	2	1	1	3	2	3	3

Sub-counties, A-Bukanga, B-Kiyunga, C-Tegres, D-Kaptanya, E- Nazigo, F-Galilaya, G-Pakanyi, H-Kiriyandango. Rating: 1-High/ Serious, 2- Medium/ Moderate; 3= Low; 4- Non existence

Table-3. Farmers' ranked causes of cob rots in four districts of Uganda during March-April 2010 (data derived from pairwise ranking and scoring)

Causes	Iganga		Kapchorwa		Kayunga		Masindi		*MDS Score
	A	B	C	D	E	F	G.	H	
Too much rain	1	1	1	1	2	2	1	1	4.75
Lodging	2	2	2	-	-	-	4	-	1.75
Susce. Varieties	-	-	3	-	1	-	-	-	1.00
Poor Storage	5	-	4	4	-	3	-	2	1.50
Late Planting	-	-	5	-	-	-	-	-	0.13
Pest damage	-	3	6	-	-	1	2	-	2.13
Delayed harvesting	3	5	-	-	-	-	-	-	0.5
Poor Soil fertility	-	-	-	-	4	-	-	-	0.25
Early harvesting	4	4	-	2	-	-	-	-	1.00
Poor Weeding	-	-	-	3	3	-	-	-	0.75
Drought	-	-	-	-	5	-	-	-	0.13
Lack of Crop Rotation		-	-	-	-	-	3	-	0.38

Sub- counties, A-Bukanga, B-Kiyunga, C-Tegres, D-Kaptanya, E- Nazigo, F-Galilaya, G-Pakanyi, H-Kiriyandango. * Mean derived score (MDS) is the average score across districts. First ranked criterion receives a score of 5, second ranking scores 4, third ranking scores 3, fourth ranking scores 2, and each other ranking scores 1. Where not mentioned the ranking score is 0.

Table-4. Current cultivated maize varieties by farmers across the four surveyed districts mentioned during focus group discussions in 2010, March to April

Variety	District	Maturity	Reaction to Cob rots	Associated Traits
H614	Kapchorwa	Late	Resistant	ED, CT
PH4	Kapchorwa	Medium	Assessed	Assessed
H628	Kapchorwa	Late	Susceptible	EE, CT
H513	Kapchorwa	Medium	Susceptible	EE, CT
H624	Kapchorwa	Medium	Assessed	Assessed
H629	Kapchorwa	Late	Resistant	ED, CT
H626	Kapchorwa	Late	Susceptible	EE, CT
DH04	Kapchorwa	Early	Resistant	ED, CT
Longe 5	Iga., Kap., Kay., Mas.,	Medium	Varied	CT
Longe 4	Iganga , Masindi	Early	Varied	CT
Longe 1	Iga., Kay., Mas.	Medium	Varied	EE, CT
Longe 2H	Masindi, Iganga	Medium	Resistant	EE
Longe 6H	Masindi, Iganga	Medium	Varied	EE
Katwogere	Masindi	Early	Resistant	EE
Katulika	Iganga, Kayunga	Early	Resistant	OT

Kap- Kapchorwa, Kay- Kayunga, Mas- Masindi, Iga- Iganga, EE- Erect Cob, ED- Early Drooping , CT- Closed tip, OT- Open tip

Table-5. Old and abandoned varieties across the four surveyed districts as reported by the farmers during the focus group discussions in 2010, March to April

Varieties	Districts	Year Abadoned	Cob rot Reaction	Abadonment Reasons	Associated Traits
Munandi	Kayunga, Iganga	1990's	Resistant	Low yields+ late maturing	CT, DE
D161	Iganga	1990's	Susceptible	late maturity	EE, OT
DK 8053	Iganga	2000-2005	Susceptible	No seed availability	OT
Katumani	Kayunga, Masindi	1990's	Resistant	low yield + small grains	EE, OT
Maringon	Masindi	1970's	Susceptible	Disease susceptibility + low yielding	EE, OT
SC 625	Masindi	1990's	Susceptible	Low yielding	OT
SC 627	Iganga	1990's	Susceptible	Disease susceptibility	OT
H622	Kapchorwa	2000-2005	Susceptible	No seed availability	EE, CT
H632	Kapchorwa	2000-2005	Susceptible	No Seed availability	EE, CT
H511	Kapchorwa	2000-2005	Resistant	No Seed availability	EE, CT
*Subende	Kapchorwa	-	Resistant	Low yields + variegated seed	EE, CT
kawanda composite	Masindi	1993-94	Resistant	Low yields	EE
Ndere	Masindi	1970's	Resistant	Low yields	DE, CT

*Only 5% of the participants indicated still growing the variety and the rest abandoned. Kap- Kapchorwa, Kay- Kayunga, Mas- Masindi, Iga- Iganga, EE- Erect cob, ED- Early Drooping, CT- Closed tip, OT-Open tip

Table-6. Current grown varieties with different reactions to cob rot as perceived by the farmers in different locations as reported in 2010, March to April, during focus group discussions

Variety	Reaction to Cob rot							
	Iganga		Kapchorwa		Kayunga		Masindi	
	A	B	C	D	E	F	G	H
Longe 1	R				S	S		
Longe 5	R	S	R		S	S		S
Longe 4	R	S						S
Longe 6H							R	S

Sub-counties, A-Bukanga, B-Kiyunga, C-Tegres, D-Kaptanya, E- Nazigo, F-Galilaya, G-Pakanyi, H-Kiriyandango. R-Resistance, S- Susceptible

Table 7. Mean scores for reaction to *S. maydis* and *F.graminearum*cob rots obtained from Namulonge in 2010 second season to confirm farmers perceptions on reaction to cob rot on selected varieties

Variety	*S.madyis* Mean Score	*F. graminearum* Mean Score
WL 118-10	1a	1a
Katulika	1a	1a
Longe 4	2.5b	2b
Longe 5	3.5bc	2.5bc
Longe 6H	3.5bc	3c
Longe1	4c	3c
LSD	1.0	0.74

Table 8. Analysis of farmers' perception on the likelihood of traits to the associated variety reaction to cob rots mentioned during focus group discussions across districts in 2010, April to March

Variety Traits	No. of Ass. varieties	% resistant to cob rot	Fisher- one sample sign test; 95% CI	Verdict R or S
Early Drooping	5	100	X=0; Xcritical= 1	Likely R
EE and CT	13	53.9	X=6; Xcritical= 2	Equally likely
EE and OT	5	20	X=1; Xcritical= 1	Likely S

No.- Number, Ass- associated, EE- Erect cob, CT- Closed tip, OT- Open tip, R- Resistance, S- Susceptible, CI- Confidence Interval

Table 9. Preferred selection criteria ranked by farmers across districts and seed merchants reported in 2010, March- April: a summary of pairwise ranking and scoring

Selection Criteria	MDS- SM	SM- Overall Rank	MDS- Farmers	Farmers- Overall Rank
Yield	4.8	1	4.5	1
Earliness	3.4	2	3.75	2
Pest/ Disease resistant	2	3	1.25	5
Drought resistance	1.8	4	2	3
Marketability	-	-	1	6
Palatability	0.8	5	1.75	4
Big grain	-	-	0.75	7
Grain Density	-	-	0.75	7
Resistant to Lodging	0.4	7	-	-
Good Husk Cover	0.8	5	0.25	9
Cob Inclination	0.6	6		-
Adaptability	0.2	8		

MDS-SM and MDS-farmers'-Mean derived score obtained from averaging specific scores for a particular trait obtained from each seed merchants and farmers group discussion ranking respectively. SM- Seed Merchant