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Evaluation of resistance reaction of maize germplasm to common foliar diseases in Kenya

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Abstract
Use of resistance varieties is the most practical method of managing crop diseases. There is a great variation in terms of resistance reaction to diseases among the various maize germplasm and with the liberization of seed market, the sector has witnessed proliferation of massive introduction of new varieties whose reaction to diseases cannot be ascertained. This study was conducted to evaluate the reaction of maize varieties to northern leaf blight (NLB), common maize rust, gray leaf spot (GLS) and maize streak disease (MSD). The experiment was conducted at Kabete Field Station, University of Nairobi for two seasons namely short rains and long rains. The germplasm was bought from the commercial seed stockists and the landraces obtained from KARI Katumani and from farmers. The diseases were assessed by monitoring and scoring for disease incidence and severity. The appropriate scoring keys were used for determination of disease severity. All the varieties showed symptoms of the four diseases in both seasons but the intensity of the diseases differed significantly among the different varieties. Disease incidence was highest for common rust with a mean of 14.29% for the variety DH04, while disease incidence was highest (19.21%) for northern leaf blight in season two for Kinyanya which is a landrace. Gray leaf spot and the common smuts had the lowest mean incidence ranging from 0 to 0.25% for common smut and 0 to 2.6% for gray leaf spot. Season two had comparatively higher disease incidence means compared to season one. Meteorological data showed that season two had more rains and this explains the reasons behind this. Though all the varieties screened were found to be affected by the diseases to various levels, the varieties displayed significant differences in the disease incidence and severity. This shows that use of resistance varieties should be considered in the management of maize diseases. Focus should also be on pyramiding genes for resistance in the breeding programmes to develop varieties with multiple resistance to different diseases.
Key words: Disease incidence and severity, disease score, symptoms, varieties

Introduction

Maize (*Zea mays* L.) is one of the most important staple foods in sub-Saharan Africa, providing food and income to over 300 million resource-poor smallholders. Its cultivation spans the entire continent and it is the dominant cereal food crop in many countries, accounting for 56% of total harvested area of annual food crops and 30-70% of total caloric consumption (FAOSTAT, 2007). It accounts for about 40 percent of daily calories and has per capita consumption of 98 kilograms; this translates to between 30 and 34 million bags (2.7 to 3.1 million metric tons) of annual maize consumption in Kenya. Kenya produces only 28 million bags and the deficit is bridged by imports from neighboring countries (Kabaara, 2005). Diseases and insects are serious constraints to yield improvement throughout the country.

Southern leaf blight caused by *B. maydis,* common rust caused *by Puccinia sorghi,* northern leaf blight caused by *Exserohilum turcicum* and maize streak are the most important diseases in Kenya (Mwangi, 1998). Different studies have been carried out in the past regarding the reaction of maize germplasm to diseases. Muriithi and Mutinda (2001), using commercial hybrids, found out that only 4 out of 30 genotypes tested were susceptible to northern leaf blight. Mwangi (1998) carried out a study on status of northern leaf blight, *Phaeosphaeria maydis* leaf spot, southern leaf blight, common rust and maize streak disease in Kenya and reported widespread occurrence of these diseases. He further noted that ideal temperature and moisture conditions coupled with susceptible genotypes could result in high disease yield losses. Evaluations done by Adipala *et al.* (1993) on Ugandan maize germplasm for resistance to *E. turcicum*, showed that all the germplasm had necrotic susceptible reactions when inoculated with races of the pathogen. Mwangi (1998) also found out that even the hybrids that have been developed for maize improvement program were susceptible to two or three different pathogens. In the recent past, different germplasm have been introduced into the country it is vital to establish the reaction of these germplasm to the common maize diseases found in the country. The study was undertaken with the aim of screening the different germplasm for the resistance to common maize diseases in Kenya.

Materials and methods

The field plots were established at Kabete Campus, University of Nairobi where the field was prepared by disc ploughing and harrowing to obtain a fine tilth. A total of 19 different maize lines were planted at a depth of 5cm and DAP fertilizer was applied at the rate of 10 g per hill. The trial was laid out in a randomized complete block design. The rows represented the experimental plots and these were replicated four times. Each row had 20 hills with crop spacing of 75cm and 25cm and the blocks were spaced 2 m apart. Two seeds were sowed per hill and thinning to one plant per hill was done when the maize seedlings had attained a height of 15 cm.

The plants were exposed to naturally occurring population of the different pathogens. Watering was done using overhead irrigation to promote conditions that are favourable for disease development. Top dressing was done using calcium ammonium nitrate (CAN) fertilizer at the rate of 10 g per hill when the plants were about 40 cm in height. The crop was protected from stem borers using Beta-cyfluthrin 0.5g/kg granules, which is a systemic insecticide and a synthetic pyrethtroid marketed as Bulldock 0.5 GR.

Seven plants were chosen at random from each row and tagged for identification purposes and data collection. Monitoring and scoring for the reaction to different diseases among various varieties was done on the tagged plants. Weekly ratings of resistance were taken and disease incidence and severity recorded. Disease incidences were calculated as a percentage of the plants infected out of the 20 plants per row. The data was taken weekly for seven weeks and subjected to analysis of variance. Two experiments were carried out, one in the short rains (December to April) and the other one in the long rains (April to July).

Disease severity was assessed for the various diseases using the following disease scores. Severity for NLB was rated using a modification of a scoring scale of 0 - 5 described by Elliots and Jenkins (1946) as follows; 0 = indicates no symptoms, 0.5 = very slight infection (one or two restricted lesions on lower leaves), 1 = slight infection (a few scattered lesions (3-8) on lower leaves, 2 = light infection (moderate number of lesions (9-15) on lower leaves), 3 = moderate infection (abundant lesions [>16] on lower leaves and a few on middle leaves), 4 = heavy infections (lesion abundant on lower and middle leaves and extending to the upper leaves), 5 = very heavy infection, lesions abundant on all leaves, plants may be killed.

Common rust was assessed using a key adopted from Danson *et al*. (2008) as follows; 1 = no symptoms, 2 = a few lesions corresponding to less than 1% of the leaf area with symptoms, 3 = several lesions, but not linked together corresponding to 1-5% infected leaf area, 4 = many lesions some linked together to form a necrotic (dead) area corresponding to 6-20% infected leaf area, 5 = necrotic areas linked together and a few leaf tips are dead corresponding to 21-50% infected leaf area, 6 = 50% of the leaf tips are dead corresponding to more than 50% leaf area with symptoms, 7 = most of the leaves are dead or the plant is dead.

Gray leaf spot was assessed using a modified scale by Danson *et al*. (2008) as follows; 1= no symptoms, 2 = moderate lesion below the leaf subtending the ear, 3 = heavy infestation on and below the leaf subtending the ear with few lesions above it, 4 = severe lesion on all but the uppermost leaves which may have a few lesions, 5 = all leaves dead.

Maize streak disease severity rating was done using a scoring key modified from Gichuru (2011) and Danson *et al*. (2008) as follows; 1 = no symptoms, 1.5 = very few streaks on leaves, 2 = light streaks on old leaves gradually decreasing on young leaves, 2.5 = light streaking on old and young leaves, 3 = moderate streaks on old and young leaves, 3.5 = moderate streaks on old and young leaves and slight stunting, 4 = severe streaking on 60% of leaf area, plants stunted, 4.5 = severe streaking on 75% of leaf area, plants severely stunted, 5 = severe streaking on 75% or more of the leaf area, plants severely stunted and or dying.

Results

Disease incidence

All the varieties tested showed varied reaction to the various diseases. Northern leaf blight, common rust, GLS, MSD and common smut were recorded infecting the different types of germplasms. Three major diseases NLB,

common rust and MSD were recorded in the two seasons, in season one, common rust had the highest incidence at an average mean of 14.29% for the variety DH04. In season two, northern leaf blight had the highest mean disease incidence at 19.21% for the variety Kinyanya and common rust followed closely with 18.32% for the variety Katumani.

Gray leaf spot and the smuts had the lowest disease incidence means ranging between 0 and 0.25% for common smut and 0 and 2.6% for GLS. The means for northern leaf blight were significantly different within the varieties (p =0.05) with the most susceptible variety Katumani recording a mean of 4.79% and the least susceptible Hybrid 625 with a mean of 2%. The incidence of common rust was highest in DH04 with 14.29% and lowest in Pannar 4m-19 with a mean of 6.36% in season 1. Season 2 had higher means where the most susceptible maize variety was Hybrid Katumani with 18.32% –and the lowest incidence being observed in Pannar 4m-19 with a mean of 15.32% (Table 1).

Table 1: Mean disease incidences of different diseases infecting maize during long and short rains

	Season one					Season two			
Variety/Disease	**NLB**	**Common Rust**	**MSD**	**GLS**	**C. Smut**	**NLB**	**Common Rust**	**MSV**	**GLS**
Hybrid Katumani	4.78 a	14.11ab	1.96bc	0.67b	0.101a	18.75a	18.32a	10.68 de	0
Kinyanya (Mak)	4.35ab	14.21ab	2.46bc	0.42b	0.17a	19.21a	17.50a	9.04 de	0.21ab
Kikamba	4.321ab	13.21ab	1.85bc	1.14b	0.14a	16.68a	15.68a	12.07cd	0.10bcd
Pannar 4m-19	4.03 abc	6.36e	1.92bc	2.67a	0.03a	17.93a	15.32a	11.82 cd	0
Dry Highland 01	4.00 abc	12.39abc	1.67c	2.21ab	0.14a	18.46a	17.36a	13.64 abc	0
Hybrid 513	4.00 abc	12.39abc	3.50ab	1.21ab	0.10a	18.39a	16.32a	16.50 abc	0
Kisakwa Kitune	3.89 abc	11.68abcd	1.67c	0.28b	0.03a	-	-	-	-
Dry Highland 04	3.71 abc	14.29a	2.46bc	1.53ab	0.25a	18.54a	17.54a	15.25 abc	0
Pioneer	3.67 abc	13.21ab	1.28c	2.00ab	0a	19.21 a	18.04a	13.00 bcd	0.35a
DK 8031	3.28 abc	12.96ab	2.75bc	1.75ab	0a	17.96a	17.89a	8.21 e	0.14bc
Duma 43	3.17 abc	12.43abc	1.50c	1.14b	0a	18.68a	17.61a	5.50 e	0.03cd
Hybrid 624	3.17 abc	9.29cde	1.85bc	0.64b	0.07a	18.11a	16.21a	14.57 abc	0.14bc
Githigu	3.10 abc	12.21abcd	3.53ab	1.64ab	0a	17.82a	16.64a	13.64abc	0
Hybrid 628	2.57 abc	8.64de	3.03ab	1.10b	0.10	17.50a	16.68a	16.64 abc	0
Pannar	2.53 bc	12.82ab	1.50c	1.07b	0.25a	18.25a	16.93a	6.50 de	0.03cd
Hybrid 629	2.46 bc	9.14cde	3.92ab	0.75b	0.25a	18.82a	17.64a	17.46 ab	0
Hybrid 614	2.42 bc	10.29bcd	5.14a	1.60ab	0da	17.04a	15.54a	17.89 a	0
Hybrid 516	2.21 b	10.64bcd	4.10ab	0.85b	0.21a	16.25a	16.79a	15.96 abc	0
Hybrid 625	2.00 c	10.79bcd	2.60bc	1.25ab	0.10a_	17.86a	16.04a	14.32 abc	0
Hybrid 6213	-	-	-	-	-	17.07a	15.36a	17.32ab	0
p-value	0.113	0.001	0.001	0.775	1.000	0.360	0.188	1.000	1.000
LSD	2.23	3.61	2.38	1.50	0.46	3.33	3.25	4.78	0.36

Key: NLB:-Northern leaf blight, GLS:- gray leaf spot, MSD:-Maize streak disease, _ the variety was not planted in this particular season. Means are calculated as averages out of 20 plants. Means bearing the same letters along the columns are not significantly different (p=0.05)

Disease Severity

Disease severity mean scores for the various genotypes were generally low for all the diseases. Three diseases namely northern leaf blight, common rust and maize streak disease had the highest severity mean scores and this was observed in both seasons. These diseases were recorded in all the 19 varieties screened. Common rust and maize streak disease had higher severity means in season 1 than in season 2. Gray leaf spot incidence was relatively low as observed in the evaluation with means across all the genotypes being <2. Northern leaf blight had higher means in season one compared to season two (Table 2).

Table 2: Mean disease severity scores for various diseases infecting maize for the different seasons

	Season one				Season two			
Variety/Disease	GLS	MSV	NLB	Common rust	GLS	MSV	NLB	RUST
Kikamba	1.65a	1.35c	1.44ab	2.53b	1.01a	2.46a	0.92ab	2.25a
Githigu	1.64ab	1.62a	0.93c	2.24bcd	1.01a	2.52a	0.71bc	1.95abc
Pioneer	1.61ab	1.27c	0.95c	2.21cd	1.02a	1.76bc	0.67bc	2.04a
Duma 43	1.60ab	1.65ab	0.95c	2.39bc	1.01a	1.36cd	0.59c	1.94abc
Hybrid 614	1.58ab	1.65ab	0.75d	2.07cd	1.01a	2.45a	0.74bc	1.78c
Dry Highland 04	1.55ab	1.6a	1.03cd	2.40bc	1.02a	2.10a	0.72bc	1.93abc
Hybrid Katumani	1.53abc	1.30c	1.61a	2.52b	1.07a	2.22a	1.03ab	2.05a
Hybrid 516	1.51abc	1.49bc	0.87cd	2.11cd	1.02a	2.34a	0.79bc	1.77c
Hybrid 628	1.51abc	1.66a	0.80d	2.00cd	1.04a	2.49ab	0.66bc	1.82c
Hybrid 513	1.51abc	1.40bc	1.01cd	2.37bc	1.00a	2.31a	0.72bc	2.06a
Pannar 4m-19	1.49abc	1.39bc	1.02cd	1.96d	1a	1.79bc	0.6c	1.79c
Kinyanya (Maku)	1.46abcd	1.40bc	1.23bc	2.49bc	1.05a	1.64bcd	1.14a	2.03a
Hybrid 624	1.45abcd	1.36c	0.97cd	2.12d	1.01a	1.90bc	0.92ab	1.90bc
Dry Highland 01	1.45abcd	1.20c	1.79a	2.53b	1.06a	1.93bc	1.04ab	2.24a
Hybrid 629	1.40abcd	1.82a	0.8d	2.15d	1a	2.23a	0.75bc	2.14ab
Pannar	1.38bcd	1.31c	0.94cd	2.23cd	1.02a	1.16d	0.65bc	1.81c
DK 8031	1.28cd	1.38c	0.92cd	2.37bc	1.07a	1.86bc	1.12a	1.96abc
Hybrid 625	1.26cd	1.47bc	0.63d	2.14d	1a	2.29a	0.87ab	1.95abc
Kisakwa Kitune	1.20d	1.49bc	0.95c	2.83a	-	-	-	-
p. value	1.00	1.00	0.001	0.001	1.00	1.00	0.004	0.735
LSD	0.28	0.27	0.36	0.29	0.13	0.57	0.29	0.33

Key: NLB=Northern leaf blight, GLS= gray leaf spot, MSV=Maize streak virus. -The seeds for variety Kisakwa Kitune were not enough for season two. Means bearing the same letters along the columns are not significantly different (p=0.05).

Discussion

The study was undertaken to screen different maize genotypes for their reaction to common diseases in various maize growing regions in Kenya. All the genotypes screened were observed to be infected with two or more of the diseases they were screened for. Three diseases; common rust, northern leaf blight and maize streak disease, had higher incidences and severity in both seasons, with season two showing higher scores. This shows that the environmental conditions were favourable for the diseases. This agrees with report by Muiru (2008) who reported that northern leaf blight is favoured by mild temperature and high humidity which occurs in several areas of the country where maize is grown. Mwangi (1998) also reported that heavy dews, cool temperature and frequent rains create conducive environmental conditions for disease development. Continuous cropping allows for the build up of the inoculum that is critical in infecting the subsequent crops. This explains why the mean incidences of various diseases were higher in season two compared to season one since there was overlap of the seasons (December to April for season one and April to July for season two). This observation agrees with Pedersen and Oldham, (1992) who reported similar findings. Similarly Brewmaker, (1974) reported that common rust thrives in high humidity and moderate temperature conditions and it is favored by continuous production of maize.

Although the disease incidence was relatively higher in season two compared to season one, it was different with the disease severity where season one had slightly higher disease severity scores. This result agrees with findings from Dillard and Seem (1990) who carried out an experiment on incidence-severity relationship for common rust and reported that severity levels can be high for one season but the severity levels are relatively low. He observed that disease severity levels increases at low rates until the third year when positive correlation between disease incidence and severity was evident. Meteorological data showed that for season one the rainfall, temperature and pan evaporation were higher compared to season two rendering it favorable for the pathogens to thrive and this explains the higher disease severity scores.

Maize streak disease showed higher incidence and severity means in season two compared to season one. This can be attributed to alternate and successive cropping of maize which allows the vector *Cicadulina mbila* to be more successful in acquiring Maize Streak Virus from maize than from other hosts as also reported by Magenya et al., (2008). Given that at the time season two experiments was planted season one experiment was still in the field, this allowed the vector to easily acquire and transmit the virus to the younger crop. Once the virus is acquired, it persists in the vector throughout its lifespan (Bock, 1974; Alegbejo et al., 2002). Hence the virus

acquired by the vector in season one continued infecting the season two crops. This allows a significance increase of incidence and severity for MSD in subsequent seasons. The incidence and severity of gray leaf spot reduced between season one and season two. The severity and incidence means were higher in season one compared to season two. This too was due to the fact that the environment for the establishment of the fungus was conducive in season one where there was higher amounts of rainfall and higher temperatures.

The varieties grown in the country both local and imported were found to be susceptible to two or more of the pathogens studied. The resistance reaction was found to differ among the different varieties and this agrees with Welz et al., (2000) working on turcicum leaf blight who reported differential reaction of various maize germplasm to the disease. The reaction of the varieties to the various pathogens is governed by the resistance genes incorporated in the varieties in the breeding programmes.

Conclusions and Recommendations

All the hybrids that were screened were found to be susceptible to the common diseases of maize but the degree of susceptibility varied among the varieties. So there is a need to pyramid genes for resistance in the elite varieties to enable farmers increase their productivity. A more comprehensive screening program is necessary for maize germplasm to include other diseases affecting the crop and to include other maize germplasm. Varieties identified to possess resistance to the various diseases should be made available to the farmers.

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