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Tolerance and resistance of maize hybrids to maize streak virus in Uganda

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Abstract

Maize streak virus disease is the most important disease of maize in Uganda. On susceptible varieties, yield losses of 90% have been observed. Many of the varieties private seed companies brought into the country claiming to be resistant to the disease have succumbed. It is therefore, mandatory to screenfor MSV resistance in local and introduced maize varieties. A study was initiated to ascertain the resistance levels of the hybrids from private seed companies for their consideration of release in Uganda. Results obtained showed that out of 20 hybrids evaluated, two were resistant, fourteen tolerant and four susceptible. However, most hybrids with high incidence had high severity scores and this was positively correlated (r=0.66). Some hybrids like PAN 33 despite being resistant to MSV had other shortcomings like susceptibility to gray leaf spot and ear rots. These constraints are likely to affect its utilization in Uganda as is the case with SC 625 which failed to be released because of its susceptibility to ear rots.

Keywords: Maize streak Virus, Maize hybrids; Host plant resistance; Gray leaf spot Private Seed Companies

Introduction

Maize streak virus disease (MSVD) is a major constraint to maize production in many African countries. Yield losses of up to 100% in susceptible varieties have been recorded (Fajemisin et al. 1986; Barrow, 1992). The disease is incited by maize streak geminivirus and is transmitted by leafhoppers of genus Cicadulina (Webb, 1987). Out of the twenty-two species of the genus, only eight have been confirmed to transmit maize streak virus (Rose, 1962; Okoth and Dabrowski, 1987). The eight species have been found in Uganda two of which (*Cicadulina mbila* and *C. storeyi)* are the most predominant, with the former being more efficient in transmitting the disease (Page, 1994).

Several control strategies have been investigated, but host plant resistance has been found to be reliable and sustainable (Barrow, 1992). In view of this, several national programs, private seed companies and international research centers like IITA and CIMMYT have put considerable amount of resources to achieve this option. This has led to the development of many resistant/tolerant maize varieties. The reaction of these cultivars though considered resistant tends to vary. Factors like leafhopper infestation method, different MSV isolates, genotype by environment interaction (GXE), and different disease rating scales among others, have been noted to complicate interpretations of results obtained from studies on genetics of tolerance to MSV (Kyetere, 1996). The two terms resistant and tolerant have been used in describing maize varieties and will be used in this presentation hence the need for their definitions.

The government aims at reducing poverty through modernization of agriculture and one way of achieving this is by using improved varieties. In addition, following the liberalization of the seed sub-sector, many private companies have come in and are making attempts to bring in their varieties for growing in Uganda. However, some of the varieties described as resistant have succumbed to the disease when grown in Uganda (Bigirwa unpublished). The objective of the study therefore was to ascertain the level of resistance/ tolerance of maize hybrids that private companies were intending to introduce in Uganda.

Materials and methods

Twenty hybrids from private seed companies including two checks from the Cereals Research Program were tested at NAARI during the first season of 2000. Test materials were assigned in a randomized complete block design, with four replications. Each plot had four rows of 5 meters long with a plant spacing of 75 x 30 cm, 1 plant/hill. The trial was observed under natural infection.

Data recorded

Severity was assessed according to Kim et al (1989) using a 1-5 score; where 1=no or very few leaf streaks and widely dispersed spots on leaves, 2=light streaking and multiple spots on older leaves, gradually decreasing on younger leaves, 3= moderate streaking on older and young leaves, 4= severe streaking on all leaves, about 60% of leaf area and causing yellow appearance of plants, 5= severe *streaking, very little green leaf tissue visible – 80-100% chlorosis, plants severely stunted or dead. A semi*-quantitative scale was used whereby if the response was between two scores, a middle class was recorded. In a way, this is a nine-class scale with increments of 0.5 between scores. Additional data was taken on plant height, ear height and yield of 10 healthy and 10 diseased plants.

To verify the results obtained from natural infection, a sub-set of the varieties was tested under artificial infestation in the screen house. The varieties were planted in pots measuring 7 x 6 x 5cm. Each hybrid was planted into three replications and each replicate consisted of 20 pots per variety of one plant each. At V4 stage (Ritchie et al., 1989) seedlings were introduced into cages containing virulent leafhoppers for 48 hours. The plants were then removed from the cages and immediately transplanted in the field.

Reduction in height and yield of infected plants were calculated using the mean height or yield of healthy plants in each variety using the formula (A-B/A) x 100, where A= height or yield of healthy plants and B= height or yield of diseased plants. Stuntedness was estimated by taking the difference between height of healthy and diseased plants.

Table 1. Effects of MSV on 20 hybrids tested at NAARI, 2001A

Entry #	Variety	Severity	Incidence (%) heigh t	% reduction in plant	% reduction in ear height	% reduction in yield	Stuntedness
1	H 623	3.5	68.9	21.8	28.3	58.8	41.0
2	H 98 M34	3.5	50.9	21.9	18.2	22.5	37.4
3	MLZ 029	3.4	71.6	23.9	20.9	51.9	41.3
4	H98 M1	3.3	46.2	23.0	16.8	40.3	41.9
5	MZ 058	3.6	66.9	24.7	20.9	20.0	43.0
6	MZ 027	3.4	69.3	19.9	17.1	30.2	31.3
7	H513	3.7	58.7	26.4	28.5	50.2	46.2
8	PAN 533	2.0	26.9	17.4	17.9	8.0	19.4
9	PAN 577	2.7	18.7	10.7	2.7	14.2	18.4
10	PAN 15	2.6	26.7	16.7	21.8	30.5	27.0
11	PAN 67	2.7	18.0	20.6	12.4	25.5	33.9
12	PAN 23	2.5	18.7	20.5	22.4	17.9	35.1
13	PAN 33	1	1.8	-	-	-	-
14	SC 713	2.3	12.7	9.9	8.0	4.4	16.5
15	SC 715	2.9	22.9	9.2	9.9	3.0	15.7
16	SC 627	2.5	15.1	8.5	15.1	3.4	14.9
17	SC 407	3.0	47.0	15.2	19.8	26.9	23.7
18	SC 625	2.8	30.0	18.4	14.7	7.0	27.7
19	Longe 2H	2.5	31.5	17.8	18.6	4.5	28.1
20	NZ 4	1.5	32.9	15.3	22.1	11.9	23.0
	Minimum	1	1.8	8.5	2.7	3.0	14.9
	Maximum	3.6	71.6	26.4	28.5	58.8	43
	Mean	2.7	34.7	18.0	17.7	22.7	30.3
	CV	25.1	23.8	19.5	16.9	17.8	41.3
	LSD	1.0	9.5	7.6	8.1	14.6	18.1

[a]Varieties 1-7 were supplied by Kenya Seed Co, 8-13 by Pannar, 14-18 by Seed Co, and 19-20 Cereals Program.

Table 2. Correlation coefficients (r) for the relationships among parameters used to assess severity of maize streak virus (MSV) on 20 hybrids.

Incidence	% reduction (plant height)	% reduction (ear height)	Severity	Stuntedness	Yield loss
% reduction	0.55**				
% reduction	0.41*	0.68***			
Severity	0.66**	0.097	0.461*		
Stuntedness	0.55*	0.67**	0.98***	0.510*	
Yield loss	0.59***	0.62*	0.71**	0.517*	-0.93

Asterisks indicate significance of r: * P<0.05; ** P<0.01 and *** P< 0.001

Incidence data was arcsine transformed to normalize variances (Steel et al., 1997). Analysis of variance (ANOVA) was performed and means separated by Fisher's Least Significance Difference test at P = 0.05, using SAS Proc GLM statistical package (SAS Institute, 1989).

Results

Maize streak virus incidence ranged from 0% on PAN 33 to 71.6% on MLZ 029. Hybrids showed significant (P=0.01) differences in incidence. Six hybrids had incidence of less than 20%, another set of six records of incidence of more than 50% (Table 1). This is clearly illustrated by a positive correlation (r=0.66, P<0.01). However, there were some exceptions; hybrid MLZ 029 with the highest incidence did not have the highest severity score neither did hybrid H 513. Another example is given by hybrid NZ 4 with the second lowest severity score of 1.5 and incidence (32.9%) being higher than that of SC 627 with a severity score of 2.5 and incidence of 15.1%.

The most susceptible hybrid H513 as reflected by the severity score and incidence, had the highest percentage reduction in plant, ear height and yield. The same is true with the level of stuntedness. Contrastingly, the resistant hybrids like PAN 577, SC 627, SC 713 and SC 715 had lower percentage reductions in plant height, ear height and yield. This again is well reflected by the positive relationship in the correlation analysis (Table 2).

MVD caused significant (P=0.05) reduction in yield and (P=0.01) in plant and ear height In the most susceptible variety (H 513) it caused a percentage reduction in plant height of 28.5 and 46.2 in yield. Contrastingly, in the resistant variety (SC 713) percentage reduction in plant height and yield was 8 and 4.4 respectively. What this reflects is that resistant varieties have less plant, ear height reduction, yield loss and stuntedness.

Results obtained from the screen house under artificial infestation showed a similar trend as those from the field under natural infection. The only difference is that screen house scores were generally higher that those of natural infestation (Figure 1). Under natural infestation, no variety had a score of 4 as opposed to some two hybrids; H513 and H623, which had scores of 4 under artificial infestation. Three hybrids, MLZ 029, H98 M34, H98M1 had similar severity scores both in the field and in the screen house. In our research program, lines or varieties with severity score of less than 2 are considered resistant, between 2 and 3.4 tolerant and above 3.5 are considered susceptible, and are either dropped or considered for further improvement.

In this particular study, four hybrids; H 623, H 98, M34, MZ 058 and H513 were found to be susceptible with scores of 3.5 and above, 14 tolerant with scores ranging between 2.6 and 3.4, and only 2 were noted to be resistant.

Under normal circumstances, it is rare to find a variety good in all aspects. If it is resistant to one disease, chances are that it may be susceptible to another or have other short comings like excessive height, very late maturing or poor husk cover. To verify this point, results from other studies using similar materials were used for comparison. Several shortcomings/defects were observed on many varieties considered to be resistant to MSV. An example was with hybrid PAN 33. It had the lowest MSV severity score (very resistant) but was noted to be susceptible to ear rots caused by both *Fusarium monilliforme* and *Sternocarpella maydis* (Table 3). Hybrid PAN 23 is also resistant to MSV but susceptible to gray leaf spot (GLS) caused by *Cercospora zeae-maydis* and ear rots. SC 625 has good levels of resistance to the three foliar diseases; MSV, GLS and northern leaf blight (NLB) caused by Exserohilum turcicum but is very susceptible to ear rots (Table 3).

Table 3. Reaction of 20 hybrids to other diseases

Entry #	Hybrid	Severity score (1-5 scale)			Ears rotten (counts[b])
		MSV	GLS	NLB	
1[a]	H 623	3.5	3.6	1.9	2.5
2	H 98 M34	3.5	2.5	1.9	0.7
3	MLZ 029	3.4	2.6	1.9	2.5
4	H98 M1	3.3	3.0	1.8	2.7
5	MZ 058	3.6	2.4	2.0	2.5
6	MZ 027	3.4	2.3	2.0	2.9
7	H513	3.7	3.4	2.0	2.1
8	PAN 533	2.0	3.6	2.0	2.3
9	PAN 577	2.7	2.5	1.9	2.3
10	PAN 15	2.6	3.1	2.0	1.9
11	PAN 67	2.7	2.4	2.0	2.1
12	PAN 23	2.5	3.6	2.0	1.9
13	PAN 33	1	3.1	2.0	2.5
14	SC 713	2.3	1.9	2.0	0.7
15	SC 715	2.9	2.4	1.8	2.1
16	SC 627	2.5	1.5	1.8	2.7
17	SC 407	3.0	3.4	2.0	3.2
18	SC 625	2.8	1.8	1.9	3.7
19	**Longe 2H2.5**	**3.3**	**1.9**	**0.7**	
20	NZ 4	1.5	2.8	1.9	1.8
	Minimum	1	1.5	1.8	0.7
	Maximum	3.6	3.6	2.0	3.7
	Mean	2.7	2.8	1.9	2.2
	CV	25.1	11.4	11.4	17.8
	LSD	1.0	0.4	0.3	0.1

[a]Varieties 1-7 were supplied by Kenya Seed Co, 8-13 by Pannar, 14-18 by Seed Co, and 19-20 Cereals Program.

[b]Counts of ears rotten transformed (square root). Fusarium moniliforme and Sternocarpella maydis were the major causal agents

Discussion

Results from the study clearly show that the level of resistance in the 20 hybrids tested was very variable; two were resistant, fourteen tolerant and four susceptible. Some hybrids like H 98 M34, which are susceptible but tolerant to other diseases like NLB and ear rots would be eligible for further improvement. Barrow (1992); Oketch and Chinsembu (1994) suggested that resistance is not always related to symptom expression and that it is important to consider yield when screening for MSV to avoid varieties with tolerance and attributes to other constraints being discarded. Severity and incidence are important when dealing with MSV because a variety with many tolerant plants will have high incidence and low severity. If one only considered incidence, the impression got would be that that variety is susceptible which is not the case. In this particular study this is exemplified by NZ4 with incidence of 32.9% and severity score of 1.5. On the other hand a variety with high incidence and high severity score clearly shows that it is susceptible and yield losses are expected to be high.

Yield losses of 93% by Fajeminsin et al (1986) and 100% by Van Rensburg and Kuhn (1977) and Guthrie (1978) have been reported. In this particular study losses were low compared to those above because the materials used had some levels of tolerance as intimated by the companies, which provided the varieties. However, contrary to what the companies indicated that all their varieties were resistant, this was not found to be true for some. This can be attributed to various screening techniques, different rating scales and genotype x environment interaction (Kyetere, 1996). Most of the hybrids from Pannar Seed Company and Seed Co were found resistant perhaps because their selections are done under artificial infestation as opposed to natural infection method used by Kenya Seed Company. Selection under natural infection has got limitations of the absence of the disease when required and non-uniformity. Kim et al (1981) suggests that when breeding for MSV tolerance/ resistance, selections should be done under artificial infestation. From past experience and this study, MSV symptoms under natural infestations appear slightly late at V20 and only on young leaves. This does not result in high yield losses to warrant rejection of a variety. However, with artificial infestation, the symptoms can be obtained on almost all leaves making it easy *to discriminate susceptible from resistant varieties.*

When breeding for resistance, besides foccussing on one particular constraint, attention should always be given to other constraints in the locality. And while it is difficult to come across a variety which meet all selection criteria, attempts should be made to strike a compromise and include entries showing tolerance to other constraints.

In conclusion, it is noted that MSV is still a problem causing yield losses of up to 43% in some apparently tolerant hybrids and definitely higher figures in materials lacking resistance. In selecting for resistance/tolerance a combination of incidence and severity should be adopted.

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