

Effect of maize lethal necrosis disease on seed quality of commercial hybrid varieties

Kinyungu, T. N.,¹ Muthomi, J. W.,¹ Olubayo, F.¹ & Miano, D. W.¹

¹Department of Plant Science and Crop Protection, University of Nairobi, P.O. Box 30197, GPO, Nairobi, Kenya

Corresponding author: sheilaesther@yahoo.com

Abstract

The recent maize outbreak of maize lethal necrosis (MLN) disease is a big threat to the already strained food security in Kenya. The disease is caused by co-infection of maize with Maize chlorotic mottle virus and cereal potyviruses mostly Sugarcane mosaic virus. The disease has spread to many parts in Kenya causing losses of up to 100%. The objective of the study was to assess the transmission of viruses causing maize lethal necrosis disease through seeds. Seeds of 12 maize varieties were harvested from plants infected with at least 60% MLN disease severity and the seeds were evaluated for quality parameters including mould contamination, shriveling, germination, seedling length, seedling dry weight and vigour. Infection of maize with maize lethal necrosis (MLN) disease significantly increased the proportion of shriveled, discoloured and mouldy seeds. Seedlings from MLN disease-infected plants showed significant reduction in length, dry weight and vigour as compared to seedlings from certified seeds. The study showed that viruses causing maize lethal necrosis disease are transmitted through seed resulting in plants with low emergence, vigour and yield.

Key words: Kenya, maize, maize lethal necrosis, seedling vigor, seed quality

Résumé

La récente flambée de la nécrose létale du maïs (MLN) est une grande menace pour la sécurité alimentaire déjà tendue au Kenya. La maladie est causée par la co-infection du maïs avec le virus de la marbrure chlorotique du maïs et les potyvirus des céréales, principalement le virus de la mosaïque de la canne à sucre. La maladie s'est propagée dans de nombreuses régions du Kenya, provoquant des pertes pouvant atteindre 100%. L'objectif de l'étude était d'évaluer la transmission de virus causant la maladie de nécrose mortelle du maïs par les semences. Des semences de 12 variétés de maïs ont été récoltées à partir de plantes infectées par au moins 60% de gravité de la maladie MLN et les semences ont été évaluées pour les paramètres de qualité, y compris la contamination par les moisissures, le rétrécissement, la germination, la longueur des semis, le poids sec et la vigueur des semis. L'infection du maïs par la maladie de la nécrose létale du maïs (MLN) a considérablement augmenté la proportion de graines ratatinées, décolorées et moisies. Les semis de plantes infectées par la maladie MLN ont montré une réduction significative de la longueur, du poids sec et de la vigueur par rapport aux semis de semences certifiées. L'étude a montré que les

virus responsables de la nécrose létale du maïs sont transmis par les semences, ce qui donne des plantes à faible émergence, vigueur et rendement.

Mots clés: Kenya, maïs, nécrose létale du maïs, vigueur des semis, qualité des semences

Introduction

Among the viruses infecting maize, MCMV, SCMV and MDMV, JGMV are transmitted through seeds (Makumbi and Wangai, 2013). Li *et al.* (2007) reported that transmission of SCMV on seed of susceptible inbred line Mo17 I was on average 4.8%. Transmission of MCMV was found to be 0.04% (Jensen, 1991). Transmission of SCMV on seed of susceptible inbred line Mo17 I was on average 4.8% (Li *et al.*, 2007), while incidence of SCMV in seedling planted from seed obtained from infected plants with the virus was 4.8-5.64% (Wang and Zhou, 2007). Maize dwarf mosaic virus transmission through seeds is estimated at very levels of 0.008-1.5% while Wheat streak mosaic virus is estimated at 0.5-1.5% (Hadi *et al.*, 2011).

Seed transmission is determined by the ability of the virus to move into and replicate in reproductive tissues and subsequently withstanding the physiological changes associated with seed maturation (Simmons and Munkvold, 2014). Seed transmission is essential for survival, introduction into new crop production areas and a protective link between crop growing seasons, if not checked can cause epidemics (Lanoiselet *et al.*, 2008). In Kenya, transmission of Maize Lethal Necrosis (MLN) viruses may be enhanced through sowing of informal maize seed by the producers, which is estimated at 31%. Although transmission of the viruses causing MLN disease through seed is low, the effect on commercial varieties and of accumulation of viruses in subsequent crops grown from farmers' saved seeds has not been documented. The present study was therefore conducted to assess seed transmission of viruses causing maize lethal necrosis disease through commercial maize hybrid seeds.

Materials and Methods

A total of 12 maize varieties with MLND infection severity levels of at least 60% were collected from farmers' fields during 2016 long rain season. The cobs were harvested separately, manually shelled discarding the first and the last three grains from each cob to obtain a relatively uniform seed size. The seeds were dried to a moisture content of 15%. The infected seeds were evaluated for quality parameters alongside certified seed from seed certified seed merchants. The 12 maize varieties evaluated were H624, H6213, H513, H520, Duma 43, KH500-43A, WH505, Pioneer 3253, Pioneer 30G19, DK8031, WE1101 and H614. A sample size of 400 g seed of each variety was divided into four equal sub-samples of 100 g. The quality data collected included percentage shriveled, discoloured, mouldy, germinated seeds, normal seedlings, seedling root and shoot length and seedling dry weight. Seedlings vigour index was calculated from seedling length and seedling dry weight.

Data were subjected to analysis of variance using GenStat computer software package (Lawes Agricultural Trust Rothamsted Experimental Station, 2016). Separation of means was carried out by the Fisher's Protected Least Significant Difference (LSD) test at 5% confidence interval.

Results and discussion

Infection of maize with maize lethal necrosis (MLN) disease significantly increased the proportion of shriveled, discoloured and mouldy seeds (Table 1). Certified seeds for all varieties had no shriveled and discoloured seeds. Hybrid 624 had the highest proportion of seeds which were shriveled at 26.5%. The highest proportion of shriveled seeds at 33.9% was recorded in H614. There were significant differences in proportion of discoloured KH500-43A seeds. Hybrid 513 had the highest overall mean of mouldy seeds at 27.5%. The proportion of seeds which germinated from certified seeds was significantly higher in all the varieties except H520 and WE1101. Seed from MLN disease-infected plants recorded significantly reduced germination. Significant effect on proportion of seeds which germinated was noted in variety D43 which was from parent maize plant with high percentage MLN diseased seeds. Similar observation was observed in seeds from plants with percentage MLN disease severity of 50 and 60.

Certified seeds had the highest proportion of germinated seedlings at 90.9% while those with MLN disease severity level of 60% had the lowest germination at 57.3%. Among the varieties, H624 had the highest proportion of normal seedling (96.3%). There were significant differences in the proportion of normal seedlings which germinated from seeds harvested in parent maize plant with varying percentage MLN disease severity.

For all varieties, seedlings which germinated from certified seeds were the longest, heaviest and had the highest seedling vigour while those from MLN disease-infected plants showed a significant reduction of these parameters (Table 1). The infected seed produced seedlings with significantly reduced seedling length, dry weight and seedling vigour index (Table 1).

Infection of maize plants by MLN disease causes premature dying of cobs (Adams *et al.*, 2012; Suresh, 2016) and, therefore, the high percentage of shriveled seeds may be attributed to reduction or restriction of nutrients into the seed at mother plant (Ambika *et al.*, 2014). At the same time the amount of food available to the seed may be insufficient due to the reduction of photosynthetic area as a result of mottling, chlorosis and necrosis caused by the MLN viruses (Mahuku *et al.*, 2015). The proportion of seed germination, seedling length, seedling dry weight and vigour index were significantly reduced by seed infection with MLN disease and this could be attributed to seed deterioration as a result of infection with the disease. Seeds that are infected with pathogens have a faster derioration (Ghassemi-Golezani *et al.*, 2014).

Conclusions

The three attributes (shriveled, coloured, mouldy) of the seed studied determines the performance of the seed under standard germination and eventually in the field under harsh condition (Ambika *et al.*, 2014). When these low quality and infected seeds are used they are likely to introduce pathogens to new areas thus contributing to reduced seedling and plant vigour and also introduce disease to

Table 1. Mean percentage shriveled, discoloured, germination, seedling dry weight and vigour of seeds of maize varieties harvested from plants infected with maize lethal necrosis disease

	PHB-30G19	PH-3253	D-43	DK-8031	H-513	H-520	H-614	H-6213	H-624	KH-500	WE-1101	WH-505	Mean
Percentage of shriveled seeds													
Infected	24.6	16.7	12.0	18.5	24.5	13.4	20.3	23.5	26.5	24.3	10.9	23.4	19.9
Control	0	0	0	0	0	0	0	0	0	0	0	0	0
Percentage of discoloured seeds													
Infected	13.9	25.4	23.4	24.1	25.2	24.4	33.9	26.8	25.6	33.8	20.4	25.5	25.0
Control	0	0	0	0	0	0	0	0	0	0	0	0	0
Percentage of mouldy seeds													
Infected	28.5	25.8	26.0	34.0	43.5	29.8	37.3	40.8	37.0	26.3	28.5	26.5	32.0
Control	4.5	5.0	4.0	4.8	11.3	7.3	3.8	5.3	4.0	6.0	4.0	13.3	6.1
Percentage seed germination													
Infected	86.0	90.8	87.8	85.8	85.5	84.3	90.0	82.5	85.0	85.0	88.8	85.5	86.4
Control	97.0	98.8	97.3	97.5	94.8	95.3	94.5	96.8	99.8	96.5	97.8	97.0	96.9
Percentage of normal seedlings													
Infected	63.0	59.0	67.3	52.0	49.0	60.3	58.8	48.3	43.5	67.2	59.5	59.8	57.3
Control	89.8	94.3	86.8	94.8	88.5	87.3	90.5	92.5	96.3	89.2	95.8	85.3	90.9
Seedling length (cm)													
Infected	12.2	9.5	11.6	12.4	9.1	3.5	11.5	13.0	11.4	12.1	14.1	9.5	10.8
Control	28.5	23.6	27	25.5	27.8	9.5	28.4	24.2	23.2	27.3	24.4	27.0	24.7
Dry weight (gms)													
Infected	25.2	16.1	21.6	17.5	6.5	8.9	6.8	22.8	13.4	6.8	21.2	17.9	15.5
Control	38.0	50.8	47.9	53.4	49.6	47.6	46.7	51.1	62.8	46.7	49.1	44.4	49.3
Seedling vigour index													
Infected	2406	1869	1756	2029	795	844	797	2376	1277	1157	1507	1206	1502
Control	6145	7443	7339	7618	7074	6921	7205	4081	8509	6120	7511	6780	6895

new areas. Therefore, farmers should be discouraged from using shriveled, discolored and mouldy seeds to reduce on transmission and introduction of maize lethal necrosis disease to disease-free areas.

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