academicJournals

Vol. 11(8), pp. 652-660, 25 February, 2016
DOI: 10.5897/AJAR2015.10616
Article Number: E0A8A2857301
ISSN 1991-637X
Copyright ©2016
Author(s) retain the copyright of this article
http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Status of maize lethal necrosis in eastern Uganda

Frank Kagoda[1]*, Robert Gidoi [1] and Brian E. Isabirye[2]

[1]Crops Research Department, Buginyanya Zonal Agricultural Research and Development Institute Mbale – Uganda.
[2]Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) Uganda.

Received 5 November, 2015; Accepted 19 January, 2016

Maize lethal necrosis (MLN) is the latest emerging disease of maize in Sub-saharan Africa. It was first reported in Uganda in 2013. Consequently, information regarding its prevalence, yield loss, applicable mitigation measures and socio-economic effects is still scanty, hence this study. A survey involving 300 respondents on the status of the disease was conducted in seven districts of eastern Uganda. Results revealed that MLN became prevalent in eastern Uganda in the first season of 2012 (2012A), which stretches from March to June. The MLN disease symptoms, especially chlorosis, were prevalent in most of the farmers' fields in all the districts surveyed but particularly in Tororo, Mbale, Greater Sironko and Busia. Almost all farmers from the lowland areas reported MLN to be more destructive in the second season (B), which stretches from August to November. The disease can attack at any stage of crop growth from two weeks after planting. Very low yields (0.25 to 1.0 t ha^{-1}) attributed to the MLN epidemic, were obtained, causing an average yield loss of 50.5% valued at US$ 332 per hectare. Use of home saved seed especially in Busia, Tororo, Iganga and Mbale was common and partly explains the prevalence of MLN in these districts. Roguing emerged the most popular means farmers in eastern Uganda were using to control MLN. By intensifying MLN sensitization programmes, farmers will learn other management practices such as crop rotation, good sanitation practices and use of chemical sprays to control MLN. Finally expediting the breeding process for the development of MLN resistant or tolerant varieties will bring a lasting solution to the disease.

Key words: Eastern Uganda, DAS-ELISA, maize chlorotic mottle virus (MCMV), maize lethal necrosis (MLN).

INTRODUCTION

Maize (*Zea mays* L.) is the most important cereal crop in sub-Saharan Africa (FAO, 2006). In Uganda it is a key food security crop and a source of income for smallholder farmers with the eastern region accounting for over 50% of annual national production (USAID, 2010). The crop provides over 40% of the population's calorie requirements with an annual consumption of about 23 kg per capita per year (Magnay, 2004). The high, mid and low altitude areas of eastern Uganda grow different varieties of maize. This has greatly impacted on the economic growth and food security of most households. Production in the region is 1,108,554 MT as compared to the country's total production of 2,361,956 MT (MAAIF, 2011).

*Corresponding author. E-mail: fkagoda@gmail.com. Tel: +256772898988.

Author(s) agree that this article remain permanently open access under the terms of the Creative Commons Attribution License 4.0 International License

However, maize on-farm yields no longer exceed 2.5 t ha^{-1}, against a potential of 5.0 to 8.0 t ha-1 (World Bank, 2006). The drop in yields has mainly been a result of the unpredictable weather patterns, scarcity of adapted varieties and emerging stresses such as the maize lethal necrosis (MLN). Therefore, to achieve adapted varieties for the zone, breeding initiatives need to target specific environments, and particularly address MLN which so far has been associated with 50 to 80% reduction in yield (ASARECA, 2013). The MLN results from combined infection by two viruses: maize chlorotic mottle virus (MCMV) and either maize dwarf mosaic virus (MDMV) or sugarcane mosaic virus (SCMV) or wheat streak mosaic virus (WSMV) (CIMMYT, 2004). Recent findings indicate that MCMV can be a threat on its own even in the absence of other viruses (Miano, 2014). Cabanas et al. (2013) reported that both MCMV and SCMV are seed transmitted though MCMV can also be transmitted by thrips, and SCMV by aphids and mechanical means. Other insect vectors associated with MCMV transmission and spread are maize rootworms, leaf beetles and leafhoppers. The virus may also be spread through soil and through infected plant debris since the virus can survive in plant residues (Nyvall, 1999). Continuous maize production in a field greatly increases the incidence of the viruses and vectors (Miano, 2014).

The disease was first reported in Kenya, Bomet county in 2011 at about 1900 m asl but had spread up to 2100 m asl in a period of about six months (Wangai et al., 2012). In Uganda, it was earlier reported in the eastern districts of Busia, Tororo, Iganga and Mbale (ASARECA, 2013; Plantwise, 2013) but with no concrete evidence especially regarding the prevalence, awareness, associated yield loss and socio-economic effects. The current study was therefore designed with the major objective of determining MLN current status in eastern Uganda. The specific objectives were to i) determine MLN prevalence in the different parts of eastern Uganda, ii) ascertain the yield losses associated with MLN and applicable mitigation measures.

MATERIALS AND METHODS

Study area, sampling size and design

The study targeted both small and large-scale maize farmers in seven districts of eastern Uganda, namely: Iganga, Busia, Tororo, Kapchorwa, Bukwo, Greater Sironko and Mbale. Notably, Greater Sironko, hereafter referred to as Sironko, is inclusive of the now independent Bulambuli district. A descriptive cross-sectional survey design using largely quantitative methods of data collection and analysis was adopted. However, it was supported by qualitative information obtained from key informants and document reviews. The study was conducted in eastern Uganda because the MLN epidemic is concentrated in this part of the country. A three-stage cluster sampling technique was used to select the 300 households based on existing reports on the presence of MLN in such districts. In the first stage of clustering, the districts of Iganga, Busia, Tororo, Kapchorwa, Bukwo, Sironko and Mbale were purposively selected. In the second stage of sampling, two subcounties were purposively selected from each district where cases of the disease were evident. The third stage involved random selection of 300 households from within the group villages based on the criteria agreed upon that such households were involved in maize cultivation at that time and at least for the previous year. A list of maize farmers within the villages was obtained from the agricultural extension officers and used for the random selection of respondents. On average, 43 farmers were interviewed from each of the seven districts. Interviews were conducted in a sub-county with highest reports of MLN incidences. Respondents were those with maize as one of the major crops on their farm, and particularly those who had planted maize on at least 250 m^2 in the second season (August to November) of 2014 and in the previous year (2013).

Methods and procedure of data collection

The interview method supported by documentary review and analysis was used. The interview approach involved administering a structured questionnaire of both closed and open-ended questions to the respondents. The questionnaire was preferred because it is a quick way of data collection and it is easy to categorize, quantify and generalize the information. The questionnaire was pre-tested on ten households outside the randomly selected villages to ensure reliability and validity. Relevant documents with related information to the study at district and sub-county production offices were reviewed. These mainly comprised copies of reports submitted to the Ministry of Animal Industries and Fisheries (MAAIF). The major elements during interviews were: (i) maize production constraints with emphasis on the MLN epidemic, (ii) maize varieties grown and the source of seed, (iii) estimated maize grain yield and yield losses attributed to MLN (iv) MLN origin, symptoms and mitigation measures. Identification of MLN symptoms was aided by displaying photographs showing MLN infected plants.

Leaf isolates of about 15 cm beginning from the apex of the leaf were collected from maize fields suspected to be having the MLN disease. In total, about 42 leaf samples were collected from the seven districts, comprising on average six samples per district. The samples were packed in an 11.4 × 24 cm kraft brown envelopes and stored under cool conditions before conducting ELISA tests at the National Agricultural Research Laboratories (NARL) in Kawanda. The double antibody sandwich (DAS) ELISA technique (Hill, 1984) was conducted using a Model 680 microplate reader on the 17th June 2014. The instrument was set at a standard measurement filter of 405 nm. The samples were divided into two parts therefore making two replications. Using the DSMZ culture technology, an MCMV infected maize leaf and a clean leaf were used as positive controls and negative controls, respectively; also a buffer, making a total of 45 samples. Optical density (OD) values equal or above positive control were regarded as positive for the virus, whereas those with equal or less than that of negative control were taken as negative (no virus). In addition, OD values two times higher than the negative control were regarded as positive for the virus.

Data analysis

Qualitative data were coded and analyzed using SPSS version 16.0 (SPSS 1989-2007). Chi-squared tests were used to compare performance between locations. The SPSS was also used to provide summaries of the farmer household's maize production characteristics such as frequencies and means. Mean results from ELISA tests were obtained per sample and compared with the positive and negative controls to deduce presence or absence of

Table 1. Farmers' sources of maize seed.

District	Respondents (%)					
	Home saved (n=70)	Agro-input shops (n=178)	Neighbours/ friends (n=3)	Kenya (n=32)	Extension Agent (n=10)	Other sources (n=7)
Bukwo	0.0	19.7	0.0	53.1	0.0	0.0
Busia	22.9	7.9	33.3	6.2	10.0	14.3
Sironko	1.4	20.8	0.0	3.1	40.0	0.0
Iganga	37.1	5.6	0.0	0.0	0.0	28.6
Kapchorwa	2.9	15.7	0.0	18.8	20.0	28.6
Mbale	18.6	23.0	0.0	0.0	10.0	28.6
Tororo	17.1	7.3	66.7	18.8	20.0	0.0
Chisquare	575.48					
Prob. (df=42)	< 0.001					

Table 2. Most popular maize varieties planted in 2013.

District	Respondents (%)						
	DK8031 (n=5)	Duma (n=4)	H614D (n=39)	Landrace (n=30)	Longe 5 (n=85)	Longe10 (n=49)	Others (n=42)
Bukwo	0.0	0.0	61.5	0.0	0.0	0.0	4.8
Busia	80.0	25.0	0.0	16.7	10.6	6.1	14.3
Sironko	0.0	0.0	0.0	0.0	18.8	49.0	7.1
Iganga	20.0	0.0	2.6	40.0	16.5	6.1	16.7
Kapchorwa	0.0	50.0	35.9	0.0	8.2	0.0	11.9
Mbale	0.0	0.0	0.0	3.3	34.1	38.8	19.0
Tororo	0.0	25.0	0.0	40.0	11.8	0.0	26.2
Chisquare	1080						
Prob. (df=84)	P < 0.001						

the MLN disease.

RESULTS

Social demographic trend of farmers and farming type

Of the 300 household heads visited, 60 were females. Majority of the respondents comprised farmers growing maize on a purely subsistence system (73%), followed by commercial producers (17.5%) and lastly the semi-commercial (9.5%). Most commercial farmers were found in Bukwo and Sironko (32%), while the subsistence farmers were mainly in Mbale (22%). Other than maize, the other popular crops in the districts visited were cassava, beans, sweet potatoes and groundnuts. Beans were by and large popular in Mbale (76.2%), cassava in Busia (39.3%), sweet potatoes in Iganga (100%), groundnuts in Busia and Tororo (50%).

Source of maize seed and the maize varieties popular in the zone

Majority of farmers obtain maize planting seed from agro-input shops (59.3%) followed by use of home saved seed (23.3%). Notably, 10.7% of farmers especially in Bukwo, Kapchorwa and Tororo obtain planting seed from Kenya (Table 1). Other sources where farmers obtained seed include traders, middlemen and retail shops.

The most popular maize varieties planted in the year 2013 varied based on the region but with Longe 5, an open pollinated variety from Uganda, being the most popular (28.3%) across districts followed by Longe 10 (16.3%), a three-way cross hybrid from Uganda (Table 2). Other varieties were popular in specific districts such as H614D, a hybrid from Kenya, was popular in Bukwo and Kapchorwa (35.9 and 61.5%, respectively). The landraces were popular in Tororo and Iganga (40%) followed by Busia (16.7%) and Mbale (3.3%). None of the respondents admitted growing landraces in Bukwo, Sironko and Kapchorwa. Varieties such as Hybrid

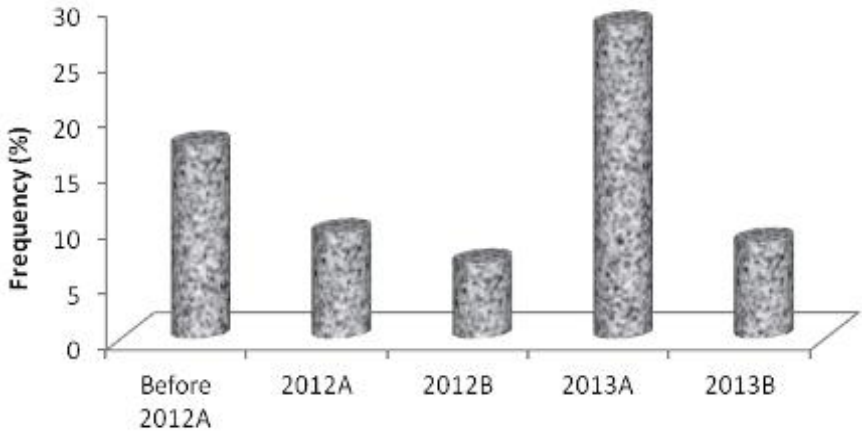

Figure 1. Season of the year MLN first observed.

405, 513H, 6213 & 624 and PAN 67 (not included in the table) were found in Tororo, Kapchorwa, Bukwo and Busia, respectively. Notably, all of these hybrids have their origin in Kenya except PAN 67, which is a South African variety though packed Kenya.

Year MLN first observed and the current status

Majority of the farmers (28.2%) first encountered MLN in 2013A, which runs from March to June of each year (Figure 1). However, 17.4% of the farmers confessed observing the disease as early as the first season of 2012. This implies that the disease became prevalent in Uganda in 2012A. Currently, the disease is on farmers' fields but more destructive in the second season (August to November) than the first season. Notably, 10.6% of farmers either had no clue on when the disease began or had never observed the disease at all.

A section of farmers (51.8%) especially from Mbale and Bukwo reported that the disease is still on the increase. However, some farmers (11.8%) from Sironko and Tororo districts, earlier affected by the disease, reported a tremendous decline in MLN. Majority of the farmers (33.2%) reported having experienced the highest MLN yield losses during periods of drought. However, as regards the origin of the disease, a reasonable number of farmers (43.2%) expressed ignorance (data not shown). Other popular opinions about origin of MLN included seed from Kenya (15.8%), soil (14.3%) and use of home saved seed (12.1%).

MLN symptoms and stage of maize at first observation of symptoms

Chlorosis was reported by 34.5% of the farmers as the most common symptom associated with MLN. Other recognizable symptoms were stuntedness (5%), dead heart and necrosis (2.9%), mottling of leaves (2.6%), and sterility or poor grain fill (1.1%). About 30.3% of the farmers reported MLN to start manifesting when the maize is at four weeks after planting (WAP), popularly referred to as the 'knee height' stage or the 7-8 leaves stage (Data not shown). Other prominent stages were booting (24.2%) and the tasseling stage (6.6%). Farmers averaging 3% reported observing MLN symptoms at germination (up to 2 WAP), grain filling and grain hardening stages.

Area under maize in 2013, corresponding grain yields and yield losses

The study indicated that most farmers (43.3%) had only 0.41 to 0.5 ha of land under maize production (Table 3). Only 19% of the respondents, mainly from Bukwo and Sironko, had more than 1 ha of land under maize. Highest number of farmers with the least area under maize (< 0.4 ha) was found in Mbale (26.2%), Busia (23.8%) and Iganga (23.8%). Other than Bukwo and Sironko, Iganga was the only other district with farmers having more than 2 ha of land under maize.

Majority of farmers (43.4%) obtained an average yield of 0.63 t ha^{-1} in the year 2013 (Table 4). Only 8.7% of farmers had yields exceeding 3.5 t ha^{-1}. These were mainly from the districts of Bukwo (28.9%), Sironko (11.9%) and Kapchorwa (5.0%). Iganga was the district where most farmers (42.1%) reported the least maize production per hectare as opposed to Bukwo where only 1.9% of farmers had yields below 0.25 t ha^{-1}. A greater number of farmers (54.5%) reported selling their maize between U. Shs. 500 to 650 per kilogramme, which gives an average price of U.Shs. 575.

The MLN disease symptoms were recorded in all the seven districts surveyed each registering minimal

Table 3. Area under maize in the year 2013 (average for one season)

District	Respondents (%)					
	< 0.4 ha (n=42)	0.41-0.5 ha (n=130)	0.51-1.0 ha (n=71)	1.1-1.5 ha (n=32)	1.51-2.0 ha (n=19)	> 2.0 ha (n=6)
Bukwo	4.8	13.1	14.1	53.1	26.3	16.7
Busia	23.8	10.0	11.3	12.5	0.0	0.0
Sironko	4.8	13.8	15.5	3.1	36.8	66.7
Iganga	23.8	16.9	7.0	0.0	0.0	16.7
Kapchorwa	2.4	13.1	19.7	12.5	21.1	0.0
Mbale	26.2	22.3	18.3	9.4	5.3	0.0
Tororo	14.3	10.8	14.1	9.4	10.5	0.0
Chisquare	497.089					
Prob. (df=42)	< 0.0001					

Table 4. Summary of maize yields, yield losses and financial losses incurred due to the MLN epidemic.

Grain yield (t ha^{-1}) in 2013	Mean grain yield (t ha^{-1})	[1]Grain yield loss due to MLN (t ha^{-1})	[2]Monetary loss (Ug. Shs.)	Monetary loss (US dollars)	Farmers (%)
<0.25	0.25	0.13	72,594	29.0	15.8
0.25-1.0	0.63	0.32	182,936	73.2	43.4
1.1-2.0	1.6	0.81	464,600	185.8	18.9
2.1-3.5	2.8	1.41	813,050	325.2	13.1
3.6-4.5	4.1	2.07	1,190,538	476.2	4.7
4.6-5.5	5.1	2.58	1,480,913	592.4	1.0
> 5.5	5.5	2.78	1,597,063	638.8	3.0
Average per ha	2.9	1.4	828,813	331.5	14.3

Calculations based on data from respondents. Note 1US$ = 2500 U. Shs. at time of the study.[1] Calculated using mean of 50.5% yield loss per hectare attributed to MLN. [2]Calculated using mean of U. Shs.575 per kg (US $ 0.23) as the average farm-gate price of dry maize grain in eastern Uganda at the time of the study.

variations. Key to note is that most farmers (38.6%) reported having experienced yield losses ranging from 31 to 70% as a result of the MLN disease (data not shown), giving a mean yield loss of 50.5%. There were also incidences of over 90% yield loss reported by 5.5% of the farmers, mainly from Nabongo sub-county in Sironko district. Precisely, the most MLN affected districts were Sironko and Tororo both with over 60% of farmers reporting above 50% yield losses due to MLN. Therefore, average grain yield loss as a result of the MLN disease in the year 2013 was 1.4 t/ha, which translates into a monetary loss of US$ 332 for each hectare of maize planted.

MLN mitigation measures

Most respondents (51.4%) mentioned roguing as the commonest mitigation measure being used against MLN (Table 5). The practice was found commonest in Tororo (65.7%) and Mbale (64.9%). However, 20.6% of respondents, especially in Kapchorwa and Bukwo, had not started taking any precautions against MLN. Other methods being used to curb MLN but on a small scale include chemical sprays, fertilizer boosts, crop rotation and the use of certified seed. Farmers in Tororo particularly mentioned that they no longer grow a lot of maize in the second season (August - November), having experienced too much MLN in the second season of 2013. They hence associated the disease to the short rain season and long dry spell which occurs during this period of the year.

Source of information on MLN and sensitization measures so far undertaken

Most farmers (75.8%) reported having no source of information on MLN (data not shown). Some farmers acknowledged receiving information on MLN from agriculture extension agents (11.3%), and the print and electronic media (10%). Other sources of information

Table 5. MLN mitigation measures.

Variables	Respondents (%)							
	Bukwo	Busia	Sironko	Iganga	Kapchorwa	Mbale	Tororo	Mean
Chemical sprays	17.3	2.9	9.3	0.0	0.0	5.3	2.9	5.4
Roguing	26.9	45.7	46.5	57.9	52.5	64.9	65.7	51.4
Fertiliser boosts	0.0	2.9	2.3	2.6	2.5	3.5	0.0	2.0
Crop rotation	0.0	8.6	2.3	0.0	0.0	3.5	8.6	3.3
Use of certified seed	0.0	2.9	0.0	7.9	0.0	0.0	0.0	1.5
None	32.7	17.1	16.3	5.3	37.5	21.1	14.3	20.6
Others	0.0	0.0	11.6	0.0	2.5	0.0	5.7	2.8
Chisquare	349.2							
Prob. (df=49)	P < 0.0001							

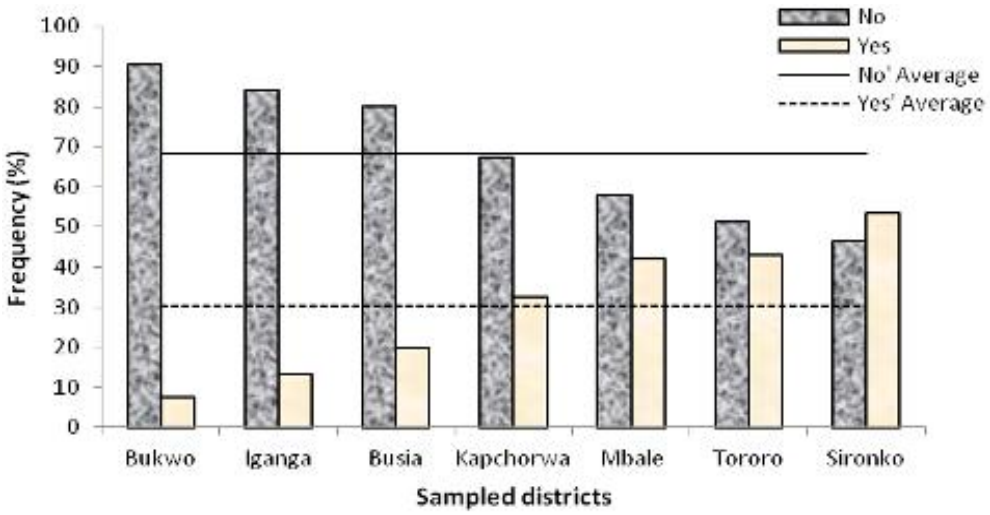

Figure 2. Farmers' response on whether they have got any sensitization on the MLN disease.

were the neighbours, friends, traders and politicians. Most farmers (68.3%) reported having received no sensitization on the MLN disease (Figure 2). Majority of these were from Bukwo, Iganga and Kapchorwa, respectively. Only 30.3% of farmers confirmed having received some sensitization on the MLN disease, most of whom (53.5%) were from Sironko, Tororo and Mbale. Interestingly, it is Sironko where the disease is most rampant.

Results from the leaf ELISA test

Of the seven sets of samples tested, MCMV was confirmed in four sets from Mbale (Busiu subcounty), Busia (Busitema subcounty), Tororo (Mella subcounty) and Sironko (Nabongo subcounty) (Table 6; Figure 3). Though no MCMV was confirmed from Bukwo, results obtained had an OD value above that of the negative control, which necessitates a confirmatory test during an MLN pick period in these locations.

DISCUSSION

In the traditional African setting, it is normally the man who talks to visitors, and by default is the head of the household. It is for this reason that majority of the respondents were men though women (80%) are the most involved in farming in sub-Saharan Africa (AfricaRenewal, 2014). Eastern Uganda contributes 50% of the total maize production in Uganda (UBOS, 2011). It is therefore not surprising that it was ranked as the most important crop of all households visited, and almost 99% of the households had planted maize in the last two years. According to Gibson et al. (2005), though farmers may buy good seed from agro-input shops, they grow them for many cropping cycles leading to a breakdown in

Table 6. MLN sample results following DAS-ELISA test based on presence of MCMV.

Sample Location	S/county	Altitude (m)	Latitude	Longitude	Mean reading (405 nm)	Deduction
Positive control					0.390	+
Negative control					0.125	-
Buffer					0.111	-
Mbale	Busiu	1152	0°55'33.3''.	34°10'24.6''.	0.474	+
Sironko	Town Council	1260	1°13'31.5''	34°14'31.1''	0.427	+
Busia	Busitema	1125	0°33'41.5''	33°59'13.7''	0.333	+
Iganga	Buyanga	1107	0°40.027.	33°38'11.5"	0.130	-
Tororo	Mella	1155	0°39'47.3''	34°15'7.5''	0.462	+
Bukwo	Riwo	1762	1°19'27.3''	34°47'33.5''	0.145	-
Kapchorwa	Kawowo	1110	1°21'54.3''	34°19'53.9'.	0.092	-

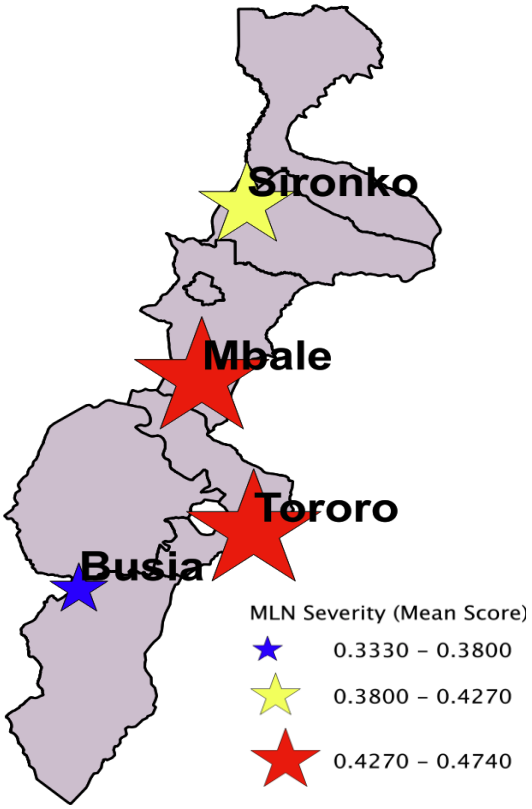

Figure 3. Map of eastern Uganda showing districts with highest MLN severity scores.

resistance to various stresses as a result of out-crossing in the field. Similarly, Abalo (2007) reported that peasant farmers in eastern Uganda rely on the landraces as planting seed. The popularity of Longe 5, an open pollinated variety, in the sampled households is because it is cheaper compared to hybrid maize but not necessarily the highest yielding.

Notably, the popularity of the Kenyan hybrids, especially H513 was truncated by the MLN epidemic. Cultivar H614D is still the most popular hybrid in the highland areas of eastern Uganda, namely Bukwo and Kapchorwa districts. These regions also had the least incidence of MLN at the time of the survey. However, H614D is not resistant to MLN but probably it is a bit more tolerant compared to the landraces and other varieties like H513, H520, Duma43 and DK8031, which are equally popular in the region (Das et al., 2015). Almost all respondents had abandoned the growing of hybrid H513 after being informed by MAAIF agents in 2013 that the variety is very susceptible to MLN. Farmers

testified that they actually got very low yields of H513 in 2013. However, according to the Joint Assessment Report (2012), all commercial varieties are affected by MLN, of course not excluding plants from farmers' own saved seed.

The MLN symptoms observed by farmers in the study districts are similar to those earlier reported by Makumbi and Wangai (2012). However, mild mosaic or mottling symptoms and a moderate reduction of growth might be due to single infections of MCMV or SCMV. According to DSMZ (2014), in the case of mixed infections, early infected plants appear stunted and show a general chlorosis, leaf bleaching and necrosis. In addition, from the results, MLN can attack at any stage of crop growth since at every stage, right from two weeks after planting, farmers observed the MLN symptoms. This corroborates with findings from Joint Assessment Report (2012) that the disease attacks crops at all stages of growth. They further add that drought conditions enhance disease expression.

The area under maize of 0.41-0.5 ha per household was quite high compared to a national average of 0.31 ha (Okoboi, 2010). This indicates that farmers are interested in maize production despite the numerous production constraints. The corresponding yields of 0.25 to 1.0 t ha^{-1} were too low compared to average yields of 2.2 t ha^{-1} in eastern Uganda (Okoboi, 2010), and a potential of 4.5 to 7.0 t ha^{-1} in Uganda (UBOS, 2011). The low yields were attributed to the MLN epidemic in the period of the study, which caused an average yield loss of 50.5% valued at US$ 332 per hectare. Other constraints such as use of inferior seed, inadequate rains, poor soil fertility and a plethora of pests and diseases could have exacerbated the MLN epidemic in some of the districts, especially Iganga, Busia, Tororo and Mbale. ASARECA (2013) reported MLN to cause yield losses of 50 to 80% in Uganda, which is within the range obtained in the current study.

Though roguing emerged the most popular means farmers in eastern Uganda are using to control MLN, it cannot be used in isolation. According to Nelson et al. (2011), most effective control involves an integration of cultural practices with insecticides and host resistance. Crop rotation for at least two seasons with alternative non-cereal crops has been reported to effectively control MCMV (Uyemoto, 1983). A great section of farmers (23.3%) reported using home saved seed for planting, which presents a big risk of MLN infection. According to Wangai et al. (2012), farmers should plant certified seed only instead of recycling seed. Sensitization programmes, however, need to be intensified since over 70% of farmers reported having no information on MLN.

The presence of MCMV in Mbale, Busia, Tororo and Sironko following the DAS-ELISA tests is a confirmation of presence of MLN in these regions, as earlier reported by ASARECA (2013) and Plantwise (2013), and the farmers interviewed in the current study. Other affected districts though not covered in this study but through personal observation include Kween, Bugiri, Budaka, Butaleja and Mayuge. Efforts to curb the epidemic have concentrated on sensitization of farmers on the good agronomic practices, and breeding for resistant varieties. The ministry of Agriculture should however, not relent on testing for MCMV in all seed coming into the country. There is also need to collect more isolates and test for MLN during the pick periods of the disease.

Conflict of interests

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENT

This study was funded by Government of Uganda through the Agricultural Technology and Agribusiness Advisory Services (ATAAS) Project. Our appreciations go to all the District Agricultural/Production officers at the sampled districts for your input during the survey exercise.

REFERENCES

Abalo G (2007). A comparative analysis of conventional and marker assisted selection methods in screening for resistance to maize streak virus disease. Ph.D Thesis. University of KwaZulu-Natal, Pietermaritzburg.

Africa Renewal (2014). Gendering Agriculture. Available at: http://www.un.org/africarenewal/magazine/special-edition-agriculture-2014/gendering-agriculture

ASARECA (2013). Regional Conference on fighting against Maize Lethal Necrosis (MLN) disease to boost maize production.

Cabanas D, Watanabe S, Higashi CHV, Bressan A (2013). Dissecting the Mode of Maize Chlorotic Mottle Virus Transmission (Tombusviridae: Machlomovirus) by Frankliniella williamsi (Thysanoptera: Thripidae). J. Econ. Entomol. 106:16-24.

CIMMYT (2004). Maize Diseases: A Guide for Field Identification. 4 Ed., Mexico, D.F.

Das B, Beyene Y, Mugo S, Gowde M, Makumbi D, Olsen M, Prasanna BM (2015). Breeding for MLN tolerance CIMMYT Africa. MLN Diagnostic Workshop, Naivasha 17th to 19th March 2015.

DSMZ (2014). Data Sheet on Maize Lethal Necrosis (MLN) Disease. Leibniz Institut DSMZ GmbH, Plant Virus Department, Inhoffenstraße 7 b, 38124 Braunschweig, GERMANY.

FAO (2006). Food and Agricultural Organization of the United Nation Crop Production statistics for West Africa. Available at: http://faostat. fao.or/site/567/default.aspc.

Gibson RW, Lyimo NG, Temu AEM, Stathers TE, Page WW, Nsemwa LTH, Acola G, Lamboll RI (2005). Maize seed selection by East African smallholder farmers and resistance to maize streak virus. Ann. Appl. Biol. 147:153-159.

Hill SA (1984). Methods in Plant Virology. Vol. 1. British Society for Plant Pathology. Oxford, UK. 167p.

Joint Assessment Report (2012). Report on status of maize lethal necrosis disease and general maize performance. Joint Assessment Report July 2012. Stakeholders' maize tour. Dates: 2nd to 12th July, 2012. Available at: http://www.fao.org/fileadmin/user_upload/drought/docs/Maize%20Lethal%20Necrotic%20Disease%20in%20Kenya_Joint%20Assessment%20Report%20(July%202012).pdf.

MAAIF (2011). Statistical abstract 2011. Ministry of agriculture, animal industry and fisheries. Agricultural Planning Department.
Magnay J (2004). The Uganda maize industry P. 10. In: Agricultural Successes in the Greater Horn of Africa, NEPAD/IGAD Regional Conference, Nairobi, Kenya.
Makumbi D, Wangai A (2012). Maize lethal necrosis (MLN) disease in Kenya and Tanzania: Facts and Actions. Available at: file:///C:/Users/Ulysses/Downloads/MLN%20in%20Kenya%20and%20Tanzania%20--%20Facts%20and%20actions.pdf
Miano DW (2014). Maize Lethal Necrosis Disease: A real threat to food security in the eastern and central Africa region. Faculty of Agriculture, College of Agriculture and Veterinary Sciences, University of Nairobi.
Nelson SJ, Brewbaker, Hu J (2011). Maize Chlorotic Mottle Virus. Plant Dis. 79:1-6.
Nyvall R (1999). Field crop diseases (Third Edition). Iowa. State University Press, Ames, Iowa.
Okoboi G (2010). Improved Inputs Use and Productivity in Uganda's Maize Sub-Sector. Research Series No. 69, Economic Policy Research Centre, Makerere University, Kampala.
Plantwise (2013). Maize Lethal Necrosis Disease Spreads To Uganda. Available at: http://blog.plantwise.org/2013/04/04.
UBOS (2011). Uganda Bureau of Statistics. The 2011 Statistical Abstract. Available at: http://www.ubos.org/onlinefiles/uploads/ubos/pdf%20documents/abstracts/2011%20Statistical%20Abstract.pdf.
USAID (2010). Market Assessment and Baseline Study of Staple Foods, Country Report-Uganda. USAID.
Uyemoto JK (1983). Biology and control of maize chlorotic mottle virus. Plant Dis. 67:7-10.
Wangai AW, Redinbaugh MG, Kinyua ZM, Miano DW, Leley PK, Kasina M, Mahuku G, Scheets K, Jeffers D (2012). First Report of Maize chlorotic mottle virus and Maize Lethal Necrosis in Kenya. Plant Dis. 96(10):1582.
World Bank (2006). Uganda: Beyond Recovery: Investment and Behavior Change for Growth. Draft Country Economic Memorandum (part I. Overview). Poverty Reduction and Economic Management Unit, Africa Region. Washington, DC.