MAIZE LETHAL NECROSIS DISEASE:

A REAL THREAT TO FOOD SECURITY IN THE EASTERN AND CENTRAL AFRICA REGION

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Importance of maize and production constrains

Maize Lethal Necrosis (MLN) disease is "a looming threat unlike anything farmers have ever faced before"[i] especially in the Eastern and Central Africa (ECA) region where maize is an important staple and food security crop.

About 90% of the regional population depends on maize for food, labor and income. Maize production in the region is constrained by both biotic and environmental factors. The abiotic factors include drought, low use of farm inputs especially fertilizers, low soil fertility, low rates of adoption of new technologies and in-appropriate agronomic practices. The main biotic factors include infestation by weeds particularly *striga* spp and insect pests such as the maize stalk borers, soil pests like termites, nematodes, cutworms, and chaffer grubs. Diseases include Grey leaf spot, Northern leaf blight, rusts, different types of rots (root, stalk and ear), smuts, *Maize streak virus* and Maize Lethal Necrosis (MLN) disease. Other biotic factors include wildlife damage on crops that neighbor forested areas, birds and post-harvest losses. Managing these constraints has been a continuous process involving different stakeholders in the maize industry and production was on the increase with the introduction of different maize varieties which met different consumers. However, the emerging of MLN disease in the region has thrown everyone back to the drawing board.

Maize Lethal Necrosis Disease

Maize lethal necrosis disease was first reported in the ECA region in Kenya in the year 2011 (Adams *et al*., 2012; Wangai *et al*., 2012). The following year, MLND was reported in all the major maize growing districts of Kenya. The disease has since spread to other ECA countries including Tanzania, Uganda, South Sudan and Rwanda, with devastating food security and economic damage. The disease is reported to be a result of combination between *Maize chlorotic mottle virus* (MCMV) with any cereal infecting potyviruses such as *Sugarcane mosaic virus* (SCMV), *Maize dwarf mosaic virus* (MDMV) or *Wheat streak mosaic virus* (WSMV). However, recent findings indicate that MCMV is a threat on its own and may have a significant yield loss even in the absence of other viruses. MCMV was first reported in Peru in 1973 (Hebert and Castillo, 1973) where losses in floury and sweet corn varieties were between 10 and 15%. In experimental plots, inoculated plant yields were reduced by up to 59% (Castillo-Loayza, 1977). In Kansas crop losses due to Corn lethal necrosis (Synonym for MLN) disease were estimated at between 50% to 90% (Niblett and Claflin, 1978; Uyemoto *et al*., 1980) depending on the variety of maize and the year. In China MLND poses a major challenge to maize crop production in many regions. Information on the effect of MLND in Kenya and the region is currently being generated.

Disease transmission and spread

The transmission of MCMV can be mechanical. Several insect vectors (maize thrips, maize rootworms, leaf beetles and leaf hoppers) and seeds are also associated with MCMV transmission and spread. Earlier reports indicated that seed transmission occurred at very low rates (Bockelman *et al*., 1982; Jensen *et al*., 1991). 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. SCMV is mainly spread by mechanical means and by aphid vectors.

Disease symptoms

Infected plants show a wide range of symptoms depending on the variety, number of viruses infecting the plant at a particular time, part of the plant infected, time of infection and prevailing environmental conditions. Common symptoms include chlorotic mottle on the leaves usually starting from the base of the young leaves in the whorl and extending upwards toward the leaf tips, mild to severe leaf mottling, dwarfing and premature aging of the plants, necrosis of young leaves in the whorl before expansion leading to a 'dead heart' symptom and drying up of whole plant.

MLN infected maize field

MLN infected maize plant showing general chlorosis of leaves and necrosis of leaf margins

MLN infected plant showing typical symptoms on the immature cobs

Tassels of maize plants infected by viruses ends up being sterile

The grains of MLN infected cob may not fill

Prevention and control

The most effective control for MCMV has been achieved through the integration of cultural practices with insecticides and host resistance (Nelson *et al.*, 2011). A number of sources of resistance to MCMV have been identified and are being incorporated into commercial maize varieties (Nelson *et al*. 2011). Alternatively, crop rotation with non-maize crop has been shown to reduce the incidence of MCMV the following year (Phillips *et al*., 1982; Uyemoto, 1983).

Plant host resistance

Existence of genetic resistance to MLND causal agents, the MCMV and SCMV has been confirmed (Jones *et al.*, 2007; 2011). SCMV is controlled by 2 major Quantitative Traits Loci (QTL) on chromosome 3 and 6 (Xia *et al*., 1999) while MCMV is polygenically controlled (Nelson *et al*., 2011). Many temperate inbred and hybrids are highly susceptible to the disease, while resistant tropical germplasm is being developed (Nelson *et al*., 2011). Screening of maize germplasm from different parts of the world for resistance to the disease in the ECA region is going on. However, most of the lines and hybrids evaluated have succumbed to the disease. There still are many important questions to be addressed concerning the MLND etiology and its causative viruses. Researchers are in the process of developing a sustainable management solution.

Research areas of interest

Since 2011 when MLND was first reported in Kenya, information is being generated on causal viruses, their vectors, and possible management options. Efforts are directed at creating awareness among farmers, studying disease epidemiology, determining alternative hosts, determining the possible vectors, and screening for possible sources of resistance to the disease. Initial work was being done in Kenya but has now been extended to other ECA countries. There is need to generate information on diversity and distribution of viruses causing MLND in the region, determine the virulence and effects of different virus combinations identified from different countries on disease development, and come up with simple but effective detection methods that can be adopted by small-holder farmers.

The main viruses causing MLND in Kenya was identified as *Maize chlorotic mottle virus* (MCMV) in combination with *Sugarcane mosaic virus* (SCMV) (Adams *et al*., 2012; Wangai *et al*., 2012). While aphids spread SCMV, different vectors have been associated with the spread of MCMV. The role and efficiency of each of the potential vectors is being established. The spread of MCMV through seeds has also been identified as critical. The rate of disease spread in the region has been extremely rapid; raising the question of the significance of each of these methods in disease dissemination. There is need to determine the efficiency of different vectors in virus spread and to monitor the extent to which different seed systems adopted in different countries contribute to the spread of the viruses.

Initial reports from Kenya indicated that fungi and nematodes could be associated with the disease. While it is now clear that the disease is mainly caused by MCMV, alone or in combination with other viruses, the contribution of other associated pathogens cannot be ruled out. Nematodes and other root feeders may create avenues for virus entry from the soil. The root feeders also weaken the plants resulting in the plants' inability to protect itself from infection. Infection by viruses may also weaken the plants resulting in susceptibility of the plants to other opportunistic pathogens. It is important to determine the role of root-damaging organisms (nematodes, beetles etc) and other associated pathogens in disease development.

The survival of the viruses within a farming system is important in designing a management strategy. Viruses causing MLND may survive in different ways in the absence of a maize crop including through maize seeds, in vectors, plant debris and or in alternative hosts. Some of the recommended ways of managing the disease include crop rotation and planting of non-maize crops for a period. Whereas these are good recommendations, presence of viruses in other sources may have a negative effect of the management strategies. There is need to determine the survival of viruses causing MLND in the maize farming systems (intercrop, crop rotation or sequential, monoculture, relay cropping, zero tillage) and their contribution to disease development.

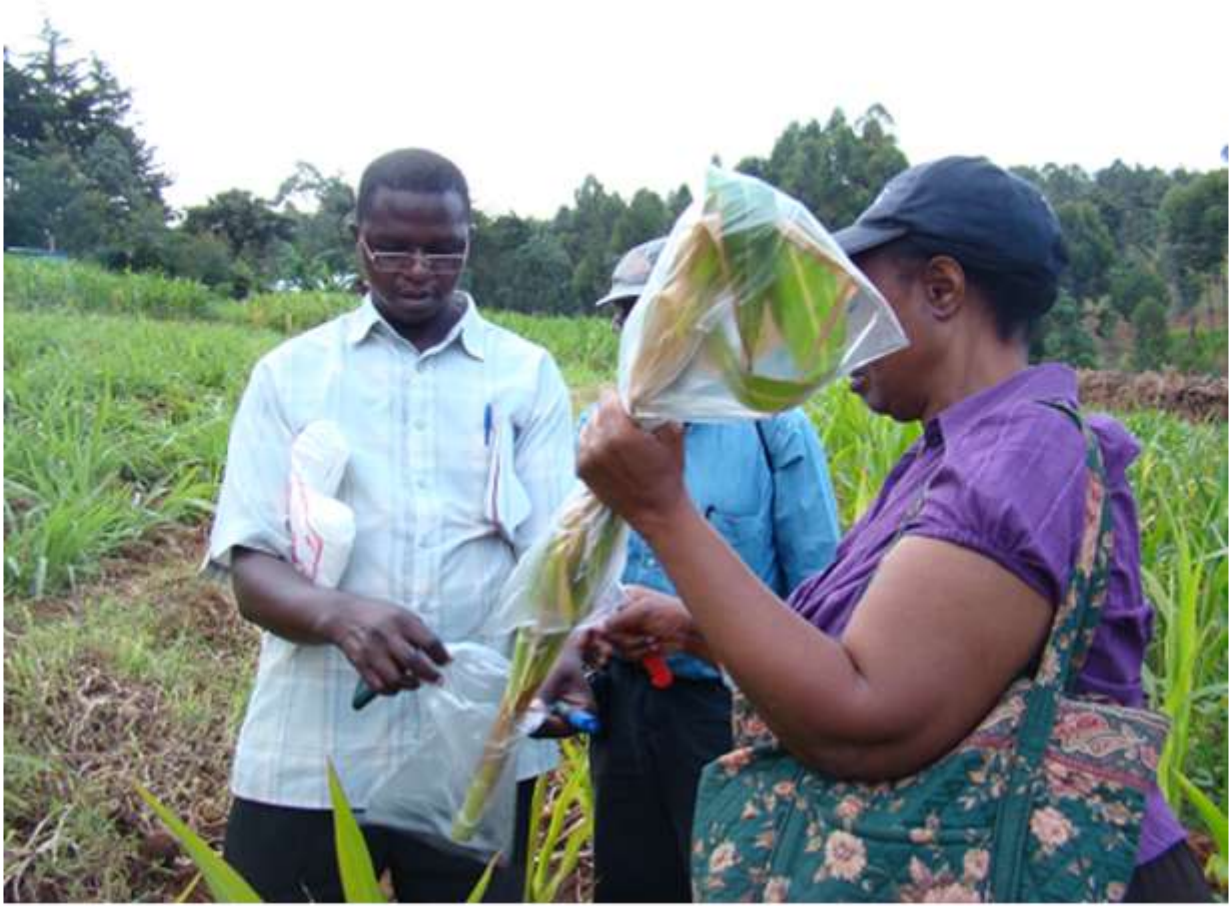
Environment plays a critical role in disease development. Poor plant nutrition makes a plant weak and therefore more susceptible to disease. Low moisture contents in the soil may also result to plants becoming weak. It would be important therefore to assess the potential of enhancing tolerance to infection through higher nutrient and water supply to plants with mild resistance to MLND (irrigated and non-irrigated conditions).

Different methods of vector control may include use of insect traps. This will help in establishing vector dynamics and therefore predicting possible vector outbreaks and disease spread. Combining botanical repellants, plant extracts, entomopathogenic fungi and lures in the management of arthropod vectors of the MLND-causing viruses may limit the effects of the disease.

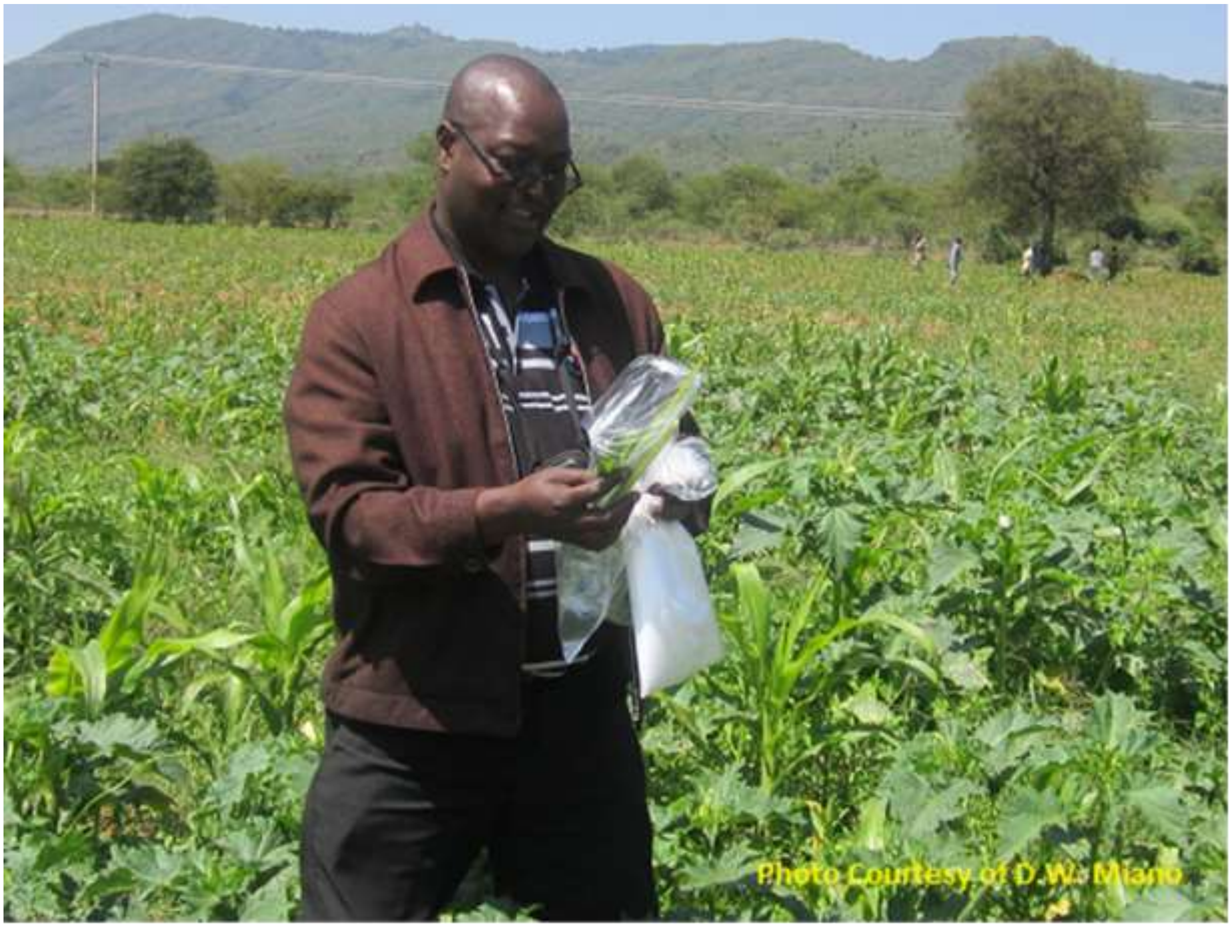
Identification and development of maize varieties with resistance to MLND is important in the management of the disease. CIMMYT and KALRO have been leading in efforts towards identification of resistant maize genotypes through screening of different lines and hybrids collected from all over the world. Once resistant genotypes have been identified, some will be deployed to farmers while new hybrids may need to be developed through breeding. Most of the genotypes screened so far have been susceptible to the disease, though some have shown some promise as good sources of tolerance and or resistance. While screening for maize germplasm against the disease continues, there might be need to seek for other sources of genes for resistance.

Research efforts going on in the region

Multi - disciplinary teams consisting of researchers from local and international universities and research institutions, regulatory bodies, extension agents, NGOs, CBOs, and communication specialists has been assembled in different countries within the region. Scientific support has been tapped from laboratories all over the world. Different projects aim to manage MLN threat by combining state-of-the art science with down-to-earth experience in upscaling technologies and innovations for disease management. Key donors supporting research work in the region include (but not limited to) National governments, ASARECA, World Bank (e.g. through KAPAP in Kenya), Bill and Melinda Gates Foundation, and Syngenta Foundation.



Dr Douglas Miano of the University of Nairobi and Dr Ann Wangai of KALRO collecting samples for virus characterization in farmer's field in Bomet, Kenya



Mr Ben Orina Aguta, MSc Crop Protection student sampling for MLN infected samples in Baringo county during the survey for disease spread in Kenya.

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[i] http://www.nuruinternational.org

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