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IMPACT OF MAIZE LETHAL NECROSIS DISEASE ON MAIZE YIELD: A CASE OF KISII, KENYA

***Samson M. Makone, Dickson Menge, Evans Basweti**
Kisii University, Faculty of Agriculture and Natural Resources management, Department of Agricultural Education and Extension, Kisii, Kenya.

A B S T R A C T

The study aimed at determining the level of Maize Lethal Necrosis Disease and its effect on maize yield in Kisii County and come up with a document showing the prevalence and distribution of the disease across the nine Sub-counties in the region. A simple random sampling technique was used to obtain a sample of 172 respondents from a target household population of 10,000 maize farmers. A structured questionnaire was used to collect data that was subjected to Microsoft Excel and Statistical Package for Social Sciences (SPSS) software (Version 20) for analysis. The findings indicated that the mean age of the respondents was 41.5 years and the average proportion of land allocated for maize production was 1.25 acres. Majority of the respondent had secondary education as their highest level of education. The findings further showed that, Masaba South was the most affected Sub-County by Maize Lethal Necrosis Disease at 74.8%, followed by Bobasi at 74% while Kitutu Chache South was the least affected at 31.2%. The correlation between maize yields and Maize Lethal Necrosis Disease revealed a negative weak relationship of r= -0.277 at a p value of 0.000. It is recommended that farmers should avoid growing maize in consecutive seasons, movement of affected crop debris or materials from one region to another should be stopped to minimize the incidence rates; diversify crops planted and practice crop rotation with non-cereal crops, formulation of extension policy and implement them in all counties to ensure that farmers get necessary information on how to mitigate Maize Lethal Necrosis Disease hence improved maize yield.

Keywords: Maize yield, maize lethal necrosis disease, maize shortage.

INTRODUCTION:

Maize is the main staple food for more than 1.2 billion people in Latin America and Sub-Saharan Africa (Iken & Amusa, 2004). The crop is ranked the third most important cereal plant after wheat and rice (Khalili *et al*., 2013). The majority of producers in Africa are small scale farmers who grow maize for human consumption although it has increasingly been utilized for livestock feed (Onasanya *et al*., 2009). Maize grain has greater nutritional value since they are rich in carbohydrates, vitamins, essential minerals and contain 9% protein. In addition, the grains are also rich in dietary fiber and calories which are a good source of energy (Mghenyi, 2006). Maize lethal necrosis is a serious disease of maize from its first appearance in Kenya (Wangai *et al*., 2012). The disease has now gained the momentum in spreading to many countries of East African where maize crop is grown simply because of insufficient knowledge on how to manage the disease. It has therefore raised a major concern in Eastern Africa communities because of the effect associated (CIMMYT, 2013). The disease is naturally known to affect varieties of maize resulting in chlorotic mottling of the leaves, severe stunting and necrosis which as a result hinders the physiological processes of the plant such as photosynthesis, chlorophyll formation as well as denaturing enzymes necessary for the crop to produce, this further leads to low maize yields or plant death (Wangai *et al*., 2012).

Maize Lethal Necrosis disease is caused by double infection with Maize chlorotic mottle virus (MCMV) and any of the cereal viruses in Potyviridae group; Sugarcane mosaic virus (SCMV), Maize dwarf mosaic virus (MDMV) or Wheat streak mosaic virus (WSMV). In Kenya and

* Corresponding Author:
Email: manozy08@gmail.com

other countries of East Africa, the most frequently is Sugarcane mosaic virus (SCMV) in synergism with Maize chlorotic mottle virus (MCMV) causing MLND. Single infections of MCMV or SCMV cause only mild mosaic or mottling symptoms and a moderate reduction of growth. In mixed infections, early infected plants appear stunted and show a general chlorosis, leaf bleaching and necrosis. Both MCMV and SCMV are transmitted through mechanical means and are known to be seed transmitted. In addition, MCMV can be experimentally transmitted by thrips and beetles while SCMV is vectored by aphids (Cabanas *et al*., 2013).

Maize lethal necrosis was recently identified as the most devastating foliar disease responsible for highest yield loss. According to Ochieng *et al*. (2012), highly affected areas may experience a massive yield loss of over 90% and this will affect total maize yield produced in a country. About 90% of the Kenyan population depends on maize directly or indirectly in terms of food, labour and income. The national consumption per capita is 98kg in Kenya. Kenya produces 25,000 tons against the national demand of 35,000 tons (Ministry of Agriculture Biannual report, 2012).The disease has placed the entire maize sub-sectors across the country at a greater risk and the hardest hit is its food security role (Wangai *et al*., 2012). Majority of Kenyans still prefer maize grain as their main staple food and the shortage in supply is to a large extent, synonymous with food insecurity (Nyameino *et al*., 2003). Historical trends indicate that maize yields fluctuate more widely than any other cereal crops simply because of its sensitivity and vulnerability to disease attack. (Kodhek, 2005)

Despite the importance of maize and its widespread production and consumption, recent reports indicated drastic reductions of expected maize yield in Eastern, Coast and Rift Valley with 79%, 32% and 14% respectively. These regions are considered the food and "grain basket" in Kenya (Murenga, 2014). However, reduction in production of maize is about 250,000 metric tons (Government of Kenya, 2010). At the national level, this is likely to affect the livelihood and the overall market prices (Government of Kenya, 2009; Oscar, 2009). The highest loss in maize yields is caused by biotic constraints such as MLND (Ajala *et al*., 2010; Morais *et al*., 2012; Wangai *et al*., 2012).

Kisii County has a high potential for agricultural activities and receives bimodal rainfall. It is among the counties that are expected to produce enough food for their people and surplus to feed people in other parts of the country. However, maize yield in the region like the rest of the country is facing a number of challenges over time despite good climatic conditions and soils. Evidence from previous studies indicated that most farmers had little knowledge on MLND and its control mechanisms. Further evidence showed that, there was limited research on crop diseases and more particularly in maize lethal necrosis disease. The present study therefore was conducted to determine the Impact of Maize Lethal Necrosis Disease on Maize yield in Kisii County.

METHODOLOGY

The Study area: The study was conducted in Kisii County which is located in the western Kenya. It lies between latitude 0 30'and 1 0'South and longitude 34 38'and 35 0'East. The County covers an area of 1,317 km2 with a total population of 1,152,282 and 245,029 households. It consists of nine sub-counties namely; Bonchari, South Mugirango, Bobasi, Bomachoge Borabu, Bomachoge Chache, Nyaribari Masaba, Nyaribari Chache, Kitutu Chache North, Kitutu Chache South. The county exhibits a highland equatorial climate resulting into a bimodal rainfall pattern with average annual rainfall of 1500mm with the long rains between March and June while the short rains are received from September to November. The months of July and January are relatively dry. The maximum temperatures in the county range between 21°C – 30°C while the minimum temperatures range between 15°C – 20°C. The high and reliable rainfall coupled with moderate temperatures is suitable for growing crops such as maize, beans, bananas, tea, coffee, pyrethrum as well dairy farming.

Sampling and data collection procedures: A simple random sampling technique was used to get one hundred and seventy two (172) respondents from accessible household population of ten thousand (10,000) maize farmers. Since the farmers affected by Maize lethal necrosis disease were unknown, the researcher decided to use Snowball sampling technique to identify them. Once the first respondents were identified by the researcher, it became easier to locate the next and the subsequent respondents. The respondents were the ones to direct where to go next as they knew them in their community. The study applied fishers' formula as described by Cochran (1963:75) to yield a representative sample size (Mugenda & Mugenda, 1999). Data collection questionnaire was used as

research instrument. Questionnaires administered by the researcher were used to collect data from the respondents on maize lethal necrosis disease and maize yields. The research instrument content was shared with the experts in the field of study for their necessary input and approval before embarking on the field for data collection. The respondents were informed of the purpose of the study and the need to respond honestly. This was to ensure that the data collected is reliable and non-biased. Data were analyzed using Microsoft excel and Pearson correlation coefficient to test the magnitude of the relationship and influence among independent and dependent variables with the aid of Statistical Package for Social Science (SPSS) (version 20) software.

RESULTS AND DISCUSSION

Distribution of respondents according to their gender, age and educational level: Out of 172 respondents who participated in this study 102 were male which translated to 59.3% while 70 respondents were female which translated to 40.7% (Table 1). The relationship between gender and maize production is expected to be positive or negative respectively. Male households are likely to attend agricultural field days, shows,, or workshops meetings presided over by the ministry of agriculture and adopt the best agronomic practices aimed managing maize lethal necrosis disease, on the other hand female farmers are more likely to stay at home to take care of the children and to carry out household chores.

Table 1. Respondents' gender frequency table

Gender	Frequency	Percent
Male	102	59.3
Female	70	40.7
Total	172	100.0

Age of the respondents: The age of the respondents was used as a proxy for farming experience, the findings indicated that, majority of the farming population in Kisii County had an age bracket of 36-55 years which translated to 48.8%, followed by youth age of 18 years to 35 years translated to 32.1%. The average age of the farming population was 41.5 years. This concurs slightly with study of Mironga (2005)who depicted the average age of Kisii district farmers was 40.5 years. The age was therefore included to evaluate the effect of age on maize production and farming management. According to Shafiq & Rehman (2000), the age of a farmer is expected to have a positive or a negative relationship with maize production outputs. This means that younger farmers can be more energetic in carrying out their farming operations as opposed to older age; it is possible that older farmers may be traditional and conservative to change thus show less willingness to adopt new farming technology aimed at increasing farm management on disease control and productivity (Table 2).

Table 2. Distribution of respondents according to their age .

Age of the respondents	Frequency	Percent (%)
18-35	55	32.1
36-55	84	48.8
56-69	30	17.4
>70	3	1.7
Total	172	100.0

Educational level of the respondents: The respondents were of diverse levels of education ranging from none educated to educated farmers. The findings indicated that 2.9% of farmers were illiterate, 13.4% with primary education, 37.2% with secondary level, middle level were 28.5% and those with University education were 18.0 % (Table 3). The result indicated that majority of the farmers in Kisii County had secondary education. These findings are divergent from Kipng'eno (2012) points of view that majority of the farmers in Nyamarambe Division Kisii County had primary education level at 51.7%. The level of education plays an important role in farmers' decision making especially in the adoption of improved maize production technologies. Educated farmers usually have a better opportunity to access information on new technologies and are generally better able to assimilate, to process and to use this information (Taylor, 1997). The number of years a person spent in formal education is one of the most important determinants of increased household food production and adoption of good agricultural practices.

Following this observation, there was limitation in information flow and adoption of new food production technologies among low educated farmers. The findings indicated low literacy rates of 16.3% among the Kisii County farmers (those with primary education level and below).

Education was therefore used as a proxy for human capital; it is known that higher level of education may lead to high level of managing maize lethal necrosis disease. Educated farmers are likely to access information easily and use it to make well informed decisions on controlling the disease prevalence. The findings indicated that, there was no significant relationship between farmers' level of education and farmers affected by MLND (r= 0.120, p= 0.117). This means that maize lethal necrosis disease affected all the farmers irrespective of educational qualifications of the farmers (Table 4 below).

Table 3. Distribution of respondents according their educational level.

Educational level	Frequency	Percent (%)
Illiterate	5	2.9
Primary	23	13.4
Secondary	64	37.2
Middle level	49	28.5
University	31	18
Total	172	100

Table 4. Correlation between education level of the farmers and MLND control.

Correlations		Affected by MLND
Level of education	Pearson Correlation	0.120
	Sig. (2-tailed)	0.117
	N	172

Proportion of farmers affected by MLND in Kisii County: Since the main objective of this study was to determine the level of maize crops affected by MLND in Kisii County, the findings indicated that 95.9% of the farmers were affected by maize lethal necrosis in 2013-2014 cropping seasons; whereas 4.1% of the respondent indicated that they were not affected by MLND. These showed that MLND affected almost three quarter of Kisii County (Table 5).

Table 5. Farmers affected by MLND (2010-2013/2014 cropping season) frequency table.

Affected by MLND	Frequency	Percent (%)
No	7	4.1
Yes	165	95.9
Total	172	100.0

Maize Lethal Necrosis Disease (MLND) analysis by sub-county in Kisii County: The findings indicated that Masaba South Sub-county (Nyaribari Masaba) was the most affected Sub-County by MLND in (2013-2014) cropping seasons at 74.8%, followed by Nyamache Sub-county (Bobasi) at 74% while Kisii Central sub-county (Nyaribari Chache) at 55.9%. Since maize lethal necrosis is transmitted by vectors (Cabanas *et al.*, 2013), then it means that the disease might have spread through the shared border of the three leading Sub-counties. Other Sub-counties on the list were: Gucha South Sub-county (South Mugirango) at 52.9%, Gucha Sub-county (Bomachoge Chache) at 39.3%, Bomachoge Borabu 47.6%, Kitutu Chache North 40.2%, Kitutu Chache South 31.2% and Bonchari with 40.2% as shown in (Figure 1).

Maize Production Trend From 2010 - 2013/2014 In Kisii County: The findings indicated that the average household maize production in 2010 was 847.0 kgs; there was a sharp decline in household maize yield in the subsequent years 2011, 2012 and 2013/2014 cropping season with an average yields reduction of 708.6 kgs, 617.0 kg and 570.6 kgs respectively. Maize lethal necrosis disease was first observed in Kenya in 2011. Since then the county is experiencing a serious maize yield problem (Figure 2). Decline in maize yield can be attributed to various maize production constraints. The production constraints can be grouped into socio-economic, technological, policy constraints, abiotic and biotic

constraints (Oscar, 2009). Socioeconomic, technological and policy limitations facing farmers include use of poor quality seeds, population pressure leading to land subdivisions, limitations to market access, poor state of infrastructure, and high costs of farm inputs (Government of Kenya, 2010).

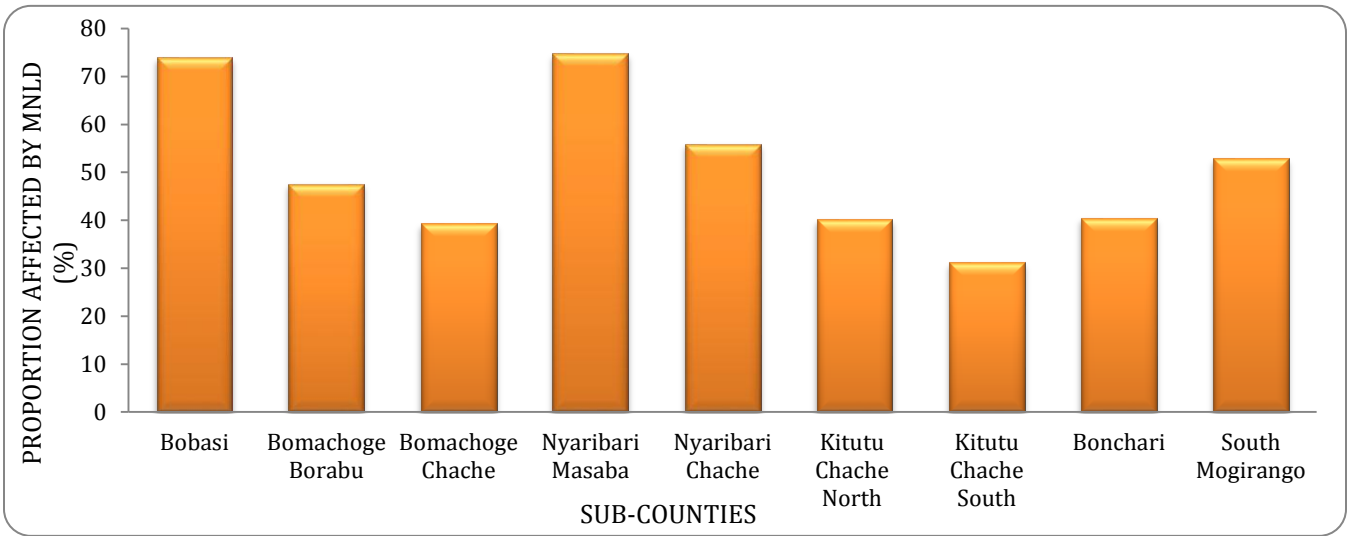

Figure 1. Bar-Graph of Maize Lethal Necrosis Disease By Sub-County.

Abiotic factors affecting maize production include declining soil fertility, low soil pH with associated nutrient deficiencies and toxicities low and unreliable rainfall leading to recurrent droughts (Government of Kenya, 2010). Foliar diseases are the most devastating biotic factors that affects maize yields. Maize lethal necrosis disease (MLND) is the major constraints to maize production because of its significant contribution to yield reductions (Ajala *et al*., 2010; Morais *et al*., 2012; Wangai *et al*., 2012). In highly affected regions, yield reduction of 90-100% may occur (Adams et al. 2012). According to the report on status of Maize Lethal Necrosis Disease and general maize performance by Ochieng *et al*. (2012) indicated that, the yield reductions due to MLND in some areas of Embu, Meru, Naivasha, Narok, Bomet and Kisii were 80%, 70%, 80%, 100%, 100% and 90% respectively. The Kenyan government has undertaken several interventions responses aimed at reducing the disease prevalence rates such as formation of a task force and monthly technical consultative forum, convening a regional workshop on the management of Maize Lethal Necrosis Disease, surveillance and monitoring on Maize Lethal Necrosis Disease spread, testing for tolerance and even conducting sensitization programmes across the country (De Groote *et al*., 2002). Despite all these efforts the yields are still low.

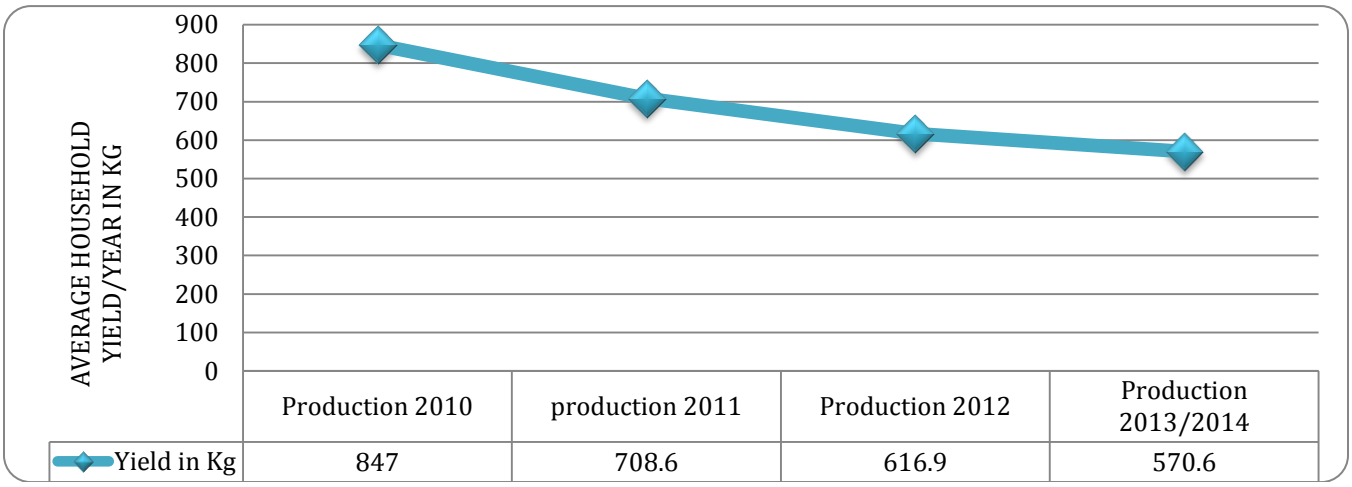

Figure 2. Graphical presentation of maize production trend 2010-2013/2014 in Kisii County.

Proportion of Maize Crops Affected By Maize Lethal Necrosis Disease In 2010-2013/2014: Majority of the respondents indicated that there were no symptoms of MLND in their farms in 2010. In 2011, some respondents indicated that there were incidences of maize lethal necrosis symptoms translated to 2.15% of crops affected. The findings further showed that in 2012 a prevalence of 22.1% was reported in 2013/2014 cropping season the disease prevalence rate of 56.7% of the crops affected was observed. Maize lethal necrosis disease was first reported in September 2011 in Bomet District and later it was noted in the neighboring districts of Chepalungu, Narok South, Narok North and Naivasha and Borabu (Wangai *et al*., 2012).

This means that in 2011 the disease might have transmitted by vectors through the neighbouring boarder of Borabu.

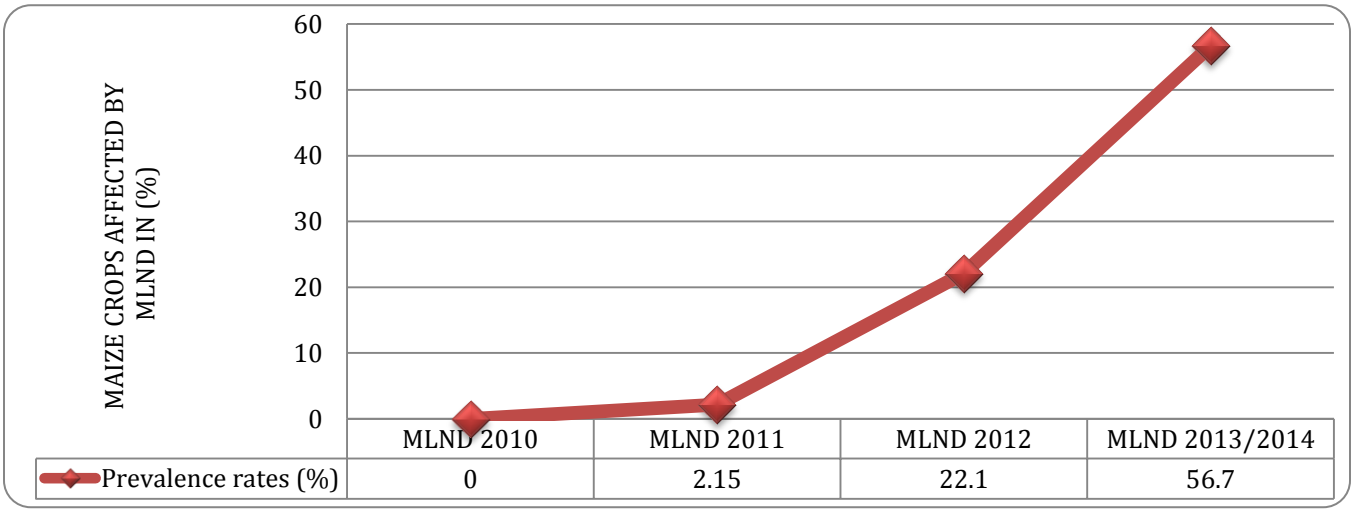

Figure 3. Graphical presentation showing prevalence rates in percentage of maize crops affected by MLND in 2010-2013/2014.

Figure 2 and Figure 3 show that there is inverse relationship between maize yields and maize lethal necrosis disease (MLND).

By using Pearsons correlation coefficient, the same results revealed a negative weak relationship of r= -0.277 at P value of 0.000. This means that as maize yields was decreasing, maize lethal necrosis disease prevalence rate was increasing (Table 6), an indication that decline in maize yields in Kisii County might have been caused by MLND.

Table 6. Pearson's correlation coefficient on MLND and Maize yield

Correlations		Proportion affected by MLND (%)
Maize yield	Pearson Correlation	-0.277
	Sig. (2-tailed)	0.000
	N	163

CONCLUSION AND RECOMMENDATIONS

Managing maize lethal necrosis disease in Kisii County can be approached both at farm and national levels. At the farm level, a number of important measures are necessary: Maintain agricultural land clean and free from weeds, execution of early and better land preparation, timely planting, planting of the most appropriate and recommended maize varieties, proper fertilization, regular crop rotation and uprooting or roughing of the affected plant. At the national level, several interventions are essential: The Ministry to set aside funds for addressing issues related to MLND, Support small scale farmers with subsidized registered systemic and contact pest control products for management of vectors (aphids, beetles and thrips) especially in the least affected Sub-counties such as Kitutu Chache South and Bomachoge Chache maize growing zones where MLND incidence is still low, Support rapid response alert and disease surveillance for early detection for prevention of MLND spread in the County. The formulation of a strategy to pursue sustainable maize production in Kisii County is indispensable mainly because of the scarcity of agricultural land caused by rapid population growth in the region.

The following recommendations are made based on the findings of this study: Farmers should avoid growing maize in consecutive seasons, diversify crops planted and practice crop rotation with non-cereal crops such as beans or other legumes, onions, pumpkins, bananas, potato and sweet potato as breeders and pathologists do their work to get the solutions; Farmers should be aware of specific season and planting time to avoid spreading of the MLND; promote Good Agricultural Practices (fertilizer, timely weeding and control of pests and diseases) to boost plant vigor and eliminate alternate hosts for MLND vectors; farmers whose fields are affected should get rid of the crop (minimize inoculums buildup), plant alternative crops to build food security and also to stop movement of affected crop debris or material from one region to another should be stopped to minimize the incidence rates.

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