INTERNATIONAL JOURNAL OF APPLIED SCIENCE AND RESEARCH
www.ijasr.org

2018 V0L.-1 ISSU.-2

Evaluation of selected cassava varieties for resistance to cassava brown streak disease in South Kivu, Eastern part of DR Congo

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ABSTRACT

Cassava brown streak disease (CBSD) has been a serious and most damaging disease in cassava crop throughout the East, Central and Southern part of Africa. Development of cassava varieties that are resistant and/or tolerant to CBSD is an important component in the CBSD management. The main purpose of this study was to evaluate both improved varieties used by farmers and clones from Mulungu research Center for possible sources of resistance to CBSD. The experiment was laid out using a Randomized Completely Block Design with three replicates in six sites. Data were collected at 1, 3, 6, 9 and 12 month after planting for plant height, CBSD incidence and severity, root yield and yield components. Results indicated that foliar and root incidences and severity varied significantly among genotypes ($P<0.001$). Almost, all the genotypes showed foliar CBSD symptoms and root necrosis, whereas one genotype, 2001/1661 did not show foliar symptoms and root CBSD symptoms across all the sites. Highest CBSD pressure was observed at Kamanyola and Katogota with foliar CBSD incidences of 62.4% and 78.5% and root necrosis incidences of 37.5% and 59.1%. In terms of yield, it was highest in Katogota (24.5 t/ha) and Runingu (24.4 t/ha) and the lowest yield was in Kaziba site. The absence of both foliar and root symptoms on 2001/1661 across all sites indicated that this variety can be adopted by farmers in Kivu region for its resistance to CBSD.

KEY WORDS: Cassava varieties, cassava brown streak disease, performance, resistance

1. INTRODUCTION

Cassava (*Manihot esculenta Crantz*, family *Euphorbiaceae*) is one of the most important food crops in the world and in developing countries (Cock, 1985). Cassava is an important staple food crop for about 800 million people across the globe, and is cultivated mostly as a subsistence crop but also for its industrial value (Patil et al 2015 and Burns et al 2010). Cassava is a leading source of food and income in the humid forest areas of West and Central Africa (Mwangi et al., 2004). After Nigeria, the Democratic Republic of Congo (DRC) is ranked as the second highest producer of cassava in Africa and is the fifth highest worldwide, with almost 15 million metric tons in 2010 (FAO, 2013). Nearly every person in Africa eats around 80 kg of cassava per year. It is estimated that 37% of dietary energy comes from cassava. The Democratic Republic of Congo is the largest consumer of cassava in

Sub Saharan Africa, followed by Nigeria (IITA, 2016). In the DRC, cassava cultivation is subsistence crop with an average production of 7 t/ha at the farm level but with a potential of 25-30 t/ha in experimental research stations and in farms with improved varieties (Tata-Hangy et al., 2009).

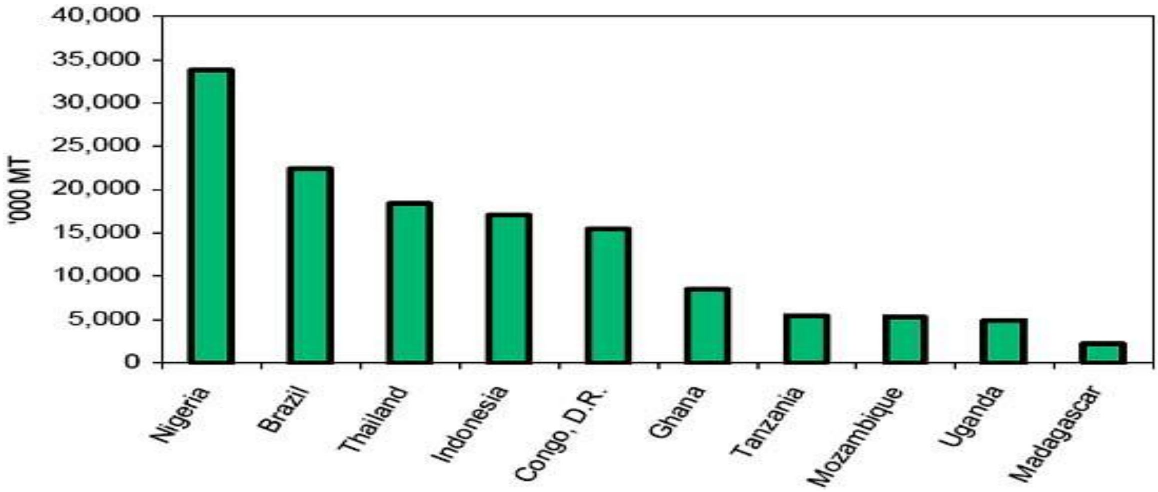

Figure 1. Top ten Cassava producing countries in the world 2015

Cassava brown streak disease (CBSD) has emerged as the most important viral disease of cassava (*Manihot esculenta*) in Africa and is a major threat to food security. CBSD is caused by cassava brown streak viruses (CBSVs), which are positive-sense ssRNA viruses (Winter et al., 2010). Recent findings have indicated that CBSD may sometimes be caused through mixed infection of the two entirely different viruses of cassava brown streak virus (CBSV) and Ugandan cassava brown streak virus (UCBSV) (Mbanzibwa et al., 2009). Both viruses belong to the genus *Ipomovirus* in the family *Potyviridae* (ICTV, 2005). Although the disease is primarily known to spread through infected planting materials, other workers (Ntawuruhunga and Legg, 2007) have attributed its spread to the whitefly vector, *Bemisia tabaci* Genn.

CBSD was first reported from the coastal region of Tanzania in the 1930s (Storey, 1936) but has received much less attention than cassava mosaic disease (CMD), partly due to its earlier geographical restriction to lowland areas of East Africa (Nichols, 1950; Hillocks and Jennings, 2003). However, since 2004, this situation has changed, and CBSD has been spreading at an alarming rate in East and Central Africa, threatening the food security of millions of cassava farmers (Alicai et al., 2007; Legg et al., 2014a). The tuberous yield loss caused by CBSD has been estimated at more than 70% per plant (Hillocks et al., 2001).

Though cassava is tolerant to most frequent biotic and abiotic stresses, the production in addition to CBSD is constrained by a number of abiotic stresses which include acidic soils found in high altitude zones, lack of adapted varieties and lack of planting materials among others (FAO 2013). Other major pests include mites, mealy bugs and whiteflies (Hillocks and Jennings, 2003).

In terms of control, the most economically viable method for CBSD management is the use of host-plant resistance (Munga, 2008). Thus, development of cassava varieties that are resistant to CBSD is an important component in the CBSD management. The main objective of this study was to evaluate the most likely improved varieties and clones for possible sources of resistance to CBSD.

2. MATERIAL AND METHODS

2.1 Description of cassava germplasm

Ten cassava genotypes of symptomless plants that comprised of four improved varieties such as N'abana (V_8), Obama (TME 419), Mugoli (V_{12}) and 2001/1661 (Kindisa), five clones: MLG 2008/001, MLG 2008/020, MLG 2008/037, MLG 2008/057 and MLG 2008/064 from National Institute for Agronomic and Research Study (INERA) of Mulungu research centre and a local variety were used. N'abana (V_8) and 01/1661 (Kindisa) are newly released cassava varieties that are tolerant to CBSD and Obama (TME 419) is very susceptible to the disease (CBSD).

2.2 Experimental site and design

Field experiments were conducted in South Kivu from October 2013 to December 2014 to determine the susceptibility of selected cultivars to CBSD. Six trials were planted in six different sites of four territories. The six sites were: Kamanyola, Katogota and Runingu in Ruzizi plain/Uvira territory, at Luhorha in Kabare territory, in Mwenga territory and Kaziba. These sites differ in altitude (Table 1), soil texture, mean annual temperature and rainfall. The plot sizes were four by eight meters, in a randomized complete block design (RCBD) with three replicates in every site using a spacing of one by one meter. Weeding was done manually using hand hoes and no fertilizer and/or herbicide was applied.

Table 1: Geographical data of experimental sites and partners

N°	Sites	Geographical data	Partners
1.	Kamanyola	S 02°44.893' E 029°00.440' Alt. 926m	IPLCI
2.	Katogota	S 02°47.664' E 028°58.137' Alt. 990m	FONIMIS
3.	Runingu	S 03°10.789' E 029°10.076' Alt. 856m	8ème CEPAC
4.	Kabare	S 02°19.490' E 028°47.000' Alt. 1774m	FEAM
5.	Mwenga	S 03°02.915' E 028°45.033 Alt. 1217m	ISANDA
6.	Kaziba	S 02°81.001' E 028°80.662' Alt. 1973m	ACOSYF

S=south; E=east; Alt=altitude

2.3 Data collection and analysis

The established cassava varieties were evaluated at 1, 3, 6, 9 and 12 months after planting (MAP) for CBSD foliar symptoms. Plants were assigned disease severity scores based on the standard five point scores scale for CBSD foliar symptoms (Gondwe et al., 2013), where 1= no apparent symptoms, 2= slight foliar feathery chlorosis, no stem lesions, 3= pronounced foliar feathery chlorosis, mild stem lesions, and no die back, 4= severe foliar feathery chlorosis, severe stem lesions, and no die back, and 5= defoliation, severe stem lesions and die back. Root severity and incidence for CBSD were evaluated at 12 MAP, using a scale of 1-5 (Gondwe et al., 2013), where 1= no apparent necrosis, 2=

less than 5% of root necrotic, 3= 5-10% of root necrotic, 4= 10-25% of root necrotic, mild root constriction and 5 = >25% of root necrotic with severe root constriction. The disease incidence was recorded as percentage proportion of the symptomatic tissue to the whole surface area of the assessed tissues.

Plant height expressed in centimetres was determined by vertically measuring the plant from the ground to the top of the canopy at 12 months after planting on twelve middle plants in each plot.

At harvest, fresh storage roots for twelve middle plants of each plot from each of the replications were selected and used for the root yield assessment. The yield of the fresh roots in t/ha was calculated as:

$$\text{FSRY} = \frac{\text{Weight of roots from harvested area}}{\text{Harvested area (m2)}} \text{ X } 100$$

The disease incidence and severity data were subjected to analysis of variance (ANOVA) to establish whether or not significant difference exists among cassava genotypes, using GenStat, 13th Edition computer Package (Goedhart and Thissen, 2010). Treatment means were separated using Least Significant Difference (LSD) and declared to be significant at 95% confidence level (P=0.05).

3. RESULTS

The typical above and below ground CBSD symptoms were observed among genotypes. The symptoms included leaf chlorosis, root necrosis and root constrictions (Figure 3). Results showed significant differences among cassava genotypes and locations, disease incidence and severity, and yield.

CBSD incidence:

Foliar CBSD symptoms were observed on all the evaluated genotypes, except genotype 2001/1661 (Table 2). However, the differences in the average disease incidence varied significantly (P<0.001) among the genotypes ranging from 0.0 to 46.7% (Table 2). With the exception of genotype 2001/1661 that had no foliar symptoms, all other genotypes were affected by CBSD (Table 2).

Incidence of root necrosis varied significantly (P<0.001) among genotypes ranging from 0.0 to 39.4% (Table 2). The highest incidences were observed on genotypes Obama (TME 419) (Figure 3A) followed by Mugoli and Mu 2008/057 (Figure 3E). Results indicated that only genotype 2001/1661 did not show any root necrosis.

CBSD severity: The mean foliar CBSD severity scores varied significantly (P<0.001) among genotypes ranging from 1.0 to 2.2 (Table 2). The highest foliar severity was observed in improved varieties (Mugoli, Nabana and Obama) and the local variety used as check and lowest in genotypes 2001/1661, MLG 2008/020 and MLG 2008/064 (Table 2).

The severity root necrosis scores were significantly (P<0.001) different among genotypes ranging from 1.0 to 2.0 (Table 2). The lowest root severity was observed on genotypes: 2001/1661, MLG 2008/020, MLG 2008/064, N'abana, 2008/001, MLG 2008/037 and MLG 2008/057 and highest on Obama and Mugoli.

In terms of locations, the highest CBSD incidence and severity were observed in Katogota followed by Kamanyola and not present in Luhorha and Kaziba on the evaluated genotypes (Table 3).

Plant height: The genotypes differed significantly (P < 0.001) in plant heights. The height among cassava genotypes varied from 92.3 cm to 149.8 cm with an average mean of 113.7 cm (Table 2). The tallest genotype was Obama followed by N'abana and the shortest were genotypes Mugoli and MLG 2008/037.

Fresh root yield: Fresh storage root yield varied significantly (P<0.001) among genotypes ranging from 7.4 to 20.1 t/ha with an average mean of 14.1 t/ha. The highest yields were observed on genotype MLG 2008/037 (20.1 t/ha) followed by MLG 2008/020 (18.8 t/ha) and lowest on local variety (7.4 t/ha) and Mugoli (9.7 t/ha).

Table 2: Mean CBSD foliar and root incidence and severity, Plant height, Number of roots per plant, total weight of roots and yield of the evaluated cassava genotypes

Genotypes	Plant height (cm)	Average roots number/plant	Total roots weight (kg)	CBSD foliar		CBSD root		Yield (t/ha)
				Incidence	Severity	Incidence	Severity	
N'abana	142.9	6.0	16.8	16.7	2.0	10.5	1.2	15.6
Obama	149.8	4.3	14.4	41.7	2.0	39.4	1.9	12.9
Mugoli	92.3	4.5	9.5	35.8	2.2	38.9	1.9	9.7
2001/1661	113.2	3.9	13.8	0.0	1.0	0.0	1.0	14.8
MLG 2008/001	103.1	4.8	16.2	21.7	2.1	15.5	1.2	14.8
MLG 2008/020	103.7	5.4	10.3	15.8	1.7	13.5	1.1	18.8
MLG 2008/037	97.1	5.6	12.6	22.5	1.8	13.9	1.3	20.1
MLG 2008/057	112.2	6.7	12.3	18.3	1.9	32.8	1.3	11.7
MLG 2008/064	118.3	4.3	16.0	21.7	1.7	8.9	1.1	15.5
Local	104.9	3.3	5.4	46.7	2.1	15.6	1.3	7.4
Mean	113.7	4.9	12.7	24.1	1.9	18.9	1.3	14.1
CV (%)	12.8	10.7	16.2	114.5	4.9	85.3	33.8	35.8

CV=coefficient of variation; CBSD=cassava brown streak disease; t/ha=ton per hectare

Table 3 below shows the mean plant height, average roots number per plant, total roots weight, CBSD foliar and root incidence and severity, and fresh root storage yield of the cassava genotypes evaluated in different locations. CBSD foliar symptoms and root necrosis were observed in four sites: Kamanyola, Katogota, Runingu and Mwenga, except Luhorha/Kabare and Kaziba sites. Root necrosis was highest in Katogota (59.1%, 2.0) followed by Kamanyola and Runingu (37.5%, 1.9 and 20.6%, 1.3, respectively). The genotypes were generally tall when grown at Katogota, Runingu, Mwenga and Kamanyola, in that order, compared to Kaziba and Luhorha. In terms of fresh storage root yield, it was highest in Katogota (24.5 t/ha) and Runingu (24.4 t/ha). The lowest yield was found in Kaziba. Low yield was also observed at Kamanyola due to the incidence of rotten roots on N'abana variety. Total root weight also followed the same trend, highest in Katogota (20.7 kg) and Runingu (20.8 kg) and lowest in Kaziba (1.7 kg).

Table 3: Mean CBSD foliar and root incidence and severity, Plant height, Number of roots per plant, total weight of roots and yield of the evaluated cassava genotypes in different locations

Genotypes	Plant height (cm)	Average roots number/plant	Total roots weight (kg)	CBSD foliar		CBSD root		Yield (t/ha)
				Incidence	Severity	Incidence	Severity	
Kamanyola	103.2	4.0	2.5	62.4	3.0	37.5	1.9	7.3
Katogota	161.5	4.7	20.7	78.5	3.0	59.1	2.0	24.5
Runingu	148.7	5.6	20.8	69.5	2.4	20.6	1.3	24.4
Luhorha	73.3	4.5	18.7	0.0	1.0	0.0	1.0	11.6
Mwenga	134.1	6.5	12.3	0.0	1.0	4.1	1.1	15.9
Kaziba	62.1	3.1	1.7	0.0	1.0	0.0	1.0	2.6
Mean	114.4	4.7	12.8	24.3	1.9	20.2	1.4	14.4
CV (%)	18.3	8.9	28.7	127.3	22.1	65.3	18.9	23.8

CV=coefficient of variation; CBSD=cassava brown streak disease; t/ha=ton per hectare

Figure 2A. Obama root construction

Figure 2B. CBSD root symptoms

Figure 2C. CBSD foliar symptoms

Figure 2D. N'abana rotten roots in Kamanyola

Figure 2E. CBSD root symptoms on evaluated cassava genotypes in

Figure 2. CBSD foliar symptoms and roots necrosis on evaluated cassava genotypes

4. DISCUSSION

The main objective of this study was to identify resistant or tolerant variety to CBSD in Eastern part of DRC. Materials used in the study were sourced from breeding program at Mulungu research center. Results indicated that average foliar CBSD and root necrosis incidences varied significantly among genotypes. Similarly, the severity of foliar and root necrosis were different among genotypes. These results indicate the differential response of the genotypes to CBSV infection. Foliar results indicate the presence of cassava brown streak disease on all almost all the evaluated materials. This is true as these varieties were bred only for CMD and not for CBSD resistance. Only one variety, 2001/1661 did not show foliar CBSD symptoms. The result agrees with the finding of Abaca et al. (2012b), where only five cassava varieties were found to be tolerant to CBSD, amongst which NASE 14. However, the absence of foliar CBSD symptom on genotype 2001/1661 does not mean that cassava brown streak disease (CBSV) could be absent in the variety. The result supports also the finding of Musungayi et al. (2018), when cassava brown streak disease foliar symptoms were observed on local cultivars and not on elite genotypes. The result agrees also with Abaca et al. (2014), where TME 204, TME 14 and TMS – 192/00067 presented symptoms of CBSD and not on NASE 13, NASE 14 and local variety. CBSD root necrosis was observed on nine varieties (N'abana, Obama, Mugoli, MLG 2008/001, MLG 2008/020, MLG 2008/037, MLG 2008/057, MLG 2008/064 and local) and was not on 2001/1661 across all the study sites. The highest CBSD incidence and severity were observed in Obama and Mugoli, which confirm their high level of susceptibility to CBSD. This might be due to the influence of the environment on the virus and *B. tabaci* and growth activities of the plants (Fargette et al., 1993). This might also imply that virus replication and symptom expression are controlled by distinct genes in cassava as alluded to by Kaweesi et al., (2014) when working with cassava brown streak virus and Uganda cassava brown streak virus. High pressure of CBSD foliar symptoms and root necrosis were found in Kamanyola, Katogota and Runingu, which is a CBSD hot spot. This supports the earlier idea that CBSD is a disease of lowland areas (Alicai et al., 2007).

Variability was observed among genotypes and location interaction for the plant height. The genotypes were generally tall in four sites (Kamanyola, Katogota, Runingu and Mwenga) compared to Luhorha and Kaziba. According to the effect of environment, Laban et al., (2013) reported similar results where genotypes and locations significantly varied among themselves for plant height in three locations in Uganda. Assessment of the growing conditions such as rainfall, temperature, solar radiation showed that, the climatic conditions were ideal to support growth of the plant (Yihong et al., 2009).

Varying yields were observed on both locations and varieties, indicating wide genetic differences. Low yield was observed in Kaziba due to the length of the season, the weather and the soil type. Kamanyola also was observed to have low yield due to high number of rotten roots. Lower root yield in cassava have been attributed to higher disease prevalence (Bray, 1997), poor soil fertility, especially phosphorus (Howeler, 1980).

5. CONCLUSION

In conclusion, this is the first evaluation of Mulungu's germoplasm against CBSD. Results from this evaluation indicate that materials used in the study are all susceptible to CBSD. Fortunately, only one genotype, 2001/1661, has been identified to have no CBSD symptoms across all sites, indicating that this variety is resistant/or tolerant to CBSD and can be released to farmers in Kivu region for its resistance/tolerance to CBSD. Therefore, the absence of both foliar and root symptoms on 2001/1661 across all sites indicated that this variety can be used as resistant parent in a breeding program for CBSD resistance.

ACKNOWLEDGEMENT
We are grateful to the African Bank of Development (BAD) through SARD-SC project coordinated by International Institute of Tropical Agriculture (IITA) for funding this study. We also wish to thank the entire cassava crop scientists and technicians of INERA-Mulungu for their continued support that has allowed us to collect the data used here accurately.

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