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Introduction and Evaluation of New Cassava Varieties Resistant To Cassava Diseases and Pests in Maniema Province, East of DR Congo

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ABSTRACT
Cassava adaptive trial was planted in nine sites around maniema town with nine introduced and local cassava varieties to test their performance and reactions to major pests and diseases in the region. The experiment was planted in a randomized complete block design with three replicates. Results showed cassava mosaic, cassava brown streak disease and cassava green mite as major pest and diseases across all sites. Leaf and root cassava brown streak disease incidences and severities, cassava mosaic disease, marketable root weight, average number of rotten roots and root yield were significantly ($p<0.001$) related to the individual varieties. Local varieties were seriously affected by cassava mosaic and cassava brown streak disease. Introduced cultivars from mulungu research centre were found to be resistant to the two observed diseases across all the sites. The results showed a highest yield in kindisa, mlg 2009/083, mu 2009/004, mlg 2011/195, mwezi-site, kabombo, mulamba, kindewe and kankwale, in that order. High yields were found on improved cultivars compared to the local varieties. The absence of disease's symptoms and high yield on improved cultivars across all sites indicated that those cultivars are tolerant and can be released for production in maniema region.

KEY WORDS: Diseases pressure, performance, resistance, variety response, variety ranking

1. INTRODUCTION

Cassava is an important crop in Africa where it serves as a famine reserve crop, industrial raw material and livestock feed (Nweke et al., 2002). The crop stores well in the soil, has high starch productivity and performs relatively well in low fertility soils and marginal areas (Hershey, 2010). The diverse uses of cassava largely explain its popularity in the tropics (Hershey, 2010). In Africa most cassava produced is used for food consumption, with 50% in processed form, and 38% in the fresh and/ or boil form; 12% is used for animal feed.

Cassava is a leading source of food and income in the humid forest areas of West and Central Africa. After Nigeria, the Democratic Republic of Congo (DRC) is ranked the second highest producer in Africa and the fifth highest worldwide with almost 15 million tons (FAO, 2013). Annual production is estimated at 2.4 million tons under an estimated acreage of 358,000 ha (FAOSTAT, 2012).

In the DRC in general, especially in Kivu and Maniema regions, cassava is the most important staple food crop because it provides 60% of calories and it is consumed by 70% of the total population (IPAPEL, 2013). Some extra harvest is sold and good price can be obtained especially where farms are located near urban centers. In some territories, farmers grow cassava entirely for sale. The roots and the leaves are both consumed and have almost equal importance in the population diet. It plays a critical role in contributing to food security and nutrition intake enhancement due to high level of iron (Fe), vitamin A and in income generation (Augustin et al., 2016).

However, many pathogens and pests reduce cassava yields, especially in Africa including DR Congo. Diseases such as cassava mosaic disease (CMD), transmitted by a whitefly (*Bemisia tabaci*) vector and spread by infected cuttings, cassava brown streak virus disease (CBSD), Cassava bacterial blight (*Xanthomonas axonopodis* pv. *manihotis*) (CBB), and anthracnose (*Colletotrichum gloeosporoides*) (CA) are among the most important diseases. CMD mostly attacks leaves and CBSD attacks leaves, stems and roots but it has the largest effect on the roots. The two diseases are known to be transmitted by whiteflies, *Bemisia tabaci* (Maruthi et al., 2005). The productivity of cassava is being threatened by cassava brown streak disease (CBSD), now rated as the most important constraint to cassava production in Eastern and Central Africa (Mohammed et al., 2012; Hillocks and Jennings, 2003). Cassava mosaic disease (CMD) is one of the major constraints in cultivation of cassava (*Manihot esculenta* Crantz), an important tropical and subtropical root crop (Fauquet and Fargette, 1990). It is caused by several cassava mosaic geminiviruses and is the most important disease of cassava in Africa and the Indian subcontinent (Legg and Fauquet, 2004).

Pests with a wide African spread are the cassava mealybug (*Phenacoccus manihoti*) (CM), African root and tuber scale (*Stictococcus vayssierei*), cassava green mite (*Mononychellus tanajoa*) (CGM) and nematodes (particularly *Meloidogyne spp*.) (Bellotti et al., 2011).

Damage caused by cassava brown streak and cassava mosaic disease is increasing in Africa and only limited resources are available to control the spread of the diseases and pests. Most of the farmers obtain planting materials from their own field and neighbours and they are not able to institute control strategies that require buying of chemicals. A number of strategies have been employed to counter the problem due to cassava mosaic virus and cassava brown streak virus, which include breeding by making crosses and introduction of botanical seeds from other places and regions. Introduction of materials into a recipient country encourages disease transfer from plant to seed and then from seed to seedling. The only way to stop this spread is by producing disease free planting material. This will ensure that clean seeds and more planting materials are available for propagation and will help in the fight against cassava mosaic disease and cassava brown streak disease.

In this study the main objective was to test for the prevalence of major cassava pests and diseases and subject some of the elite cassava varieties to on-farm farmers' evaluation to test their adaptability and their acceptability in Maniema region through adaptive trials. There is a need therefore, to determine the reaction of introduced and local cultivars against these virus species under Maniema' conditions before they can be used as parental lines in a breeding programme.

2. MATERIALS AND METHODS

2.1 Experimental site and design

Nine adaptive trials were planted in five territories around Maniema town during 2015/2016 rainy season to determine the adaptability of selected clones in the region. The nine experiments were done with IPEDRAL and ACCOPADEM in Basoko axe, SENASEM in Kalima/Nyoka site, Mkono mkononi in Kalima/Alunguli site, CODIK and AFEVOMIKI in Lokando site and Concession Tosenge, AFDC and DOMAKA in Kabondo site. The plot sizes were four by ten meters using a spacing of one meter between rows and one meter between plants in a randomized complete block design (RCBD) with three replicates. Weeding was done manually using hand hoes and no fertilizer and or herbicide was applied.

2.2 Description of cassava germplasm

Five local cultivars namely: Kindewe, Kabondo, Mulamba, Kankwale and Mwezi-sita, with varying levels of sensitivity to diseases and pests were evaluated together with four clones namely: Kindisa, Mu 2009/004, Mu 2009/083 and Mu 2011/195 from National Institute for Agronomic and Research Study (INERA) of Mulungu research centre. The four clones were selected based on their performance on diseases resistance, high vitamin A, yield and yield component as these are also factors influencing adoption by farmers.

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 and root symptoms, CMD, CBB and CGM. 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 symptoms assessment was done 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. Root severity and incidence for CBSD were evaluated at 12 MAP at harvest. Cassava mosaic disease (CMD) severity was scored at 1, 3, 6, 9 and 12 MAP in each plot using a score scale of: 1= No observable symptoms, 2= Leger chlorotic appearance on all the young leaves or little deformation limited on their base, 3= Strong mosaic on the whole of the sheet accompanied later narrow and deformation of the lower third of the leaflets, 4= Mosaic with severe deformation of the lower two thirds of leaflets and general reduction of the sports sector surface, 5= Mosaic with severe deformation of the leaflets on at least four fifth of their surface (Gondwe et al., 2013). Cassava mosaic disease incidence was calculated as the ratio of the number of plant with symptoms to the number of observed plants in each plot (IITA, 1990). Fresh storage roots for sixteen 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:

FSRY (kg/ha) = $\frac{Weight\ of\ roots\ from\ harvested\ area}{Harvested\ area\ (m2)} X100$

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. Treatment means were separated using Least Significant Difference (LSD) and declared to be significant at 95% confidence level (P=0.05).

3. RESULTS

3.1 Reaction to cassava brown streak , cassava mosaic diseases and cassava bacterial blight

There were significant differences (P<0.001) among cultivars and location, diseases and pest such as cassava green mite damages. Cassava brown streak disease foliar symptoms were observed on local cultivars and not on the elite genotypes (Table 1). The mean foliar CBSD severity ranged between 1.0 and 2.5 (Table 1). The highest severity scores were observed in the genotypes, Mulamba followed by Kabombo, Kankwale, Mwezi-sita and Kindewe. Root necrosis severity score varied significantly (P<0.001) among genotypes ranging between 1.0 and 4.0. The highest scores were observed in genotypes, Kabombo and Mulamba followed by Mwezi-site, Kankwale and Kindewe (Table 1). In different locations, stem symptoms were not observed on both local and elite genotypes.

Cassava mosaic disease symptoms were observed in all the local varieties used with a severity score ranging between 2.3 and 3.3 with incidence between 81.3 and 93.8 (Table 1). The highest severity scores were observed on Kabombo followed by Mulamba and Kankwale. The lowest score was on Kindewe cultivar (Table 1).

Cassava bacterial blight was significantly (P<0.001) different among genotypes with severity scores ranging between 1.0 and 2.3 (Table 1), and the incidence was not observed to be high. Only local varieties showed their susceptibility on CBB symptoms. Cassava bacterial blight was highest in Kabombo and lowest in Mwezi-sita (Table 1).

3.2 Reaction to cassava green mite damages

Cassava green mite damage severity scores were observed on both local and elite genotypes with a final score ranging between 1.1 and 2.7. The lowest severity score and low incidences were observed on elite genotypes compared to local cultivars (Table 1).

Table 1: Mean cassava brown streak, cassava mosaic disease, cassava bacterial blight and cassava green mite severity and incidence on evaluated cultivars across sites in Maniema during 2015-2016 seasons

Genotypes	CBSD						CMD		CBB		CGM damage	
	Foliar		Stem		Root							
	Inc.	Sev.	Inc.	Sev.	Inc.	Sev.	Inc.	Sev.	Inc.	Sev.	Inc.	Sev.
Kabombo	37.5	2.0	0.0	1.0	15.0	4.0	81.3	3.3	18.7	2.3	100.0	2.7
Mulamba	25.0	2.5	0.0	1.0	5.0	4.0	93.8	3.1	31.3	2.0	100.0	2.5
Kankwale	43.7	2.0	0.0	1.0	22.5	3.5	93.8	3.0	12.5	1.7	87.5	2.7
Mwezi-sita	37.5	2.0	0.0	1.0	17.5	3.7	87.5	2.7	31.3	1.5	87.5	2.5
Kindewe	25.0	1.8	0.0	1.0	12.5	3.3	93.8	2.3	37.5	1.7	100.0	2.0
Kindisa	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	50.0	1.9
Mu 2009/004	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	50.0	1.5
Mu 2009/083	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	31.2	1.3
Mu 2011/195	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	43.7	1.1
Mean	18.7	1.6	0.0	1.0	8.1	2.5	50.0	2.0	14.6	1.5	72.2	2.0
CV (%)	125.3	41.9	-	0.0	142.0	35.4	133.5	35.6	156.1	24.7	44.8	8.1

CBSD=cassava brown streak disease; CMD=cassava mosaic disease; CBB=cassava bacterial blight; CGM=cassava green mite; Sev=severity; Inc=incidence

3.3 Yield and farmers participation in selection

In term of locations, genotypes varied significantly ($P<0.001$) for weight of marketable roots, average number of rotten roots and yield. The weight of marketable roots ranged between 21.3 kg and 74.1 kg (Table 2). The highest weights were with Mu 2009/004 followed by Kindisa but the lowest was by the local variety Mulamba. The average number of rotten roots ranged between 1.0 and 4.3. Kabombo and Mulamba were found to have the highest average number of rotten roots but the lowest was with Mu 2009/004 and Kindisa. Highest yields were found on Kindisa, Mu 2009/083, Mu 2009/004 and Mu 2011/195, in that order. A low yields were observed on local cultivars ranging between 16.1 t/ha and 18.8 t/ha (Table 2).

According to farmers' ranking of the varieties, Mu 2009/083 was accepted by many farmers for its test for cassava leaves after cooking and its cassava flow (see plate 1d). According to farmers, genotype Kindisa was selected for its ability to give good bread, and the most rejected for the three criteria was Mulamba and Kindewe (Table 2).

Table 2: Mean weight of marketable roots, average number of rotten roots, yield and farmers' ranking of the cassava varieties studied across sites in Maniema during 2015-2016 seasons

Genotypes	Weight of marketable roots	Average number of rotten roots	Yield (t/ha)	Farmers' Ranking of the variety testing		
				Cassava leaves	Cossettes	Cassava bread
Kabombo	25.3	4.3	17.7	5	8	7
Mulamba	21.3	3.9	16.8	8	9	8
Kankwale	23.0	2.0	16.1	6	7	3
Mwezi-sita	26.6	2.0	18.8	7	5	6
Kindewe	23.2	3.0	16.2	9	6	9
Kindisa	70.8	1.7	55.4	3	2	1
Mu 2009/004	74.1	1.0	51.7	2	3	4
Mu 2009/083	57.9	2.0	54.3	1	1	5
Mu 2011/195	42.3	3.0	33.3	4	4	2
Mean	40.5	2.5	33.1			
CV (%)	42.2	9.7	41.9			

CV=coefficient of variation




Plate 1a. Field experimental Trial

Plate 1b. With heads of different organisations before harvest

Plate 1d. Mu2009/004 during harvest time

Plate 1c. During variety testing with famers' groups

4. DISCUSSION

Varied responses to CBSD were recorded among the evaluated cultivars in different experimental sites. The incidence and severity of the disease was specific to materials used. Throughout the experiment, all the elite cultivars exhibited resistance to the disease while local varieties were most affected. This supports the finding of Abeca et al., (2012b) when only five cassava varieties were found tolerant to CBSD. The observation agrees also with Rwegasira and Rey 2012 where severity data suggested that the disease was influenced by the inherent characteristics of individual cultivars. Hillocks et al., (2001) and Jennings (1960)

reported that different cultivars respond differently to CBSD. Symptoms for CBSD were clearly expressed on leaves and roots, but not on stems across all the study sites. The observation agrees that of Rwegasira and Rey (2012) when symptoms were expressed on leaves compared to stems. Similar observations have been reported by Hillocks (1997), Hillocks (2003) and Hillocks and Jennings (2003).
All local varieties showed susceptibility to CMD as observed for CBSD, whereas elite's cultivars showed their resistance to the disease. This is true as these cultivars were bred for CMD and CBSD resistance. Abaca et al., (2014) reported that it's only under rare circumstance that dual symptoms of both CMD and CBSD can be seen clearly. The nature of interaction between CBSD and CMD could be more apparent at molecular level than the observable incidences and severity of the diseases on the affected plants.

Cassava green mite was present on all cassava genotypes at all experimental sites. However, it should be noted here that CGM effects was observed to be greatest during the dry period than the wet period. The observation confirms that of Abaca et al., (2014) when he got the same result. Skovgård et al., (1993) had a similar finding with the cassava green mites in Kenya, when both the root yield and dry matter of cassava was affected by cassava green mites.

Varying yield was observed among local and elite cultivars in different locations. Specifically low yield was observed on local varieties due to their susceptibility to diseases and pests compared to high yield on elite cultivars introduced in the region. This explains why these cultivars declined in yield drastically. Abaca et al., (2014) attributed variation of yield to soil type, varietal differences and management practices employed by the different farmer groups. This might have also due to varietal superiority especially in their ability to utilize resources more efficiently through appropriate partitioning of assimilates (Grange and Hand, 1987). Lower root yield in cassava have been attributed to higher disease prevalence (Bray, 1997), poor soil fertility, especially phosphorus (Howeler, 1980). Farmers' ranking of cassava varieties was not based only on yield but a combination of factors; CBSD root necrosis, CMD resistance, taste and prior knowledge on milling qualities of some varieties, processing techniques required. This is also similar to the finding of Githunguru et al., (2005).

5. CONCLUSION

In conclusion, absence of both foliar and root symptoms of CBSD, CMD and CBB damages on cassava elite cultivars across all sites indicated that those cassava materials are resistant/tolerant to the mentioned diseases and can be released for the livelihood of population in Maniema region.

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