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Impact of African Cassava Mosaic Disease on the Production of Fourteen Cassava Cultivars in Yangambi, Democratic Republic of Congo

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Summary

The effects of cassava mosaic disease (CMD) on growth and yield components were systematically determined on 14 different cassava genotypes in Yangambi. The results show that the tested cultivars differed significantly in terms of severity of the virus, harvest index and tuber production (P< 0.05). CMD had a variable depressive effect on vegetative development. Stem dimensions were hardly reduced, while the height of cultivars Ponjo (38%) and Mboloko (29%) and Ponjo, Lofiongi, Bangi as the leaf area of cultivar Mboloko were significantly lower. The impact of CMD on yield components was generally greater on local cultivars and insignificant on resistant varieties. The cultivars Mvuazi (TMS I 95/0528), Mahungu (TMS 92/297), 96/1089A and Disanka (TMS I 95/0211) were not affected by mosaic disease, which confirms their field immunity. Ponjo, Lofiongi and Mboloko cultivars were sensitive. This study underlines that Mvuazi (TMS I 95/0528, Mahungu (TMS 92/297), 96/1089A, Mvuama (TMS 83/138), Disanka (TMS I 95/0211), Lueki (TMS 91/377) and Zizila (MV 99/0038) and local cultivars, such as Timolo, Yauma, Ngonga and Bangi, showed resistance to CMD.

Résumé

Impact de la mosaïque africaine du manioc sur la production de quatorze cultivars de manioc à Yangambi (République Démocratique du Congo)

Les effets de la mosaïque sur la croissance et la production du manioc ont été systématiquement déterminés sur 14 génotypes différents à Yangambi. Les résultats obtenus montrent que les génotypes étudiés diffèrent significativement entre eux concernant la sévérité de la virose, l'indice de récolte et la production en tubercules (P<0,05). La maladie a eu un effet dépressif variable sur le développement végétatif. Les dimensions des tiges n'ont presque pas été réduites alors que la hauteur des plantes des cultivars Ponjo (38%) et Mboloko (29%) ainsi que la surface foliaire de Ponjo, Lofiongi, Bangi et Mboloko ont été sensiblement déprimées. L'impact sur la production a été globalement plus important sur les cultivars locaux et négligeable sur les variétés résistantes. Les variétés Mvuazi (TMS I 95/0528), Mahungu (TMS 92/297), 96/1089A et Disanka (TMS I 95/0211) n'ont subi aucun effet de la mosaïque, confirmant leur immunité. Les cultivars Ponjo, Lofiongi et Mboloko sont sensibles. Les variétés Mvuazi (TMS I 95/0528), Mahungu (TMS 92/297), 96/1089A, Mvuama (TMS 83/138), Disanka (TMS I 95/0211), Lueki (TMS 91/377), Zizila (MV 99/0038) ainsi que les variétés locales Timolo, Yauma, Ngonga, Bangi ont manifesté une résistance à la mosaïque.

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Introduction

Cassava (*Manihot esculenta* Crantz, Euphorbiaceae), which is native to South America, is a major source of nutrition for over 700 million people in the tropical countries. It is cultivated on approx. 19.1 million hectares, which produce approx. 241 million tonnes, half of which come from Africa (3, 11). In the Democratic Republic of Congo (DRC), both the tubers and the leaves are eaten by population. Leafy vegetables are an important source of proteins, mineral elements and vitamins. Cassava cultivation can be adapted to variable environmental conditions, even during long drought periods (12). However, African cassava mosaic disease (CMD) represents nowadays one of the major biotic constraints affecting cassava cultivation in tropical and subtropical regions (5, 11). This disease is caused by single-stranded circular viruses of the *Begomovirus genus*; *Geminiviridae* family (1, 2). This virus is transmitted to the cassava by the insect vector *Bemisia tabaci Gennadius* (Hemiptera: Aleurodidae) (2, 7). Strategies for controlling the disease include the use of resistant varieties (4, 6, 10, 13). In fact, while the sensitivity of the cassava varieties cultivated in Africa is related to environmental conditions, it depends greatly on their genetic pool (8). That's why, the present study aimed to evaluate the behaviour of 14 cassava cultivars in their natural environment, together with the effects of CMD on their productive performances under the agro-environmental conditions in Yangambi (DRC). The objective of our study was to establish a relationship between CMD infection level, whitefly pressure and tubers production (9), in order to quantify the resulting losses for each cultivar (11). The study focused on the 14 most common cassava cultivars in the Yangambi region (Table 1). In addition to varietal screening for resistance or tolerance to CMD in the DRC, our study enabled us to compile a database of epidemiological indices for African cassava mosaic disease in the DRC. The availability of these epidemiological data on the parasitic pressure caused by CMD and tuber yield is a major asset and facilitates the task of selecting cassava varieties.

Materials and methods

The trial focused on 14 cassava cultivars, seven of which were local, while the remaining seven were IITA accessions (Table 1). Trial was set up in a randomised blocks design using 3 replications. Each of the blocks included 15 cassava plants spaced 1x1 m, with 1.5 m tracks between the blocks. The Mbongo cultivar (*cv.*) highly contaminated by mosaic disease (severity 3) was planted in lines between the blocks as virus inoculation source. The stem diameter, plant height and leaf surface were measured after three months' growth using a sample of 10 plants per block. The growth index was calculated using the ratio between height and stem diameter.

Figure 1: Tuber production in some of the cultivars tested. The 96/1089A cultivar produced the longest tubers, followed by Disanka; whereas cv. Bangi, Ngonga, Mboloko and Mvuama produced slightly shorter and fatter tubers.

The severity, incidence and development of CMD, together with the number of whitefly observed on the first 3 leaves, were weekly evaluated from 1-6 months after planting (MAP).

Table 1

Average values of pathological parameters and PCR amplification results recorded for the 14 cassava cultivars tested. Agro-technical characteristics were observed in the fields and additional information was obtained from the IITA technical bulletins.

Cultivars	Origin	Status	Harvest period (month)	Taste	Plants	Onset of symptoms (MAP)	PCR results (6 MAP)	Severity index	Incidence (%)	Whitefly
Ponjo	INERA	Local	10-déc.	bitter	44	1	AE	3.00^{a}	93.26^{a}	7.66^{a}
Lofiongi	INERA	Local	12	bitter	33	1	AE	3.00^{a}	33.01^{b}	5.66^{b}
Yauma	INERA	Local	10-déc.	bitter	46	2	E	2.00^{b}	6.60^{cd}	7.00^{a}
Timolo	INERA	Local	12	bitter	47	1	E	1.70^{cb}	8.41^{cd}	3.33^{cd}
Ngonga	INERA	Local	12	sweet	41	1	AE	3.00^{a}	94.00^{a}	3.33^{cd}
Bangi	INERA	Local	10-déc.	bitter	48	1	E	2.00^{b}	20.83^{cb}	2.33^{e}
Mboloko	INERA	Local	12	sweet	45	1	AE	3.00^{a}	88.52^{a}	5.00^{b}
Mvuazi (TMS I 95/0528)	IITA	Improved	12	bitter	34	-	-	1.00^{d}	0.00^{d}	3.33^{cd}
Mahungu (TMS 92/297)	IITA	Improved	sept.-15	bitter	37	-	E	1.00^{d}	0.00^{d}	4.33^{c}
96/1089A	IITA	Improved	10-déc.	bitter	42	-	-	1.00^{d}	0.00^{d}	5.33^{b}
Mvuama (TMS 83/138)	IITA	Improved	déc.-24	sweet	34	2	E	1.30^{cd}	2.31^{cd}	3.00^{cd}
Disanka (TMS I 95/0211)	IITA	Improved	oct.-18	bitter	44	-	-	1.00^{d}	0.00^{d}	5.33^{b}
Lueki (TMS 91/377)	IITA	Improved	sept.-15	bitter	34	2	E	2.00^{b}	7.40^{cd}	3.66^{cd}
Zizila (MV 99/0038)	IITA	Improved	sept.-15	bitter	40	2	E	2.00^{b}	6.25^{cd}	5.33^{b}
Average								1.93	25.75	4.62
Standard deviation								0.22	6.40	0.57
Coef. Variation (%)								11.39	24.85	12.49
R^2								0.95	0.97	0.91
P<0.05								***	***	***

MAP: month after planting A: ACMV E: EACMV-UG A+E: ACMV and EACMV-UG (mixed infection)

Table 2

Measured parameters for vegetative growth in cassava, yield components and tuberous roots yields produced by 14 cassava cultivars experienced under the agro-environmental conditions in the Yangambi region.

Cultivars	Total plants	Stem diameter (mm)	Plant height (cm)	Leaf surface (cm2)	Growth index	No tubers/ plant	Tuber length (cm)	Tuber diameter (cm)	Weight of one tuber (g)	Weight tubers/plant (g)	Harverst index	Stem index for tubers	Yield obtained t/ha	Health plant yield (g)	Diseased plant yield (g)	Prod. Loss/ plant (%)
Ponjo	44	10.43^{df}	122.00^{d}	89.64^{cd}	11.66^{b}	5.68^{ba}	18.80^{ed}	3.98^{e}	95.00^{c}	540.00^{e}	0.51^{ba}	4.75^{a}	2.69^{c}	216.67^{b}	114.33^{c}	47.00^{a}
Lofiongi	33	14.87^{de}	195.67^{c}	161.47^{c}	13.33^{b}	2.33^{b}	17.17^{e}	5.57^{dce}	233.33^{bc}	516.70^{e}	0.30^{c}	3.08^{bc}	3.30^{c}	250.00^{b}	165.00^{c}	37.33^{ba}
Yauma	46	19.36^{d}	165.00^{d}	204.48^{b}	8.33^{c}	6.00^{ba}	25.33^{bdc}	9.76^{a}	821.53^{a}	4168.70^{bc}	0.66^{a}	2.60^{c}	27.58^{ba}	4162.00^{a}	2805^{bac}	31.33^{ba}
Timolo	47	22.00^{c}	273.33^{b}	252.58^{b}	12.66^{b}	11.00^{a}	24.37^{bdc}	5.64^{dce}	325.48^{bac}	3333.00^{d}	0.58^{ba}	4.41^{ba}	25.28^{ba}	3066.33^{ba}	2433.33^{bc}	19.00^{bc}
Ngonga	41	24.30^{c}	361.33^{a}	143.28^{c}	14.66^{a}	11.00^{a}	22.53^{bdc}	6.37^{dc}	339.43^{bac}	3727.30^{d}	0.50^{ba}	3.58^{ba}	27.32^{ba}	3727.33^{ba}	3232.67^{bac}	13.67^{bc}
Bangi	48	23.60^{c}	276.00^{b}	192.15^{b}	12.00^{b}	6.33^{ba}	26.40^{bc}	5.50^{de}	555.01^{bac}	3089.70^{d}	0.47^{bac}	4.79^{a}	19.16^{ba}	2911.00^{ba}	1996.67^{bc}	33.00^{ba}
Mboloko	45	24.30^{c}	220.66^{c}	220.04^{b}	9.00^{cd}	6.67^{ba}	26.20^{bc}	6.06^{dc}	765.15^{bac}	5018.70^{ba}	0.57^{ba}	4.35^{ba}	28.00^{ba}	3708.67^{ba}	1969.67^{bc}	46.33^{a}
Mvuazi (TMS I 95/0528)	34	24.73^{c}	272.66^{b}	98.38^{cd}	11.00^{b}	8.33^{ba}	18.23^{ed}	5.15^{de}	524.08^{bac}	4270.00^{bc}	0.48^{bac}	3.53^{ba}	30.65^{ba}	4238.67^{a}	4238.67^{ba}	0.00^{c}
Mahungu (TMS 92/297)	37	23.67^{c}	195.00^{c}	197.67^{b}	8.33^{c}	8.33^{ba}	28.83^{bac}	7.44^{bc}	596.25^{bac}	4953.30^{ba}	0.66^{a}	3.91^{ba}	33.55^{a}	4603.33^{a}	4603.33^{ba}	0.00^{c}
96/1089A	42	24.47^{c}	201.67^{c}	164.73^{c}	7 .66^{c}	10.67^{a}	34.90^{a}	9.43^{a}	620.54^{ba}	6544.30^{a}	0.59^{ba}	3.69^{ba}	27.59^{ba}	5711.00^{a}	5711^{a}	0.00^{c}
Mvuama (TMS 83/138)	34	30.13^{b}	248.33^{c}	156.09^{c}	8.33^{c}	7.67^{ba}	23.33^{bdc}	9.93^{a}	614.17b^{ac}	4548.30^{bc}	0.44^{bc}	2.36^{c}	26.91^{ba}	3961.67^{a}	2896.67^{bac}	26.43^{ba}
Disanka(TMS I 95/0211)	44	25,03^{c}	205,00^{c}	118,83^{c}	8,00^{c}	7,67^{ba}	25,13^{bdc}	8,85b^{a}	364,58^{bac}	2683,30^{de}	0,52^{ba}	2,84^{bc}	16,20^{bc}	2343,33^{ba}	2343,33^{bc}	0.00^{c}
Lueki (TMS91/377)	34	32.93^{a}	325,66^{b}	276,71^{a}	10.00c^{d}	8,33^{ba}	28,20^{bac}	10,22^{a}	663,33^{ba}	5416,70^{ba}	0,50^{ba}	2,76^{c}	33,50^{a}	5091,67^{a}	4266,67^{ba}	18,33^{bc}
Zizila (MV 99/0038)	40	29.53^{b}	309,66^{b}	179,72^{b}	10,33c^{d}	7,00^{ba}	30,37^{ba}	10,33^{a}	773,60^{a}	4688,70^{bdc}	0,45^{bc}	2,94^{bc}	28,52^{ba}	3455,33^{ba}	3055,33^{bac}	16,00^{bc}
Moyenne		23.74	240,85	175,41	10,38	7,64	24,98	7,44	520,82	3821,33	0,51	3,54	23,59	3389,07	2845,12	20,6
Standard deviation		0.95	22,37	29,26	0,96	2,16	2,43	0,67	175,51	561,31	0,06	0,52	5,19	1203,64	1054,17	8,58
CV (%)		4.02	9,29	16,68	9,28	28,26	9,75	8,55	33,7	14,69	12,77	14,83	22,02	35,51	37,05	41,67
R^2		0.98	0,92	0,82	0,88	0,61	0,84	0,94	0,68	0,92	0,73	0,76	0,83	0,7	0,75	0,84
P<0.05		***	***	***	***	NS	***	***	NS	***	***	***	***	***	***	***

NS : Non-significant *** : Very significant

Table 3
Impact of CMD on the vegetative development and on the components of tubers production.

Cultivars	Total plants	Stem diameter (%)	Plant height (%)	Leaf surface (%)	Number of tubers (%)	Tuber length (%)	Tuber diameter (%)	Tuber weight (%)	Tuber weight/ roots (%)	Total biomass (%)	Prod/ plant (%)
Ponjo	44	2.97	37.70	40.51	17	17.02	24.37	13.05	27.54	28.56	47
Lofiongi	33	0.47	13.28	46.32	0	21.37	10.77	15.74	15.74	17.77	34
Yauma	46	0.83	5.25	23.53	0	6.59	10.25	16.13	16.13	19.71	33
Timolo	47	0.00	13.17	23.50	9	8.37	13.12	30.72	37.02	25.17	21
Ngonga	41	0.00	17.34	39.51	18	11.23	21.51	21.04	35.40	24.93	13
Bangi	48	0.00	10.14	51.02	0	6.82	9.09	29.91	29.91	20.83	31
Mboloko	45	0.41	29.00	42.59	0	9.92	4.29	19.62	19.62	20.52	47
Mvuazi (TMS I 95/0528)	34	0.00	0.00	0.00	0	0.00	0.00	0.00	0.00	0.00	0
Mahungu (TMS 92/297)	37	0.00	0.00	0.00	0	0.00	0.00	0.00	0.00	0.00	0
96/1089A	42	0.00	0.00	0.00	0	0.00	0.00	0.00	0.00	0.00	0
Mvuama (TMS 83/138)	34	0,43	7.18	28.04	11	5.19	8.16	8.11	18.32	13.02	27
Disanka (TMS I95/0211)	44	0.00	0.00	0.00	0	0.00	0.00	0.00	0.00	0.00	0
Lueki (TMS 91/377)	34	0.09	7.06	22.78	0	3.69	9.80	15.08	15.08	9.48	16
Zizila (MV 99/0038)	40	1.52	3.09	26.55	0	5.50	12.88	11.63	11.63	8.73	12
Total		6.72	143.21	344.35	55	95.70	124.23	181.04	226.40	188.70	281
Average		0.48	10.23	24.59	3.93	6.84	8.87	12.93	16.17	13.48	20.07

The depressive effects of CMD were evaluated by comparing measurements for healthy manioc plants and diseased plants affected by mosaic disease. The losses caused by mosaic disease within the various parameters measured are expressed in %.

Diagnosis by PCR amplification was conducted 6 MAP in order to determine the nature of the virus in the cassava genotypes tested. The specific primers used were those developed by Zhou *et al*. (15). PCR amplification was conducted according to the cycle described by Deng et al. and Were *et al.* (2, 14).

The severity of the disease was evaluated using the IITA rating scale, which ranges from 1-5, in which 1= No symptoms visible on the leaves and 5= Severe mosaic disease. Incidence of the CMD was determined using the following ratio:

$$Incidence\,(x\,100) = \frac{Number\ of\ diseased\ cultivar\ x\,100}{Total\ number\ of\ cultivar\ plants\ under\ consideration}$$

Parasitic pressure in the environment was evaluated according to the number of whitefly on the first three cassava leaves.

The parameters in relation to the relevant yield components were the number and the weight of tubers for each cassava plant, tuber length and diameter, number of tubers produced by each plot and the harvest index. The harvest index was calculated using the following formula:

$$Harvest\ index = \frac{Total\ tuber\ weight\ per\ plant}{Total\ biomass\ weight\ per\ plant}$$

The effect of CMD was evaluated using the following formula:

$$Loss\,(x100) = \frac{Healthy\ cassava\ yield - Virus\ infected\ cassava\ yield\ x\,100}{Healthy\ cassava\ yield}$$

The averages were compared after ANOVA, using SAS Enterprise Guide®4. The DUCAN's test was used to determine the significance of differences observed between the averages.

Results and discussion

Pathological parameters

The severity and incidence of CMD, together with the number of whitefly, varied depending on the individual cassava cultivar (Table 1). Symptoms of mosaic disease appeared early on the local cultivars at 1 MAP compared to 'resistant' cultivars, on which the disease could be observed in the 2nd month after planting (MAP).

It was noted that the cultivars Mahungu (TMS 92/297), 96/1089A, Disanka (TMS I 95/0211) and Mvuazi (TMS I 95/0528) apparently presented no signs of the CMD during their growth cycle. This field immunity was confirmed by the viral diagnostic using PCR amplification (Table 1). The cultivars Bangi, Timolo, Mvuama (TMS 83/138), Lueki (TMS91/377), Zizila (MV99/0038) and Yahuma were characterised by a slight infection (severity level 2) while the cultivars Ponjo, Lofiongi, Mboloko and Ngonga were moderately contaminated by the virus (severity level 3). These results demonstrate that the tendency to present symptoms is linked to the individual nature of each cultivar (8) and the

symptoms were generally moderate. Incidence of CMD was higher on the local cultivars, ranging from 6.6%-94%, with a symptom severity of 2-3; compared to improved cultivars from IITA, which presented a very low incidence (0-7.4%), combined with a very low severity level of 1-2. We noted, however, low incidence of the CMD on Lueki (TMS 91/377) of 7.4%, followed by 6.25% for Zizila (MV 99/0038) and 2.31% for Mvuama (TMS 83/138). The abundance of whiteflies on the first three leaf positions ranged from 3-8, depending on the variety (4.42±0.57). The preference shown by whiteflies for some cultivars as a food source (R^2=0.91) has been observed in other studies (1, 7). In fact, the degree of attractiveness of cultivars to whitefly varies according to their morphological characteristics, such as leaf colour, pilosity or no pilosity, cyanide content and plant size (1, 13). The cassava cultivars tested differed very significantly (P<0.05) in terms of whitefly abundance. This indicates that, in the Yangambi environment, the pressure created by whitefly on the cassava varies according to the cassava genotype. This low pressure from whitefly could affect the overall severity and incidence of CMD recorded for the cassava cultivars tested.

Three cultivars of cassava [Mvuazi (TMS I 95/0528), 96/1089A, Disanka (TMS I 95/0211)] were found to be virus-free at 6 MAP. All the resistant cultivars, as well as Bangi, Timolo and Yauma, were found to be EACMV-UG-positive, while most local cultivars presented mixed infections with ACMV and EACMV-UG. Our results show that the cultivars Mvuazi (TMS I 95/0528), Mahungu (TMS 92/297), 96/1089A and Disanka (TMS I 95/0211) did not suffer of any CMD depressive impact to their production. Otherwise, the cultivars Ponjo, Mboloko, Lofiongi, and Ngonga were moderately attacked by CMD severity of level 3, while the cultivars Yahuma, Bangi, Timolo, Mvuama (TMS83/138), Zizila (MV99/0038) and Lueki (TMS91/377) suffered less of CMD (severity index 2).

Vegetative growth and yield components

a. Vegetative development

Overall, the local varieties presented a higher average growth index 10.38 compared to accessions from IITA, which showed a relatively low growth index (on average 9). The local cassava cultivars had small stems, were globally short height and had wider leaves. However, the varieties from IITA were far more vigorous.

In general, the tubers yield and the yield components varied according to the cultivar, within a range of 2.69 - 33.55 t/ha (Table 2). The difference in genetic potential and the sensitivity degree to mosaic disease between the genotypes tested would explain this general tendency.

b. Number of tuberous roots per plant

On average, the genotypes 96/1089A, Timolo and Ngonga (Figure 1) produced the most tuberous roots (11 tuberous roots/plant) compared to the Lofiongi cultivar (2.33 tuberous roots/plant).

However, the differences observed between the number of tuberous roots were not significant at P< 0.05. The significance of the differences observed between the cultivars, using the DUCAN test (Table 2) shows that the cultivars Timolo, Ngonga and 96/1089A perform better in terms of number of tubers. This superior category is followed by an intermediate group, which consists of Ponjo, Yauma, Bangi, Mboloko, Mahungu, Mvuama, Mvuazi, Disanka, Lueki and Zizila cultivars. The least productive cultivar was Lofiongi.

c. Length and diameter of tuberous roots

The average length of the tuberous roots (17.17-34.9 cm) differed significantly depending on the cultivar (P<0.05). The cultivars tested were completely different (P<0.05). The *cv.* Lofiongi produced the shortest tuberous roots (17.17 cm), while cv. 96/1089A produced the longest tuberous roots (34.90 cm).

When the average size of tuberous roots is compared, a significant variability can be observed between the cassava cultivars (P<0.05). The conformation index for the tuberous roots produced by each cultivar reflects the same tendency between the cultivars studied. It can be seen from Table 2 that the cassava cultivars tested can be grouped into four categories, according to the conformation index for their tubers.

d. Production of tuberous roots

The tuberous root produced by the cultivar Yauma was heavier (821.53 g) than that of Ponjo (95.00 g), which can be considered as non-marketable, based on the minimum threshold of 100g suggested by (10).

In terms of production per plant, it can be seen that one plant of the 96/1089A cultivar was highly productive in terms of tuberous roots (6544.3 g), compared to a Ponjo plant (540 g). The differences in weight obtained from different cultivars are statistically significant at P<0.05.

e. The harvest index

The harvest index varied according to the cultivar and appeared higher for the least productive cultivars (Ponjo and Lofiongi). The Lofiongi cultivar produced a low harvest index (0.30) compared to the Yauma and Mahungu (0.66) cultivar. This suggests that the Ponjo and Lofiongi cultivars produce more stems than tuberous roots under the agro-environmental conditions of Yangambi.

f. Tuberous root yield

The yields obtained from IITA accessions, which were introduced in the Yangambi region, are generally greater than those recorded for local varieties. These results demonstrate that the yields recorded during this trial were influenced by the average number of tubers per plant, as well as tuberous root length and diameter. No clear relationship could be established between the harvest index and tuberous root yield, although the general tendency shows that the least productive cultivars produced a low harvest index.

Impact of CMD on growth and production

The disease hardly affected stem dimensions for cassava (Table 3). It has a profound effect on plant height and significantly reduces the leaf surface for local varieties. Accessions from IITA that were attacked by CMD became slightly smaller in size, while the presence of symptoms on the leaves reduced their surface by approx. 25%.

The negative impact of CMD was greater on local cultivars and caused a reduction in plant height of approx. 5-38%. The disease had the greatest impact on the height of cv. Ponjo and Mboloko, which it reduced respectively by 38% and 29%,. The leaf surface of all local cultivars infected by CMD was reduced significantly by 23-51%. components for local cassava cultivars than on improved cultivars from IITA (Table 3). The highest product losses (approx. 47%) were recorded for the Ponjo and Mboloko cultivars, which reflects their sensitivity to mosaic disease. CMD had no negative impact on production for some resistant varieties, such as Mvuazi, Mahungu, 96/1089A and Disanka (TMS I 95/0211). Its impact was, however, moderate on Zizila (12%), Lueki (16%) CMD had a greater negative impact on yield and Mvuama (27%). It should be noted that the various varieties tested differed significantly in terms of severity of the virus, harvest index and tuber production per plant ($P<0.05$).

Conclusion

Our results show that improved cultivars are generally more resistant and productive than local cultivars. However, despite the effect of CMD on local cultivars, some of them, such as Yauma, Timolo, Ngonga and Mboloko, produce similar yields to resistant cultivars from IITA, such as Mvuazi (TMS I 95/0528), 96/1089A, Mvuama (TMS 83/138) and Zizila (MV 99/0038). Even if these preliminary results still need to be confirmed by multi-location trials, our evaluation of 14 cassava cultivars for resistance to CMD in Yangambi in the DRC made it possible to identify high yield cultivars. The latter also present resistance levels to CMD, which could be used in future strategies for controlling this disease.

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G. Monde: organisation of field trials;

P. Bolonge: agromorphological description of local varieties of cassava and preparations for the trial in the CAPSA;

F. Bolamba: agromorphological description of improved varieties;

S. Winter: contributed the 98/1089A used as a negative control and support with ELISA during this study;

J. Walangululu & C. Bragard: study supervisors and critical reading.

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