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Evaluation of cassava hybrids performance obtained by controlled pollination of elite accessions from Niari landscape in the Republic of Congo

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Cassava is the main crop in the Congo but its low yield doesn't meet the needs of Congolese populations. The low yield is due to the use of less effective sensitive varieties to diseases, non-mastering of techniques and biotic constraint of which the African cassava mosaic. This study aims at selecting resistant genotypes to the African cassava mosaic and assessing their agronomic and production performances. Six elite accessions selected based on a villager participative approach have been crossed by controlled pollination with three clones (192/0401, 192/0325 and 197/0162) distributed by the International Institute for Tropical Agriculture (IITA). Growth, agronomic and production parameters of genotypes from the controlled pollination were evaluated at the station. Of the ten tested genotypes, the one resulting from the crossing (Mahabama x I92/0401) did not show any symptom of the cassava mosaic disease 12 months after planting. Apart from the root length, foliar surface and the height of the plant, this genotype differed from the others only by the biomass, the diameter of the stem, the harvest index, the rate of starch, the rate of dry matter and marketable or non-marketable tuberous roots. The genotype (Mahabama x I92/0401) will be included in the cassava improvement section plan in the Republic of Congo.

Key words: Cassava, Congo, African.

INTRODUCTION

Manihot esculenta is grown in the tropical and subtropical regions for its roots and leaves. These plants are a major part of the daily diet of many African populations. Cassava is the main crop in the Congo but its low yield doesn't meet the needs of Congolese populations. The cassava roots, consumed either directly in the form of "green cassava" or in the flour form, are rich in starch. They are thus a least expensive source of calories for human nutrition and animal food (Cock, 1985; FAO, 2013a; Tonukari, 2004).

Indeed, the fresh cassava roots contain between 25 to 45% of dry matter component containing 85% of starch. Cassava leaves are used as vegetables. They provide protein, vitamins and minerals to populations in East and Central Africa (Lutaladio and Ezumah, 1981; IITA, 1990; IITA, 1992; Jalloh and Dahniga, 1994). Thus, for producing countries, cassava is considered as a traditional crop for food security with its capacity to be kept in the soil, to be harvested according to the needs (DeVries and Toenniessen, 2001). For those countries, consumption needs have increasingly gone up causing an increase in prices for this commodity.

However, in Africa, the increase in cassava production is mainly related to the rise in cultivated areas (Hillocks and Thresh, 2000; Chikoti, 2011). This reflects the low yield per hectare of cassava varieties used. This poor performance cassava is also due to use of inappropriate technical by producers, the use of less efficient varieties and the fungal impact, cassava bacterial blight and viral diseases including the cassava mosaic disease (Daniel et al., 1978; Mabanza, 1980a, b; Makambila and Bakaka-Koumouno, 1982; Daniel and Boher,1985; Daniel et al., 1985; Guthrie, 1987; Fargette et al., 1985; Makambila, 1994; Gibson et al., 1996; CIAT, 1996; Thresh et al.,1997; Fokunang et al., 2000; Ntawurunga et al., 2002; Hillocks and Wydra, 2002; Neuenschwander et al., 2002).

Cassava is grown in most parts of the Republic of Congo, where 95.700 ha are under cultivation with a total production of 861.500 t (Ntawuruhunga et al., 2007). This crop mobilizes more than 70% of the rural population, mostly women, and informal activities around cassava are an important source of income for many households (MFA, 2014, FAO, 2003).

In the Congo, cassava mosaic disease is the major issue for cassava cultivation. The cassava mosaic disease is the major issue for cassava cultivation causing losses of up to 95% (Guthrie, 1987; Legg et al., 2006; Legg et al., 2005; Geddes, 1990; Mabanza et al., 1993; Thresh et al., 1994a, b; Thresh et al., 1997; Ntawuruhunga et al., 2007; Agnassim et al., 2007; Ntawuruhunga et al., 2002; Owor et al., 2004; Zinga et al., 2008; Szyniszewka et al., 2017).

An increase of the incidence of this disease causes chronic shortages of this food crop considered as a staple food for more than 90% of Congolese, in terms of crop valuation, consumption level and value chain (MAE, 2014). To overcome this cassava mosaic disease, surveillance and uprooting of infested plants was recommended as well as control of the whitefly *Bemisia tabaci* (Quiot et al., 1982; Fargette, 1987; Guthrie, 1987; Mabanza 1992). These measures have not been able to stem the disease.

In addition, the introduction of varieties selected for their resistance to the disease has been considered (Hahn et al., 1980) but the difficulty of satisfying local preferences with regard to taste, texture and agronomic traits of resistant varieties as well as their poor distribution to small farmers did not slow down their spread on local accessions (Guthrie, 1987).

Furthermore, it noted the differences between the proposed technologies and the producer's expectations. To date, integrated pest management has become a priority, including cassava breeding and the improvement of local germplasm by vitro culture to control cassava mosaic disease (Mabanza, 2006). Varietal improvement includes the development of a range of elite accessions resistant to cassava mosaic disease and cassava bacterial disease combined with high yields, stable with other agronomic qualities and traits acceptable to consumers.

F1 hybrid progeny derived from this controlled pollination were evaluated at station for their impact on cassava mosaic disease resistance as well as their growth, agronomic and yield components. The purpose of the studies was selecting resistant genotypes to the African cassava mosaic and assessing their agronomic and production performances.

MATERIAL AND METHODS

Plant material

Plant material consisted of F1 progeny obtained by controlled pollination between six elite accessions (local ecotypes) and three clones (192/0401, 192/0325 and 197/0162) distributed by International Institute for Tropical Agriculture (IIAT). These clones are cassava mosaic disease resistant, highly adaptable and highly productive (high yield). Ten crossings were made: Mauritanian x 192/0401, Mauritanian x 192/0325, Mauritanian x 197/0162, Mahabama x 192/0401, 192/0401 x Kinkeni, Manaboulenga x 192/0401, 192/0401 x Dimbouana, 192/0401 x Soleil, 192/0401 x Mauritanian and Manabulenga x 192/0325.

The IITA parental clones, native to Nigeria, were selected for their high yield potential and cassava mosaic disease resistance. Elite accessions were identified by peasant participation approach and identified according to characteristics distinguishing in positive and negative traits mentioned in Table 1. Out of 470 accessions collected in 56 surveyed localities in Bouenza, Niari and Lékoumou departments forming the Niari landscape, a hierarchy has been established according to solicitation. The accessions of Mauritanian, Mahabama, Kinkéni, Manaboulenga, Dimbouana and Soleil have had a high frequency of use, and have been described as "elite". Prior to pollination, these parental elite accessions were

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Table 1. Best accessions retained as parents of the genotypes assessed at station.

Parents	Positive trait	Negative trait to improve
I 92/ 0401*	High yield, numerous tuber, friable and sweet, CMD resistant	Small tuber size
Mauritanien	High yield, big tuber	Bitter, CMD sensitive
I 92/0325*	High yield, friable and sweet	post-maturity longevity weak CMD tolerance
Soleil	High yield, elasticity, heavy and good conservation paste	CMD sensitive
197/0162	CMD resistant	post-maturity longevity weak
Kinkéni	High yield, numerous and big tuber, friable, no fibre, good foliage quality, rot resistant, good cassava stick	Moist cassava flour, CMD sensitive
Manaboulenga	Precocity, sweet and friable, high yield, multi-users	CMD sensitive
Dimbouane	Precocity, post-maturity longevity, high yield, no fibre, white pulp, big tuber, resist an insect attack	CMD and rot sensitive
Mahabama	Big tuber, harvest distributed, high yield	CMD sensitive

*****Clone IITA CMD: Cassava mosaic disease.

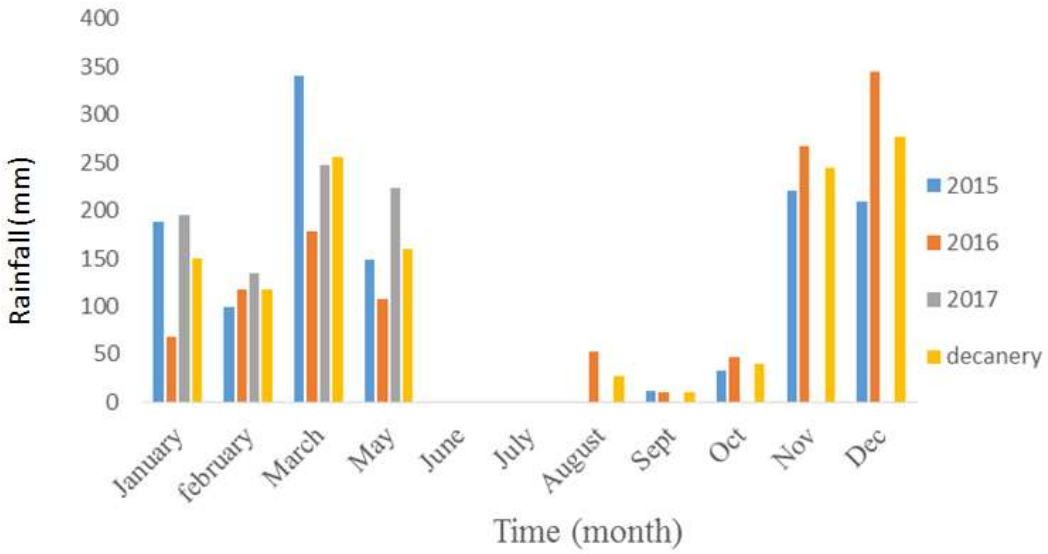

Figure 1. Distribution of the rainfall at Loudima in 2015-2016-2017.

cultivated at the Loudima Agronomy Research Station.

Description of study area

The trial was conducted in experimental plot at Loudima Research Station of the National Institute for Agricultural Research (IRA). Loudima station (13°04'21.3" and 4° 09'6.35") is located about 30 km north-east of the Nkayi town, in department of Bouenza. During 2 years of experimentation, an average monthly temperature (27.9°C) and relative humidity (90.9%) were recorded. Rainfall data were collected in experimental plot referred to as a seed nursery. Rainfall variations were recorded during 2 years of experimentation (Figure 1). Weekly total rainfall was used and expressed as sum of monthly precipitation.

Experimental layout, data collection and data analysis

The Cassava F1 progeny obtained by controlled pollination between elite accessions and IITA clones were evaluated. Seeds resulting from this pollination were germinated in screen houses. Vigorous cassava seedlings at a 4-leaf stage were transferred to seed nursery where they were planted by blocks representing a cross.

In cross block, the seedlings were transplanted in line at a space of 1 m between the lines, and in line 50 cm between the plants. After transplanting, insecticide application was carried out in

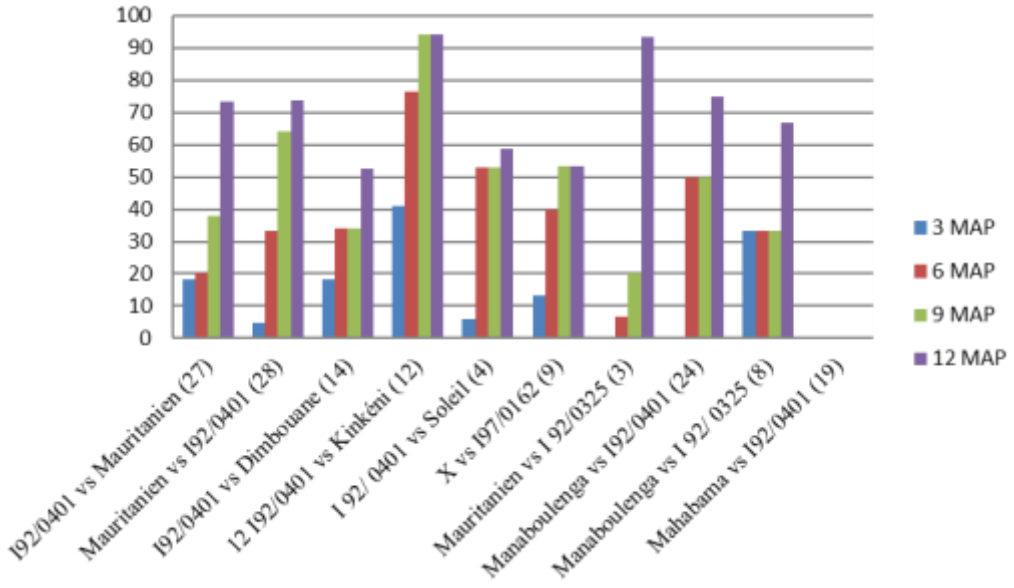

Figure 2. Evolution of cassava mosaic disease genotype at 3, 6, 9 and 12 months after planting of seedlings.

anticipation of cricket attacks. The insecticide (decis) slurry was applied at a rate of 25ml/15 L (in water). This application was repeated every fifteen day during two and half months making a total of five treatments in total. The seed nursery was maintained by weeding on demand until the end of the cycle.

In cross blocks, individuals ranged from 1 to 88 depending on seedlings number that reached 12 months after planting and were free of cassava mosaic. F1 progeny was eliminated when cassava mosaic disease symptoms appeared. The incidence of cassava mosaic was determined by counting the individuals having cassava mosaic disease symptoms out of the total of F1 progeny observed. From 12 months after planting, weekly observations were made individually for a given cross. Variables value of a given cross corresponds to the average of the individuals composing the cross. Every individual in the cross has been constituted as a repetition. These observations focused on the agronomic variables, yield components and biochemical components of cassava roots. For agronomic variables, measurements were made on leaf surface, biomass area and total biomass. To determinate the leaf surface (SF) according to Connor and Cock (1981): SF (cm^2) = 0.0067 $L^{2.042}$, with L (mm) representing the length of the central lobe of the leaf, the length of the central lobe of the fourth bloomed leaf of individual was measured using a graduated ruler. Aerial biomass was obtained by weighing stems and leaves using a scale type hanging scale. Three yield components have been estimated to evaluate the productive potential of a given genotype from different crosses. These were: harvest index, underground biomass, weight of tubers, root mass and number of tubers. The number of tubers per hybrid was counted and their weight obtained by weighing the tuber using the Hanging scale.

In addition, the roots have been calibrated. Gauging consisted of classifying the cassava roots into fleshy or not according to the volume or diameter. The fleshiest roots were said to be "marketable" and the less fleshy were called "residual roots" and therefore no marketable tubers. After harvest, the starch and dry matter content of the tubers was determined by genotype. Thus, 200 grams of tubers were taken per plant, minced and then ground using a Victoria type mill. The ground material obtained was dilacerated in 1.5 liters of water. The resulting mixture was filtered using a sieve with 500 µm mesh. The filtrate was distributed and decanted in 1.6 liter pots. After 10 hours of decantation, the supernatant was removed and the pellet constitutes the starch (starch). On a cemented drying platform, the pellet was dried in pots and the chip on plastic lids.

XLSTAT software version 7.5.3 and SPSS 10.0 were used for all statistical analyzes. For all variables measured, variance analyzes (ANOVA) included leaf area, aerial biomass, total biomass, harvest index, uunderground biomass, tuberous root weight (PRT), number of tuberous roots (NRT), root mass (MRT) and number of tuber roots. The normality of the residuals and the homogeneity of the variances have been verified. To normalize the distribution and equalize the variances, the starch and dry matter variables underwent an arcsine transformation. The comparisons between the means were made according to the Student Newman test and Keuls at the 5% threshold.

RESULTS

Cassava mosaic disease prevalence of genotypes obtained from controlled pollination

Cassava mosaic disease (CMD) incidence on station-assessed genotypes was illustrated in Figure 2. The results revealed that no cassava mosaic disease symptoms were observed in crossing (Mauritanian x I92/0325) and (Manaboulenga x I92/0401) 3 months after planting (MAP). At 3 months after planting, for CMD genotype, the least incidence was recorded in crossing (Mauritanian x I92/0401) and (I92/0401 x Soleil). At 6

Table 2. Average growth characteristics for genotypes from controlled crossing 12 months after seedlings planting in station.

Family	Crossing	Stem height (m)	Stem diameter (cm)	Branching type	Number of branching	Branching level (cm)	Gourmands
F28	Mauritanien xI92/0401	2.37^{a}	2.17^{a}	2.27^{bc}	1.64^{a}	0.43^{a}	1.00^{b}
F3	Mauritanien x I92/0325	2.50^{ab}	3.20^{a}	3.00^{c}	2.00^{a}	0.41^{a}	0.00^{a}
F19	Mahabama x I92/0401	2.54^{ab}	3.90^{a}	3.00^{c}	2.00^{a}	0.63^{a}	1.00^{b}
F12	I92/0401 x Kinkéni	2.78^{ab}	3.60^{a}	3.00^{c}	3.00^{a}	0.39^{a}	1.00^{b}
F24	Manaboulenga x I92/0401	2.91^{ab}	2.40^{a}	0.00^{a}	0.00^{a}	0.00^{a}	1.00^{b}
F14	I92/0401 x Dimbouana	3.14^{ab}	3.68^{a}	2.56^{c}	2.44^{a}	0.75^{a}	0.94^{b}
F9	Mauritanien x I97/0162	3.20^{ab}	3.49^{a}	1.57^{ab}	1.43^{a}	0.47^{a}	1.00^{b}
F4	I92/0401 x Soleil	3.24^{ab}	3.43^{a}	2.86^{c}	2.43^{a}	0.63^{a}	0.86^{b}
F27	I92/0401 x Mauritanien	3.32^{b}	3.50^{a}	2.47^{c}	2.41^{a}	0.81^{a}	0.78^{b}
F8	Manaboulenga x I92/0325	3.39^{b}	6.10^{a}	2.00^{abc}	2.00^{a}	1.13^{a}	1.00^{b}

Significat with a confidence level of 95% for the Newman-Keuls test. Values with the same index do not show a significant difference at 5% threshold. Stem heights are expressed in meters (m) and stem diameters in centimeters (cm). Branching level is the stem height where there was the first branching expressed in centimeter (cm) of which 0 no branching. Goumands is a notation whose score 0 absent and 1 presence of greedy. Branching type is a notation of which 0 absence of branching and for the presence (there are branches 1 or 2 or 3 or 4).

MAP, the CMD symptoms were observed on genotypes from 9 crossing tested. The lowest incidence (5%) was recorded in genotypes from the crossing (Mauritanian x I92/0325) while the highest incidence (58%) of CMD was observed in crossing (I92/0401 x Kinkéni) for the same period. The highest incidence (95%) was obtained at 9 and 12 MAP for genotypes from crossing (I92/0401 x Kinkeni). This same rate was found in crossing (Mauritanian x I92/0325) at 12 MAP. In addition, no cassava mosaic disease symptoms were observed from crossing (Mahabama x I92/0401). On the other hand, high cassava mosaic disease incidence was noted in crossing (I92/0401x Kinkéni) (Figure 2).

Vegetative growth components of genotypes obtained from controlled pollination at 12 months after planting

Growth components of the genotypes resulting from controlled pollination were measured at station. The results reveal that stem diameter, branching type and number of branching did not discriminate the cassava genotypes tested. No significant effect on mean stem diameter, number of branching and branching level of the genotypes was observed (Table 2).

For plant height, the genotypes from crossing (I92/0401 x Mauritanian and Manaboulenga x I92/0325) showed higher shoot height. Average plant height were 3.32 m (I92/0401 x Mauritanian) and 3.39 m (Manaboulenga x I92/0325) respectively. Mean plant height of 2.37 m recorded in genotypes from crossing (Manaboulenga x I92/0325) was lower than that from other crossing tested (Table 2). For crossing tested, the variability of branching type was observed at station. Branching type notes ranged from 0 in crossing (Manaboulenga x I92/0401) to 3 in crossing (Mauritanian x I92/0325), (I92/0401 x Soleil), (I92/0401 x Kinkeni), (I92/0401 x Dimbouane), (Mahabama x I92/0401), (I92/0401 x Mauritanian).

Genotypes from crossing (Manaboulenga x I92/0401) a branch grade score of zero (0) had an erect habit. Genotypes in crossing (Mauritanian x I92/0325), (I92/0401 x Soleil), (I92/0401 x Kinkeni), (I92/0401 x Dimbouane), (Mahabama x I92/0401) and (I92/0401 x Mauritanian) having the note 3, have a trichotomous branch. Dychotomic branches were observed on genotypes in crossing (I92/0401 x Soleil), (Manaboulenga x I92/0325), (Mauritanian x I97/0162), (I92/0401 x Mauritanian) and (Mauritanian x I92/0401) (Table 2).

For plant height and branching type, the variance analyses reveal a significant "crossing" effect at 5% threshold according to the Student Newman and Keuls test, and showed the existence of 3 homogeneous groups crossing (a, ab and b) and 5 crossing groups (a, ab, abc, bc and c) respectively. For the plant height, most pronounced effect was obtained with genotypes from crossing (I92/0401 x Mauritanian and Manaboulenga x I92/0325) (group b). For the presence of gourmands, except the genotypes from crossing (Mauritanian x I92/0325), all individuals of the tested crossing had gourmands. Statistical analyzes for the presence of gourmands reveal a significant difference at 5% threshold between the crossing tested (Table 2).

Agronomic components of genotypes obtained from controlled pollination 12 months after planting

A 12 MAP, leaf surface, harvest index and total biomass of the genotypes from different crossing were evaluated

Table 3. Average agronomic characteristics of genotypes from controlled crossing 12 months after seedlings planting in station.

Family	Crossing	SF (cm^2)	Aerial biomass (kg)	Underground biomass (kg)	Total biomass (kg)	Harvest index
F28	Mauritanien x I92/0401	102.77[a]	2.07[a]	1.48[a]	3.51[a]	0.41[a]
F3	Mauritanien x I92/0325	102.79[ab]	3.40[a]	3.70[a]	7.10[a]	0.52[a]
F19	Mahabama x I92/0401	102.91[ab]	5.90[a]	3.60[a]	9.50[a]	0.38[a]
F12	I92/0401 x Kinkéni	103.16[ab]	3.80[a]	1.90[a]	5.70[a]	0.33[a]
F24	Manaboulenga x I92/0401	102.47[a]	8.40[a]	5.60[a]	14.00[a]	0.40[a]
F14	I92/0401 x Dimbouana	102.84[ab]	6.64[a]	3.24[a]	9.88[a]	0.34[a]
F9	Mauritanien x I97/0162	103.03[ab]	4.19[a]	3.86[a]	8.04[a]	0.48[a]
F4	I92/0401x Soleil	103.32[b]	7.97[a]	4.39[a]	12.36[a]	0.38[a]
F27	I92/0401 x Mauritanien	102.79[ab]	5.32[a]	2.78[a]	8.11[a]	0.34[a]
F8	Manaboulenga x I92/0325	102.85[ab]	14.00[a]	8.10[a]	22.10[a]	0.37[a]

Significat with a confidence level of 95% for the Newman-Keuls test (SNK). Values with the same index do not show a significant difference at 5% threshold. Harvest index is the ratio of tuber roots to total biomass.

Table 4. Average tuberous roots characteristics of genotypes from controlled crossing 12 months after seedlings planting in station.

Family	Crossing	RTCom	RTRes	Root length (cm)	Starch (%)	Dry matter (%)
F28	Mauritanien x I92/0401	3.18[a]	3.64[a]	24.54[a]	17.77[a]	34.18[a]
F3	Mauritanien x I92/0325	5.00[a]	2.00[a]	46.40[b]	23.50[a]	40.50[a]
F19	Mahabama x I92/0401	3.00[a]	5.00[a]	47.00[b]	19.50[a]	32.00[a]
F12	I92/0401 x Kinkéni	3.00[a]	6.00[a]	36.10[b]	20.00[a]	43.50[a]
F24	Manaboulenga x I92/0401	5.00[a]	1.00[a]	40.20[b]	24.00[a]	42.50[a]
F14	I92/0401 x Dimbouana	3.17[a]	6.17[a]	93.34[b]	18.42[a]	36.17[a]
F9	Mauritanien x I97/0162	4.29[a]	7.43[a]	42.31[b]	20.86[a]	33.71[a]
F4	I92/0401x Soleil	5.71[a]	11.00[a]	40.59[b]	17.14[a]	40.14[a]
F27	I92/0401 x Mauritanien	3.30[a]	5.32[a]	35.02[b]	20.82[a]	38.26[a]
F8	Manaboulenga x I92/0325	7.00[a]	5.00[a]	67.00[b]	27.00[a]	42.00[a]

Significative with a confidence level of 95% for the Newman-Keuls test (SNK). Values with the same index do not show a significant difference at 5% threshold. RTCom: Marketable Tuberous Roots, RTRes : Residual Tuberous Roots ; Dry matter : content of tuber on fibres.

at station. Results show that, the leaf surface varied from 102.47 cm^2 (Manaboulenga x I92/0401) to 103.32 cm^2 (I92/0401 x Soleil) respectively (Table 3). In crossing (I92/0401 x Soleil), the leaf surface (103.32 cm^2) was larger. Statistical analyzes results of leaf area vary significantly depending on crossing made. They highlight the existence of 3 homogeneous groups of crossing made (a, ab and b). The most marked leaf area was obtained with genotypes from crossing (I92/0401 x Soleil) (group b). Analysis of all crossing did not statistically reveal any significant difference (at the 5% threshold) in aerial biomass, underground biomass (mass of all the storage roots per plant), total biomass and harvest index (Table 3). The results reveal that, these variables did not make it possible to discriminate all crossing tested at station.

Tuberous roots yield produced by 10 genotypes obtained from controlled pollination 12 months after planting

Marketable tubers, not marketable tubers, tuber length, tuber diameter, percentage of starch and percentage of dry matter of 10 genotypes tested crossing were evaluated at 12 MAP. Analysis of crossing did not statistically reveal any significant differences (at the 5% threshold) in marketable tubers, not marketable tubers, tuber diameter, starch content and root dry matter content (Table 4). The results reveal that these variables did not help discriminating between tested cassava genotypes (Table 4).The results show that tuber length varied from 24.54 cm (Mauritanian x I92/0401) to 93.34 cm (I92/0401 x Dimbouane) (Table 4). Results of

statistical analyzes of tuber length varied significantly according to cassava genotype tested, revealing the existence of 2 homogeneous groups of tested genotype (a and b) most marked was obtained with 9 genotypes evaluated (group b).

DISCUSSION

This study revealed the existence of a high cassava mosaic disease tolerance or resistance in cross (Mahabama x 192/0401) compared to other controlled crossing. For this crossing, no symptoms of cassava mosaic disease were observed until 12 MAP. The results are similar to those obtained by Hahn et al. (1980), Jennings and Hershey (1985), Kemdingao (2003), Ambang et al. (2007), Monde et al. (2013) and Bisimwa et al. (2015).

Four cassava varieties selected and popularized in Republic of Congo for their resistance to bacteriosis showed a sensibility to cassava mosaic disease (Mabanza et al., 1993). This study is the first one to set up a crossing showing an acceptable resistance to this viral disease. For a long period, it has been recognized that some varieties have acceptable resistance to mosaic when they suffer little or no damage even if they are affected (Hillocks and Thresh, 2000). Such individuals in crossing (Mahabama x I92/0401) will be used as a mean of controlling the disease.

In addition to crossing (Mahabama x I92/0401), F1 progeny from crossing (Mauritanian x I92/0401 and I92/0401 x Soleil) expressed the cassava mosaic disease incidence of 51% at 12 MAP. However, the cassava mosaic disease incidence of 95% was recorded in crossing (I92/0401 x Kinkeni and Mauritanian x I97/0162) at 12 MAP. Thus, the study results showed the existence of very clear differences in the degree of attack of the different crossing evaluated.

Difference in attack levels of cultivars or clones or varieties or genotypes with respect to cassava mosaic disease was recorded by Mabanza et al. (1993), Ambang et al. (2007), Ntawuruhunga et al. (2007), Zinga et al. (2008), Chikoti (2011), Monde et al. (2013) and Bisimwa et al. (2015). The study results showed that the cassava mosaic disease was established from 6th MAP in crossing (Mauritanian x I92/0325 and Manaboulenga x I92/0401). For these crossing, the lowest incidence of cassava mosaic disease (5% and 50%) increased to 91% and 75% at 12^{th} week after planting. This evolution of cassava mosaic disease incidence during the cultivation period was recorded for all crossing tested. Similar results were obtained by Ambang et al. (2007) and Bisimwa et al. (2015).

The study results reveal that the critical threshold for the emergence of cassava mosaic disease would be 6 MAP for the crossing tested. These results are contrary to those obtained by Mabanza et al. (1993). These authors noted that starting from the 4th month, the impact of cassava mosaic disease begins to diminish by the phenomenon of healing with four varieties selected by national program of research on cassava. To date, the use of genotypes from crossing (Mahabama x I92/0401 is a mean to manage cassava mosaic disease, given that it meets the requirements of growth, agronomy and production. Thus, in crossing (Mahabama x I92/0401) with trichotomous branching was not different from 9 other crossing tested by stem diameter, branching type, number of branch, aerial biomass, underground biomass (mass of all the storage roots per plant), total biomass and harvest index. For hybrids from crossing (Mahabama x I92/0401), the stem diameter of 3.90 cm obtained is comparable to or better than the average stem diameter of cultivars recorded by Ambang et al. (2007) and Monde et al. (2013). Those results reveal an intermediate classification of plant height, stem diameter and leaf surface of the individual of the said crossing. In hybrids from crossing (Mahabama x I92/0401), a plant height of 2.94 cm was measured, leaf surface was 102.91 cm^2 and harvest index was 0.38. These acceptable measures were similar to those of Bakayoko et al. (2007), Ambang et al. (2007), Chikoti (2011), Moundzeo et al. (2012) and Monde et al. (2013).

Similarly, it appears that crossing (Mahabama x I92/0401) is indistinguishable from other crossing for the number of marketable tubers, not marketable tubers, tuber diameter and root dry matter content. The tuber fiber content of 32% recorded in crossing (Mahabama x I92/0401) was similar to or better than that obtained by Nwangalalo et al. (1987) and Bakayoko et al. (2007). On the other hand, this content was lower than F1 hybrids of 20 families tested by Chikoti (2011).

The F1 progeny in crossing (Mahabama x I92/0401) showed tuber length of 47 cm with 8 mean number tubers per plant. These production variables in cross (Mahabama x I92/0401) were similar to those presented by cassava varieties tested (Bisimwa et al., 2015; Ambang et al., 2007, Moundzeo et al., 2012, Monde et al., 2013). Thus, F1 hybrids in Mahabama x I92/0401 which have a high tolerance to cassava mosaic disease, are interesting because of their growth, agronomic and yield components.

Conclusion

F1 progenies from crossing (Mahabama x I92/0401) showing high tolerance to cassava mosaic disease are included in the cassava selection scheme in Congo. In addition to the absence of any visible symptoms of cassava mosaic disease, these hybrids in crossing

(Mahabama x I92/ 0401) showed vegetative growth, agronomic traits, and acceptable yield components comparable to the other 9 crossing tested. This crossing is recommended in the main producing areas of the Republic of Congo, which is heavily infested with cassava mosaic disease. Before it is released, assessments in farmer's area will be carried out in order to confirm its potential to control cassava mosaic disease observed at station.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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