BirEx JOURNAL
Budapest International Research in Exact Sciences
Medical, Biological, Argiculture, Engineering Science and other related areas
e-ISSN : 2655-7827
p-ISSN : 2655-7835
http://www.bircu-journal.com/index.php/birex

Bimonthly cassava (Manihot esculenta C.) leaf yield in relation to secondary infection of the crop by African Cassava Mosaic in the Provinces of Nord-Ubangi and Tshopo in the Democratic Republic of Congo

Molongo Mokondande Médard[1], Solia Edondoto Sylvain[2], Litucha Bakokola Joseph[3], Monde te-Kazangba Godefroid[4], Dhed'a Djaïlo Bénoît[5]

[1]*University of Gbadolite, Faculty of Agronomic Sciences, Department of Plant Science B. P. 111 Gbadolite, Democratic Republic of Congo.*

[2,3,4]*Faculty Institute of Agronomic Sciences of Yangambi B. P. 1232 Kisangani, Democratic Republic of Congo*

[5]*University of Kisangani, Faculty of Science, B.P. 2012 Kisangani, Democratic Republic of Congo.*

Abstract: *The present study aimed to evaluate the yield of cassava (Manihot et al.) leaves harvested bimonthly in relation to the level of secondary infection of the crop by MAM in Kisangani and Gbadolite respectively, in the provinces of Tshopo and Nord-Ubangi in the Democratic Republic of Congo. An experimental randomized complete block design was chosen, with 4 replicates and 5 treatments according to infection levels, including Level 0: No symptoms (apparently healthy subject); Level 1: Yellowish spots covering 1/5ème of the leaf blade (light mosaic); Level 2: Spots covering half the leaf blade, and appearance of leaf deformation (moderate mosaic); Level 3: Affected leaves deformed and partly curled up, vegetative apparatus reduced (strong mosaic); Level 4: Almost all leaf blades curled up, vegetative apparatus reduced (severe mosaic); Level 5: Leaves reduced to about 1/10ème of their surface area; on some, the leaf blade becomes non-existent, twigs very short, generally knotted, plant dies within a few months. Leaf yields recorded in Kisangani were in the order of 1.99 T/ha (Level zero, apparent absence of mosaic); 1.73 T/ha (Level 1, light mosaic); 2.13 T/ha (Level 2, moderate mosaic); 1.66 T/ha (Level 3, strong mosaic); 1.16 T/ha (Level 4, severe mosaic) with the Mbongo variety. On the other hand, at Gbadolite, 2.63 T/ha (Level zero, apparent absence of mosaic); 2.67 T/ha (Level 1, light mosaic); 3.01 T/ha (Level 2, moderate mosaic); 2.26 T/ha (Level 3, strong mosaic); 1.89 T/ha (Level 4, severe mosaic) were obtained with the Yasegumba variety. With the exception of levels 1 and 2, MAM caused yields to fall by 13.1 to 41.7% and 14.07 to 28.14% from level 1 (light mosaic) to level 4 (severe mosaic) by adopting bimonthly harvesting in Kisangani and Gbadolite respectively. This harvest is, therefore, one of the best techniques for managing MAM and producing leaves.*

Keywords: *Yield; leaf; harvest; bimonthly; secondary MAM infection, Democratic Republic of Congo.*

I. Introduction

Cassava is one of the world's most important food crops, with an annual global production of around 276 million tonnes in 2013. In 2013, the main producing countries worldwide were Nigeria (accounting for around 19%), Thailand (11%), Indonesia (9%), Brazil (8%) and the Democratic Republic of Congo (6%). Global demand for cassava increased significantly between 2004 and 2013 due to its attractiveness as a crop ensuring food security for growing populations within emerging markets on the one hand and growing demand for industrially processed cassava-derived products on the other (Litucha, 2011; Sanginga & Mbadu, 2015).

DOI: https://doi.org/10.33258/birex.v5i4.7763

The same authors report that Africa accounts for less than 1% of total exports of this commodity. Moreover, cassava production is dominated by small-scale farmers (25% of whom are women), and the root crop is a source of subsistence for at least 300 million people. Almost all the cassava (90%) produced in Africa is used as a staple food for human consumption, providing calories for around 500 million people and accounting for around 37% of the population's dietary energy requirements. However, in many African countries, cassava is seen not only as a food security crop but also as a raw material for various types of industry.

In the Democratic Republic of Congo, cassava is the most important crop, providing a staple diet for at least 70% of the population, thanks to its various parts, notably the leaves and tuberous roots (Muyolo, 1987).

The leaves are one of the best and least expensive sources of protein, vitamins and minerals (FAO, 1996). The tuberous root, which resembles a sweet potato, is rich in carbohydrates, making cassava an energetic food (Anonymous, 2006). They contain about the same amount of protein as eggs, making them competitive with certain vegetables and staple foods (Adrian & Frangne, 1986).

In tropical countries, cassava, when dried, yields flours or plugs containing almost pure starch that yield more than 1 U.F. per kg. It is one of the roots that provide energetic, palatable and refreshing foodstuffs, which are very useful for fattening domestic animals (Besse, 1969).

Despite all this importance, cassava cultivation is subject to attack by several diseases, including African cassava mosaic (AMM). This leaf virosis depresses photosynthetic activity, deforms leaves and consequently reduces leaf and tuberous root yields by up to 60-70% (Muyolo, 1987).

Mahungu et al. (2014) note that, after Nigeria, the Democratic Republic of Congo ranks second among Africa's major cassava producers and fifth worldwide. Data on cassava production in the Democratic Republic of Congo for the period 1985 to 2010 illustrate two trends in the values observed. From 1985 to 1995, values rose, with an annual average of 19 169 835.9 tonnes of fresh cassava. From 1995 to 2010, cassava production fell steadily, with average values of 15 598 943.7 tonnes, representing a 47.7% loss. This drop was largely attributed to attacks on the crop by pests and diseases.

Several control methods have been considered, including the use of resistant and healthy varieties, adherence to the agricultural calendar (Lepoivre, 2003), phytosanitation, and cross-protection; this protection can be obtained by growing moderately virus-infected cassava in an area with high pressure from cassava Begomovirus inoculum (Zinga et al., 2008; Monde, 2010).

The measures mentioned above require considerable capital outlay, which primary producers and consumers need help to afford. This is why it seems essential to find a suitable cultivation technique to reduce the severity of MAM.

This study is based on the theoretical aspect that spacing out the harvest (bimonthly harvesting) would allow more or less sufficient shoot development, which would reduce leaf yield less than in the case of monthly (regular) harvesting, as observed by Muyolo (1987), since whitefly attack slows biomass development, thus reducing yield (Appert & Deuse, 1982).

In addition, it is assumed that the degree of infection (mosaic severity) can be minimized, thereby increasing cassava leaf yield under field conditions.

This study set out to test the effects of the bimonthly harvesting technique in relation to the severity of secondary infection of the crop by MAM on leaf yield and the variation in virosis from level 0.

This answered the main question: Can bimonthly harvesting in relation to crop infection levels by MAM improve cassava leaf yield and increase virosis? As a hypothesis, this practice would improve both yield and the increase in virosis.

II. Review of Literature

2.1. Study Environment

In Kisangani, the trial was carried out at kilometre point 17 on the old Buta road at the Centre d'adaptation et de production des semences améliorées (CAPSA) of the $13^{ième}$ communauté Baptiste du fleuve Congo, located at an altitude of 417 m, North Latitude 0° 36' 47,5" and East Longitude 25° 17' 46,6''. The climate of the experimental site is that of the Af type (Köppen). The land was a young fallow of ± 5 years colonized by *Musanga cecropiodes, Caloncoba welwichii, Tetorchidium didymostemone, chromolaena odorantA, Elaeis guineensis, Panicum maximum, Bidens spilosa, Manihot esculenta, ferns*.

In Gbadolite, it was carried out at the University site, located on the plateau at 4° 17' North and 21° 2' East, with an altitude of 500 m. The climate of the experimental site is that of the Aw_2 type (Köppen). The town's vegetation used to be evergreen equatorial rainforest. However, under human intervention, this has been replaced by savannahs with *Imperata cylindrica, Peninisetum sp, Chromolaena odoranta, Panicum maximum* and other gaminae. The soil is sandy-clay. Rainfall is relatively abundant, with an annual average of over 1,600 mm (Molongo et al., 2014).

2.2. Materials and Methods

2.1. Environment

The biological material used in this study consisted of cuttings from mosaic-susceptible cultivars, notably *Mbongo* and *Yasegumba,* for the first trial (in Kisangani) and second trial (in Gbadolite), respectively. These were harvested according to the severity of the virus in the field.

2.2 Methods

The experimental design chosen for each trial was that of randomized complete blocks with 4 replicates, each consisting of 5 treatments. Treatments were defined according to levels of secondary infection by MAM, assigned to plots laid out in rows (1 m x 80 m, i.e., 80 m^2 per plot) separated by one meter (1m). The plots were arranged so that infection levels were adjacent or close together. Each plot contained a population of 80 plants, of which 20 were selected as samples. T.A. 5m-wide strip of unpicked or zero-picked plants separated the blocks. This means that the field has a potential area of 0.495 ha and a sown area of 0.392 ha.

The treatments compared, according to the scale cited by Silvestre and Arraudeau (1983), were as follows: Level 0: No symptoms (apparently healthy subject); Level 1: Yellowish spots covering $1/5^{ème}$ of the leaf blade (light mosaic); Level 2: Spots covering half the leaf blade, and appearance of leaf deformation (moderate mosaic); Level 3: Affected leaves are deformed and partly curled up, the vegetative apparatus reduced (strong mosaic); Level 4: Almost all the leaf blades are curled up, the vegetative apparatus reduced (severe mosaic); Level 5: Leaves are reduced to around $1/10^{ème}$ of their surface area; on some, the leaf blade becomes non-existent, the branches are very short, usually knotted, and the plant dies within a few months (Table 1).

Table 1. The Symptom Severity Index (SSI) scale

Levels	Images	Symptoms
Level 0		Healthy plants or without apparent symptoms
Level 1		Yellowish spots covering 1/5th of the leaf blade or a light mosaic
Niveau 2		e spot covers half of the blade and the appearance of the leaf deformations or a moderate mosaic.
Level 3		fected leaves deformed, partially curled up or strong mosaic

Level 4		arly all leaves curled up, reduced vegetative apparatus or severe mosaic
Level 5		Leaves reduced to 1/10th of their surface, atrophied branches, the plant withers and dies within a few months or very severe mosaic

Planting was carried out horizontally using cuttings approximately 15 cm long, at spacings of 1m x 1m, at a depth of around 10 cm. Harvesting was carried out bi-monthly on a sample of 20 plants per treatment. It consisted of picking the tender tops of plants with 4 to 5 leaves, according to "savoir-paysan" in French, at different levels of secondary infection by MAM.

Observations included crown diameter (mm) using calipers, plant height (cm) using tape measures, disease severity using the MAM severity scale, average cumulative leaf yield (T/ha) using extrapolation and yield variation compared with level 0.

Results were analyzed using Excel and IBM SPSS 20 software; a single-criterion analysis of variance was used for classification without sampling; the F Snedecor test was adopted to identify significant differences between means; the Tukey test was used to detect smaller significant differences and group treatments.

III. Results and Discussion

3.1 Trade-in Rate

The various parameters used in Trials 1 and 2 at Kisangani and Gbadolite, respectively, are shown in Tables 2 and 3.

a. Kisangani Search and Yield Parameters

Table 2 shows the research parameters and yields for the Kisangani agricultural region.

Table 2. Kisangani search and yield parameters

Test 1 Kisangani							
	L0	**L1**	**L2**	**L3**	**L4**	**Average**	**CV**
Diameter at collar (mm)	18,20	18,35	17,68	16,37	14,68	17,06	9,03
Plant height (cm)	100,23	92,07	100,37	89,47	83,49	93,13	7,79
Infection level	1,82	2,87	2,74	3,87	3,96	3,05	29,04
Plot yield (kg/20 m)^2	1,33	1,16	1,43	1,12	0,73	1,154	23,26
Cumulative average leaf yield (T/ha)	1,996	1,74	2,14	1,66	1,16	17,06	21,56
Variation (%) from N0	**100,00**	**86,90**	**107,20**	**83,30**	**58,30**		

b. Gbadolite Search And Yield Parameters

Research parameters and yields for the Gbadolite agricultural area are presented in Table 3.

Table 3. Gbadolite search and yield parameters

Test 2 Gbadolite							
	L0	**L1**	**L2**	**L3**	**L4**	**Average**	**CV**
Diameter at collar (mm)	14,90	13,80	13,70	14,03	10,90	13,47	11,22
Plant height (cm)	103,65	92,58	88,98	94,80	81,97	92,40	8,60
Infection level	2,30	2,40	2,50	2,70	3,10	2,60	12,16
Plot yield (kg/20 m)^2	3,99	4,06	4,48	3,47	2,84	3,77	16,72
Cumulative average leaf yield (T/ha)	2,63	2,67	3,01	2,26	1,89	4,56	9,41
Variation (%) from N0	100	101,52	114,44	85,93	71,86		

The results relating plant collar diameter to secondary AMM infection are ranked as follows in descending order of magnitude: **N1>N0>N2>N3>N4** and **N0>N2>N1>N3>N4**; this shows that the *Mbongo* cultivar is more robust than the *Yasegumba* cultivar. These achieved a range of 14.68 to 18.35 cm and 10.90 to 14.90 cm, respectively.

In relation to plant height, the subjects rank in descending order of size as follows: **N0>N2>N1>N3>N4** and **N0>N3>N1>N2>N4** with a range of 83.49 to 100.37 cm and 81.97 to 103.65 cm for trials 1 and 2 respectively. The evolution of the level of infection for the different trials was evaluated, and the results, in descending order, are classified as follows: **N4>N3>N2>N1>N0** and **N4>N3>N2>N1>N0**, respectively, for the first and second trials.

Plot leaf yields (kg/20 m^2) averaged 0.73kg (N4, severe mosaic) to 1.33kg (Level0, apparently healthy plant) in Kisangani and 2.839 (N4 severe mosaic) to 4.475kg (N2, moderate mosaic) in Gbadolite. Cumulative yields (in kg/20 m^2) according to infection levels are ranked in descending order of magnitude as follows: **N2>N0>N1>N3>N4** and **N2>N1>N0>N3>N4** with a range from 2.33 kg (N4, severe mosaic) to 4.28 kg (N2, moderate mosaic) and 2.79 kg (N4, severe mosaic) to 5.97 kg (N2, moderate mosaic) in Kisangani and Gbadolite respectively.

Tables 2 and 3 show a cumulative yield range from 1.163 T/Ha (N4, severe mosaic) to 2.138 T/Ha (N2, moderate mosaic) and 1.89 T/Ha (N4, severe mosaic) to 3.03 T/Ha (N2, moderate mosaic). Based on decreasing levels of infection, yields are classified as follows: **N2>N0>N1>N3>N4** and **N2>N1>N0>N3>N4**. The variation observed is in the order of 16.7% to 41.7 and 14.07% to 28.14% in Kisangani and Gbadolite, respectively.

3.2. Discussion

Examination of Tables 2 and 3 shows that the basal diameter of plants varies with age and the level of secondary MAM infection. In general, basal stem diameter increases with age. This is consistent with physiological growth processes and vegetative development stages (Dhed'a et al., 2011).

In Kisangani, the decline in stalk size began at level 2 (moderate mosaic): 3.6% and increased at levels 3 and 4 (strong and severe mosaic) to 8.4% and 23.5%, respectively (level 4, severe mosaic). In Gbadolite, on the other hand, the trend was similar, with a downward range from 5.9% to 26.8% for levels 3 and 4, respectively.

The reduction in basal stem diameter can be explained by the fact that MAM reduces the unit leaf area, as Vandenput (1981) notes that this virosis affects plant development. This situation has led to a reduction in the photosynthetic table and the distribution of the dry matter formed between the various organs, particularly the stems. Raffaillac and Nedelec (1987) report that early contamination of cassava plants by the virus reduces stem diameter growth. The average basal stem diameter decreases as the level of virosis infection increases.

Based on the results shown in Tables 1 and 2, he observed that the evolution of plant height followed the same trends as stem size as a function of age and level of secondary MAM infection. Variations in elongation as a function of these two factors can be explained in the same way as the basal stem diameter curve in relation to apparently healthy plants. In Kisangani, MAM reduced the height of plants subjected to bimonthly harvesting by 6% (level 1, light mosaic), 1.1% (level 2, moderate mosaic), 8.4% (level 3, strong mosaic) and 23.5% (level 4, severe mosaic). However, in the agro-ecological conditions of Gbadolite, a variation in virosis was recorded at 4.7% (level 1, light mosaic), 8.5% (level 2, moderate mosaic), 10.7% (level 3, strong mosaic and 16.7% (level 4, severe mosaic).

In light of these results, each level of infection varied over the observation period. There was an increase in level 0, 1, 2 and 3 ribs and a slight decrease in level 4 (severe mosaic) ribs in Kisangani (3.96), but a remarkable decrease in Gbadolite (3.1).

These results confirm Lutaladio and Ezumah's (1980) contention that leaf harvesting increases the severity of MAM, as it favors the emission of young shoots, the site of virus multiplication and accumulation. In addition, the pronounced drop from level 4 to 3 is due to the correlation between bimonthly harvesting and higher temperatures, in line with the observation made by Autrique and Perreaux (1989) that heat during the growing season attenuates virosis symptoms. This confirms Muyolo's (1987) experience that regular leaf harvesting is a practice that increases cassava's susceptibility to mosaic disease.

In general, the MAM severity rating recorded in this research (levels 2; 0 to 3) is below level 4 (severe mosaic). This rating is lower than that recorded by Fundi (2005); therefore, the practice of bimonthly harvesting attenuates the excessive evolution of the virosis as it gives the plant time to reconstitute leaf cells or the apical bud (Ambwa et al., 2022).

This study shows that plot leaf yield was higher at the beginning of the cycle than at the end. The increase in yield observed in some plots and throughout the trial is justified by the abundance of rain that prevailed at the end of the cycle, an experience made by Lutaladio and Ezumah (1980), according to which leaf yield increases during the rainy period.

The various productions were used to obtain the average cumulative plot yield in leaves (in Kg/20m²). The results show that plants from cuttings infected at level 2 (moderate mosaic) gave a high yield compared with the other levels, in this case, level 4 (severe mosaic), with very low cumulative plot yields of 3.5 kg and 1.6 kg, respectively in Kisangani.

In terms of production, the various levels rank as follows, in ascending order of size: N4<N3<N1<N0<N2; but at Gbadolite 2.84 Kg and 4.48 Kg respectively, levels 4 (severe mosaic) and 2 (moderate mosaic).

In Kisangani, the cumulative yields for different levels of secondary infection were recorded in tonnes per hectare: 0.98 and 1.8 T/Ha, respectively N4 (severe mosaic) and N2 (moderate mosaic); in Gbadolite, on the other hand, 5.9 T/Ha and 3.79 T/Ha were obtained, which were higher than 2.0 and 5.2 T/Ha from cultivars Amuma, Moyindo, Mado or madamme, Nganza and Obama or TME 419 under Gbadolite conditions (Ambwa et al., 2022).

These yields were lower than the 11.5T/ha in fresh leaves found by Dahniya (1980) when harvesting the TMS 30211 variety at two-month intervals. The same trend is observed when compared with the cumulative leaf production ranging from 5.58 to 9.54T/ha recorded by Mahungu et al. (1992) using bimonthly harvesting on 7 clones, namely 82/255; 82/578; F150; F100; 30085/28; 02864 and Mpelolongi in Bas-Congo. Differences in genetic potential between cultivars are due to the phenomenon of branching, development of several branches, erect stems, and ability to produce secondary and tertiary regrowth after leaf harvesting, as well as differences in growing conditions, rainfall quantity and distribution, soil fertility and level of secondary infection, which explain the differences between our yields and those of our predecessors.

With the exception of levels 1 and 2, MAM caused a 13.1% drop in yield at level 1 (light mosaic), 41.7% at level 4 (severe mosaic) and 14.07%; 28.14% at level 3 (strong mosaic) and level 4 (severe mosaic) in Kisangani and Gbadolite respectively. Yield losses of less than 60% and 61%, respectively, as assessed by Monde (2005) and Mugenyi (2010).

Yields in tonnes per hectare were subjected to statistical analysis, with the following summary and interpretation: In Kisangani, the single-criterion analysis of variance classification and the F Snedecor test revealed a significant difference at the 0.05 probability level between the different levels of secondary MAM infection, and the Tukey test grouped yields according to levels of secondary infection as follows: N4 N3 N1 N0 N2; i.e., the best yield was obtained from cuttings of moderate mosaic (N2); which is not different from that of apparently healthy (N0) and light mosaic (N1) subjects; the yields of these were different from those of strong (N3) and severe (N4) mosaics during this study. In Gbadolite, analysis of variance also revealed a significant difference between the different levels of secondary infection of MAM at the 0.05 probability threshold. The comparison of means using Tukey's test can be summarized as follows: N4 N3 N0 N1 N2. Thus, the plants that produced the best yields were those from cuttings of moderate mosaic (N2), whose yields were similar to those of cuttings of light mosaic (N1) and apparently healthy plants; their yields were different from those of strong mosaic (N3) and severe mosaic (N4) in this study.

IV. Conclusion

The present study aimed to assess the yield of cassava (Manihot et al.) leaves harvested every two months in relation to the level of secondary infection of the crop by MAM in Kisangani and Gbadolite, using the local mosaic-susceptible cultivars Mbongo and Yasegumba respectively, in view of their socio-economic importance in the study environments.

The effects of bimonthly harvesting were observed on changes in stem collar diameter, plant height, level of MAM infection and leaf yield.

The results obtained during this study suggest the following:

Basal stem diameter varied with age and the level of secondary infection of the crop by the virosis, with decreases of 7.5% and 19%, respectively, at levels 2 (moderate mosaic) and 4 (severe mosaic).

Height trends followed the same pattern as stem collar diameter, with MAM causing a reduction in height of between 4.05 and 18.4%;

There was a gradual but not abrupt increase in the severity of MAM and a decrease from level 4 (severe mosaic) to 3; we, therefore, conclude that regular or monthly harvesting increases the severity of MAM, but bimonthly harvesting attenuates it.

An increase from 2.85 to 19.34% was observed. The yield range obtained was around 0.8T/ha and 1.4T/ha for levels 4 (severe mosaic) and 2 (moderate mosaic), respectively. With the exception of levels 1 and 2, MAM caused a drop in yield of the order of 13.1 from level 1 (light mosaic) to 41.7% at level 4 (severe mosaic) and 14.07 to 28.14% from level 3 (strong mosaic) and level 4 (severe mosaic) at Kisangani and Gbadolite respectively.

Therefore, if the best leaf yield is expected from mosaic-susceptible cassava, bimonthly harvesting should be used, as this technique reduces the severity of MAM, but regular harvesting worsens it.

References

Adrian J. et Frangne R., 1986. La science alimentaire de A à Z. technique et documentation, Lavoisier. P218.

Ambwa J., Idikodingo T., Molongo M., Mongbenga G., Likiti O., Mambokolo C., Diko G., Bulonza J.C., Empata L., Ebwa J., Ugencan P., Mamba-Mbayi G., Songbo M., Monde G., 2022. Evaluation of the Severity of African Cassava Mosaic (ACMV) in Ten Cassava (Manihot et al.) Clones in Relation to the Bimonthly Leaf Harvest in Gbadolite, Democratic Republic of Congo. Elixir Applied Botany 170 (2022) 56443 – 56451.

Apppert J. et Deuse J., 1982. Les Ravageurs des cultures vivrières et maraichères sous les tropiques. Edition G.P. Maisonneuve & la rose, 15 rue Victor-cousin Paris (Vè) Agence de coopération culturelle et technique 13, Quai André Citroën, Paris (XVè). Pp. 97-98.

Autrique A. et Perreaux D., 1989. Maladies et ravageurs des cultures de la région des grands lacs d'Afrique Centrale, place du champ de Mars, 5, Boîte 57, B.P. 1050 Bruxelles. 232p.

Besse J., 1969. L'alimentation du bétail, Bussière, Saint-Amand (Cher). 365p.

Buyckx E.J.E., 1962. Précis des maladies et insectes nuisibles rencontrés sur les plantes cultivées au Congo, au Rwanda et au Burundi pp 478-480.

CIRAD-GRET, 2006. Mémento de l'agronome. Ministère de coopération et développement. Technique rurale en Afrique. 4ème édition, Paris, pp 843-884.

Dahniya M.T., 1980. Effet de l'effeuillage et de l'écimage sur les rendements en feuilles et en racines du manioc et de patate douce. Plantes-racines : stratégies de recherche pour l'année 1980. Compte rendu du premier symposium triennal sur les plantes –racines de la société internationale pour le plantes-racines tropicales. Direction Afrique 8-12 Septembre 1980 Ibadan. Pp145-150.

Dhed'a B., Moango A. et Swennen R., 2011. La culture des bananiers et bananiers plantains en RD. Congo. Support didactique, Edition Saint Paul Afrique, Kinshasa. 85p.

FAO, 1996. Rôle de la recherche dans la sécurité alimentaire mondiale et développement agricole. 45p.

Fundi B., (2005). Manifestation de la mosaïque Africaine de manioc en relation avec la pratique de la cueillette des feuilles de manioc en conditions agro-écologiques de Kisangani, Mémoire inédit, IFA-Yangambi. 45p.

Lepoivre, 2003 : Phytopathologie, De Boeck Université, rue des Mines 39, B-1000 Bruxelles. 427p.

Litucha M., 2011. Effet de récolte des feuilles et du niveau d'infection secondaire de la culture par la Mosaïque Africaine de manioc sur la production de manioc (Cultivar Mbongo) dans les conditions agro-écologiques de Kisangani (R.D. Congo). Thèse de

doctorat, Institut Facultaire des Sciences Agronomiques de Yangambi. 325p.
Lutaladio N. B. et Ezumah H.C., 1980. Récolte des feuilles de manioc au Zaïre In Plantes-racines tropicales: Stratégies de recherches pour les années 1980, Ibadan. Pp 142-144.
Mahungu M., Ndombo D, Bidiaka M, Tubanza S, 1992. Sélection du manioc pour la production en feuilles. Tropical root crops. Proceedings of the fourth triennial symposium of the International Society for tropical root crops Africa (ISTRIC-AF) Kinshasa 5-8 Décembre, 1992; 125-128.
Mahungu N. M., Tata Hangy K. W., Badiaka S. M., Frangoie A., 2014. Multiplication de matériel de plantation de manioc et gestion des maladies et ravageurs. Manuel de formation destiné aux agents de terrain, Institut International d'Agriculture Tropicale (IITA). 43p.
Monde K.G., 2005. Etude de virus de la mosaïque Africaine du manioc par comparaison des gènes AC2 et AC4. DES, Université catholique de Louvain, 47p.
Mugenyi K., 2010. Rendement en feuilles de manioc (Manihot esculenta C) récoltées mensuellement en relation avec l'infection secondaire de la culture par la MAM à Kisangani, mémoire inédit, IFA-Yangambi.
Muyolo G., 1987. Situation actuelle des principales maladies du manioc au Zaïre et progrès réalisés dans leur contrôle, In séminaire sur les maladies et les ravageurs des principales cultures vivrières d'Afrique centrale. Place du champ de mars 5, Bruxelles. Pp 197–198.
Raffaillac J.P. et Second G. H., 1997. L'amélioration des plantes tropicales, Cirad, Orstrom Montpelier cedex 1. Pp 429-445.
Sanginga N., Mbabu, A., 2015. Racines et Tubercules (Manioc, Igname, Pomme de Terre et Papate Douce). IITA, 33p.
Silvestre, P. et Arraudeau, M., 1983. Le Manioc. Edition G.P Maisonneuve et la rose et ACCT Paris. 262p.
Vandenput R., 1981. Les principales cultures en Afrique centrale. Tournai: Lessaffre. Pp 339–353.
Zinga I., Nguimal C.R., Lakouetene D.P., Konate G., Kosh Komba E., Semballa S., 2008. Les effets de la mosaïque africaine du manioc en République Centrafricaine. The impacts of African cassava mosaic in Central African Republic. Geo-Eco-Trop, 32: 47–60.