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Research Paper

Cassava Cropping Systems, Incidence and Severity of African Cassava Mosaic in Bunia, Democratic Republic of Congo

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Abstract
This study was aimed to determine the cassava cropping systems and to assess the incidence and the severity of African Cassava Mosaic (ACM) in four areas of Bunia town (Bankoko, Kindia, Mudzi-Pela, and Simbilyabo) and its surroundings in the Democratic Republic of Congo (DRC). A diagnostic survey of ACM using the IITA standard scale and the characterization local cassava farming systems was then conducted from March to May 2012 using a sample of 80 farms.

The results showed a high ACM incidence, averaging 62.0%, with severity levels ranging between 3 and 4 on the scale, and an attack rate of 49.3%. Twelve cassava cultivars were identified: six sweet varieties (Mukalasa, Bumbafu, Mayayi, Caterina, Sawasawa, and Abude) and six bitter varieties (Pamitu, Rava, Vama, Boxe, Waliba, and MM96). Among these, Pamitu, Mukalasa, and Bumbafu were the most susceptible to ACM.

The study also found that cassava is commonly grown in association with other food crops in the area mainly maize and beans. To improve cassava production, the study recommends that the Congolese government—through national, provincial, and local agricultural services introduce preventive measures against the ACM and enhance farmer supervision. This includes farmer training through extension services and support for research programs aimed at selecting ACM-resistant cassava cultivars suited to Ituri agroecosystem in the DRC.

Keywords: *Cassava cropping systems, disease incidence, severity, African Cassava Mosaic (ACM)*

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Résumé
Cette étude avait pour but de determiner les systèmes de culture du manioc et d'evaluer l'incidence ainsi que la gravité de la mosaïque africaine du manioc (MAM) dans quatre quartiers de Bunia (Bankoko, Kindia, Mudzi-Pela et Simbilyabo) et leurs environs, en République Démocratique du Congo (DRC). Pour cette fin, une enquête diagnostique a été réalisée de mars à mai 2012 afin d'évaluer la présence de la MAM et de caractériser les systèmes de culture du manioc dans les milieux utilisant un échantillon de 80 exploitations agricoles. La gravité de la MAM a été évaluée à l'aide de l'échelle standard de l'IITA (1990).

Les résultats ont révélé une forte incidence de la MAM, avec une moyenne de 62,0 %, des niveaux de gravité allant de 3 à 4 sur l'échelle, et un taux d'attaque de 49,3 %. Douze variétés de manioc ont été identifiées, dont six variétés douces (Mukalasa, Bumbafu, Mayayi, Caterina, Sawasawa et Abude) et six autres amères (Pamitu, Rava, Vama, Boxe, Waliba et MM96). Parmi celles-ci, les plus sensibles à la MAM étaient Pamitu, Mukalasa et Bumbafu.

L'étude a également montré que le manioc est couramment cultivé en association avec d'autres cultures vivrières dans la région. Pour améliorer la production de manioc, l'étude recommande que le gouvernement congolais –

à travers ses services agricoles aux niveaux national, provincial et local – renforce l'encadrement des agriculteurs et mette en place des mesures préventives contre les maladies telles que la MAM. Cela inclut la formation des agriculteurs par les services de vulgarisation et le soutien aux programmes de recherche visant la sélection de variétés de manioc résistantes à la MAM et adaptées à chaque agroécosystème de la RDC.
***Mots-clés** : Systèmes de culture du manioc, incidence des maladies, sévérité, mosaïque africaine du manioc (MAM)*

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I. Introduction

Cassava is a major staple food crop and an affordable source of calories for populations in developing countries (IITA, 1990). It has progressively replaced other starchy crops, and together with banana, forms the dietary backbone of populations in forested and surrounding regions (Janssens, 2001).

Despite its many advantages, cassava yields remain low. Over the past decade, production has been in decline, primarily due to disease and pest outbreaks that significantly affect tuber yields. Additional constraints include low soil fertility and traditional farming practices that are no longer efficient (Kabeya, 2004).

In the DRC, cassava production is in decline, particularly in Ituri Province and the city of Bunia, where food insecurity is rising due to decreasing agricultural productivity. Several factors contribute to this situation as:

- The rapid population growth reducing available farmland per household;
- A Free-range livestock damaging crops during the dry season;
- The crop diseases and pests and;
- The inadequate agronomic practices.

This study is therefore aimed at identifying the major diseases affecting cassava in the Bunia area, with a focus on African Cassava Mosaic (ACM). The objective is to determine the current status of this viral disease in the region.

This research seeks to answer the following questions:

- What is the response of the cassava cultivars grown in Bunia and its surroundings to ACM?
- What is the level of ACM infestation on cassava crop in the region?
- What cassava cropping systems are practiced in Bunia and surrounding areas?

The hypotheses tested are:

- Each cassava cultivar has a unique genetic profile, and therefore may respond differently to ACM;
- The ACM incidence may be high in Bunia and its surroundings;
- The cassava crop is more likely to be intercropped with other food crops than grown in sole crop.

The main objective of the study was to assess the incidence and severity of ACM in cassava cultivars grown in Bunia and its surrounding areas, in order to evaluate their susceptibility to the disease.

II. Study area, materials and methods

2.1. The study area

The study was conducted in Bunia, the capital of Ituri Province in DRC. Situated at an altitude of approximately 1,270 meters, Bunia lies north of the Equator, at a longitude of 30°15′08″ East and a latitude 1°33′33″North. The town is surrounded by the Blue Mountains (*Monts Bleus*) (Omasombo, 2021).

The climate of Bunia falls under the Am classification in the Köppen system, which denotes a tropical monsoon climate. The average annual temperature ranges between 23 °C and 28 °C, with the coldest month averaging below 18 °C. Annual precipitation is about 1,885 mm, and the rainy season is divided into two main periods: a short rainy season from March to June and a long rainy season from September to November.

The cassava farms were established in the area of Mudzi-Pela, Bankoko, Kindia, and Simbilyabo of Bunia town and surroundings. These sites were selected for their agricultural relevance and representativeness within the study area.

2.2. Materials

The 12 cassava cultivars found in the surveyed farms are presented in Table 1.

Table 1. Cassava cultivars of the surveyed farms

Sweet types	Bitter types
Mukalasa	Pamitu
Bumbafu	Rava
Mayayi	Vama
Caterina	Boxe
Sawasawa	Waliba
Abude	MM96

Among these 12 cassava cultivars, six are sweet varieties (Mukalasa, Bumbafu, Mayayi, Caterina, Sawasawa, and Abude) while six other bitter varieties (Pamitu, Rava, Vama, Boxe, Waliba, and MM96).

2.3. Method

Participatory observation was used as the primary technique for data collection. This involved examining 80 farms, with 20 farms per area, to assess the presence or absence of ACM symptoms on cassava plants.

Fieldwork included filling out an inquiry form for each farm visited and recording the cassava cropping systems in the study, as well as the incidence and severity of ACM and the growers' knowledge about the disease.
The scoring criteria for the severity of ACM on infected plants were based on the scale established by IITA (1990):

- Level 1: no symptoms ;
- Level 2: yellowish spots covering 1/5th of the leaf area;
- Level 3: spots covering half of the leaf area; appearance of distorted leaves;
- Level 4: infected leaves distorted; plant stunted and;
- Level 5: almost all leaves distorted; plant stunted.

To gather complementary information, we conducted structured interviews with cassava growers.

2.3.1. Sampling and observations

Observations were made on 30 cassava stands per farm, selecting 10 stands along the diagonals and 5 stands in each median. The observations included:

- The incidence of ACM based on the number of infected plants compared to the total number of observed plants;
- The severity of the disease scored from levels 1 to 5 and;
- The state of knowledge of cassava growers regarding the management of ACM..

In each quarter, 30 cassava stands were selected from 20 farms, resulting in a total of 600 stands in each quarter. Symptoms of ACM were recorded on at least one plant in the selected stands, along with the scoring of the severity of the disease on affected plants.

2.3.2. Statistical analysis of the data

The data collected from the 80 investigated farms (20 farms in each of the four quarters) are presented in an Excel table of descriptive statistics. For their interpretation, we calculated sums, means, and percentages.

III. Results And Discussion

3.1. Cropping Systems

The cassava cropping systems identified in the study area are presented in Table 2.

Table 2. Cassava cropping systems in Bunia

Location	Sole Crop		Intercrop		Total no of the farms
	Number of the farms	Percent (%)	Number of the farms	Percent %)	
Bankoko	8	40.0	12	60.0	20
Kindia	2	10.0	18	90.0	20
Mudzi-Pela	10	50.0	10	50.0	20
Simbilyabo	10	50.0	10	50.0	20
Total	**30**	**37.5**	**50**	**62.5**	**80**

Table 2 indicates that cassava is mainly intercropped with other food crops such as beans, maize, taro, and groundnuts in 62.5% of the investigated farms in Bunia and its surroundings, against In contrast, only 37.5% of the farms practice sole cropping of cassava. Janssens (2001) made also the same observation that cassava is generally intercropped with other food crops. In the highlands of Eastern Africa for instance, farmers often interplant cassava with sweet potatoes, as the latter protect the soil against the run-off due to its rapid growth.

The same author also noted that in the Pool region of Congo-Brazzaville, the intercropping of cassava is related to the soil toposequence. In savannah regions, farmers particularly grow cassava as the main crop, often intercropped with maize, local vegetables, and occasionally with pineapples and plantains. In humid tropical regions, such as in some areas of the DR Congo, cassava is commonly associated with beans, which grow rapidly and cover and protect the soil.
Lokombe (2004) reported that cassava is cultivated alongside with other crops, including rice, groundnuts, and maize, but predominantly beans which provide additional financial income and rapidly cover the soil.

According to Monde (2011), mixed cropping offers documented benefits in agriculture, including a reduction in the incidence of ACM by decreasing vector populations. He observed that the association of cassava with maize effectively reduces ACM incidence.

The prevalence of intercropping practices in the DR Congo can be attributed to increasing population density and limited arable land. Additionally, this practice forms part of the traditional agricultural methods of the Congolese peasant farmers. As noted by Van den Put (1981), mixed cropping is a common practice for these farmers.

3.2. Sources of cassava planting material

They are presented Table 3.

Table 3. Sources of cassava planting material

Site	Source 1	Source 2	Source 3	Source 4
Bankoko	4	4	4	8
Kindia	6	5	4	5
Mudzi-Pela	7	5	0	8
Simbilyabo	7	2	1	10
Total	24	16	9	31
Percent (%)	30	20	11,25	38,75

Legend:

1. Cuttings collected from the previous farm
2. Cuttings collected from neighboring farms
3. Cuttings collected from distant farms
4. Cuttings distributed by government services (research stations) and NGOs

Table 3 reveals that 38.75% of cassava cuttings are distributed by the NGOs, in particular the FAO; 30% are obtained from the previous farm, 20% from nearby farms, and 11.25% from distant farms, often without regard to the phytosanitary status of the planting materials. These results suggest that most cassava planting materials are obtained and distributed without a particular accent on their phytosanitary status, leading to reduced production performance. The demand for improved planting material remains unmet. Lukombo (2004) has underlined that in the absence of improved planting materials, farmers will continue to utilize any available planting material.

3.3. Knowledge about ACM in the study area

3.3.1. Knowledge of ACM symptoms by the farmers

The farmers' knowledge of ACM symptoms is presented in Table 4.

Table 4. Knowledge of ACM symptoms by the farmers

Symptoms	Bankoko	Kindia	Mudzi-Pela	Simbilyabo	Total no of the farms	Percent (%)
Observation of symptoms on leaves	20	20	20	20	80	100,0
Observation of symptoms on stems	0	0	0	0	0	0.0
Necrotic aspect of infected plants	0	0	0	0	0	0.0

ACM symptoms are characterized by leaf distortion, rolling, reduction in leaf area, and stunted plant growth (Monde, 2011).The results of the Table 4 indicate that the owners of the surveyed farms recognize ACM symptoms on the cassava leaves. However, the symptoms were not observed on the stems neither the necrotic aspect of infected plants.

3.3.2. Knowledge of the Transmission Mode of ACM

The farmers' knowledge regarding the transmission mode of ACM is summarized in Table 5.

Table 5. Knowledge about the Mode of Transmission of ACM by Farmers

Location	Transmission via the cuttings		Transmission by the vector		Total no of the farms
	Number of the farms	Percent (%)	Number of the farms	Percent %)	
Bankoko	3	15	17	85	20
Kindia	2	10	18	90	20
Mudzi-Pela	5	25	15	75	20
Simbilyabo	6	30	14	70	20
Total	**16**		**64**		**80**
Percent (%)	**20**		**80**		

Table 5 indicates that in the 80% of the surveyed farms, the ACM is transmitted from one plant to another by a vector with only 20% by the use of infested cassava cuttings. This knowledge is attributed to training received by the cassava growers by the FAO extension workers during the distribution of planting materials.

3.3.3. Methods of ACM control by farmers

Data on the methods employed by farmers in Bunia to control ACM are shown in Table 6.

Table 6. Methods of ACM control by farmers in Bunia

Site	Method 1	Method 2	Method 3	Method 4	Total no of the farms
Bankoko	0	0	20	0	20
Kindia	0	0	20	0	20
Mudzi-Pela	0	0	20	0	20
Simbilyabo	0	0	20	0	20
Total	0	0	80	0	80
Percent (%)			100,0		

Legend:

1. *Destruction of infected plants (phytosanitation)*
2. *Use of chemical products*
3. *No methods of control*
4. *Preventive methods*

The results in Table 6 clearly indicate that cassava growers in Bunia do not employ any methods for ACM control. The absence of control measures likely contributes to the disease spread, probably due to a lack of information regarding effective cultural or preventive control methods.

3.4. Evaluation of the incidence and severity of ACM

3.4.1. Evaluation of the Incidence of ACM Symptoms on Diagonally Selected Plants

Figure 1 illustrates the incidence of ACM in Bunia.

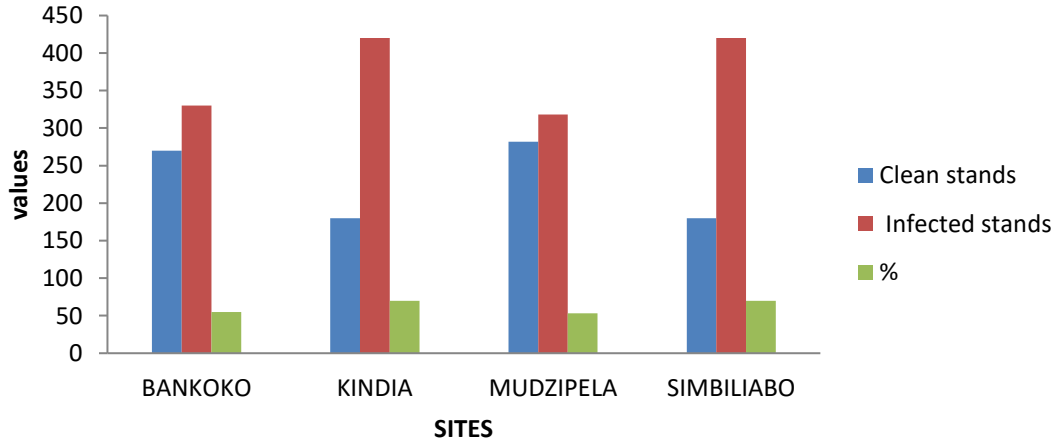

Figure 1. Evaluation of the Incidence of ACM Symptoms

The Figure indicates that the percentage of cassava plants exhibiting symptoms of ACM is highest in Kindia and Simbilyabo (70%), followed by Bankoko (55%) and Mudzi-Pela (53%). The average rate of ACM incidence in Bunia approaches 62%.

These findings are similar to those of Kalonji *et al*. (2008) in their epidemic studies on cassava farms among peasant farmers in Kinshasa and the province of Kongo Central. They observed that ACM incidence varied between 45.5% and 100%. These results suggest a high incidence of ACM in Bunia.

The incidence of viral diseases, as noted by Sommereyns (1967), is influenced by various regional conditions, particularly climatic factors that favor disease transmission.

3.4.2. Scoring of the severity of ACM on Diagonally Selected Cassava Plants According to ACM Scale (1-5)

The results of the severity scoring of ACM are summarized in Figure 2.

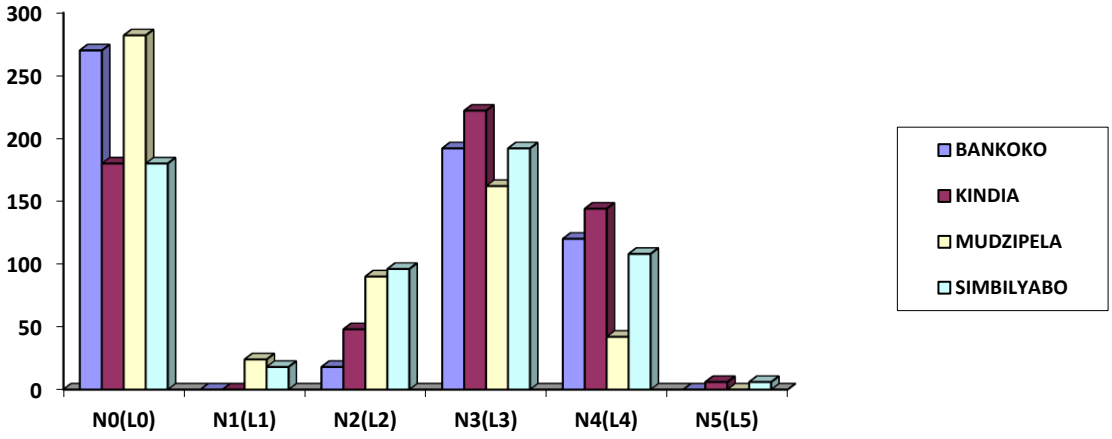

Figure 2. Scoring of the severity of ACM

Legend:

- L_0: Level 0
- L_1: Level 1
- L_2: Level 2
- L_3: Level 3
- L_4: Level 4
- L_5: Level 5

On average, Level 3 (L3) severity is the most prevalent under the tropical climatic conditions of Bunia and its surroundings, followed by Level 4 (L4), with Levels 2, 1, and 5 ranking lower (Figure 2)

Kalonji *et al*. (2008) also reported high severity levels of ACM, ranging between 3 and 4, across all cassava plants regardless of plant age in the province of Kongo Central. The relatively high severity levels of ACM can be attributed, in part, to the plant intensive response following viral infection, which may vary by environment, as noted by Sommereyns (1976). The same author asserts that the severity of symptoms and their propagation can be significantly influenced by ambient temperature conditions surrounding infected plants. In addition Roland (1958) indicates that viral symptoms on plants may exhibit variability and different manifestations depending on environmental conditions.

3.4.3. Incidence of the disease on cassava cultivars

The incidence of ACM with regard to cassava cultivars is presented in Figure 3.

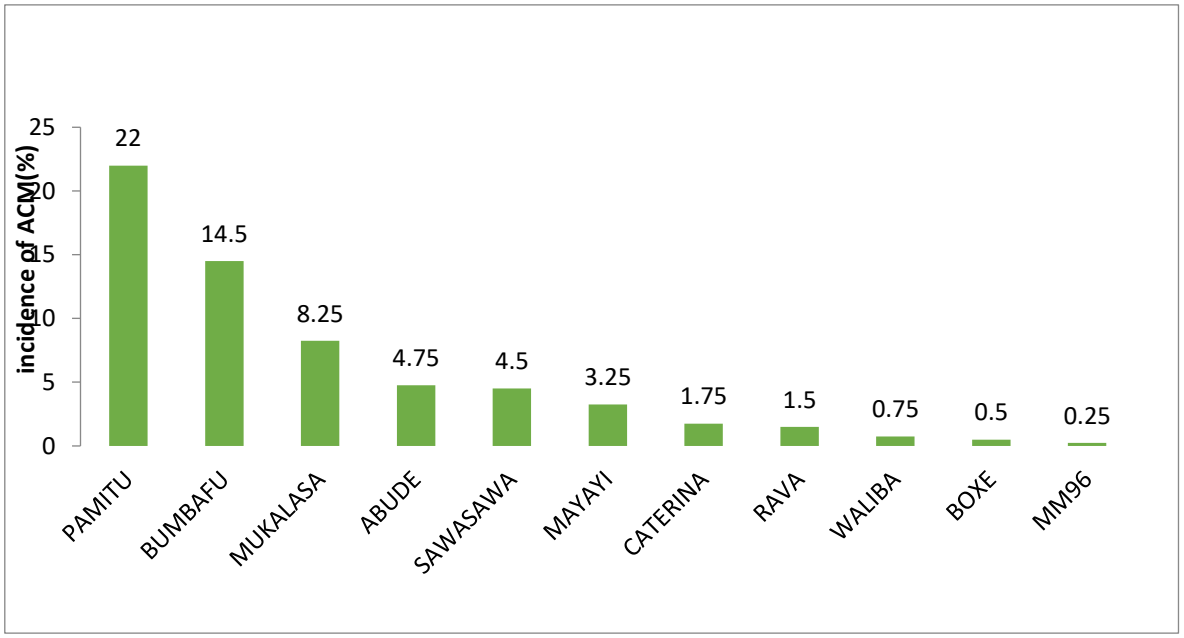

Figure 3. Incidence of the disease on cassava cultivars

The figure reveals that the cassava cultivar Pamitu exhibits the highest percentage of ACM symptoms (22%) in the study area, followed by Bumbafu (14.5%), Mukalasa (8.25%), Abude (4.75%), and Sawasawa (4.5%). Other cultivars, such as Mayayi, Caterina, Rava, Waliba, Boxe and MM 96 show a low percentage of ACM symptoms.

These results suggest that the Pamitu, Bumbafu, Mukalasa, and Abude cultivars are more susceptible to ACM compared to other cassava cultivars in the study area. Susceptibility to ACM is influenced by both the cassava cultivars and the environmental conditions, as well as the genetic variability among them. Kalonji (2008) observed in his comparative study on cassava varieties in Gandajika territory reported that newly introduced cassava cultivars exhibited lower levels of infection compared to local cultivars.

However, the average incidence observed in our study was relatively low compared to the findings of Kadima et al. (2017), who reported an average incidence of 81.7% for the susceptible cultivars Nsanginsangi and Mankanu, with a lower incidence of 52.8% for those less susceptible. This discrepancy may be attributed to climatic factors, altitude, the genetic makeup of different cassava cultivars, and varying agricultural practices.

3.4.4. Severity of ACM on planted cassava cultivars

Figure 4 presents the severity of ACM in the planted cassava cultivars.

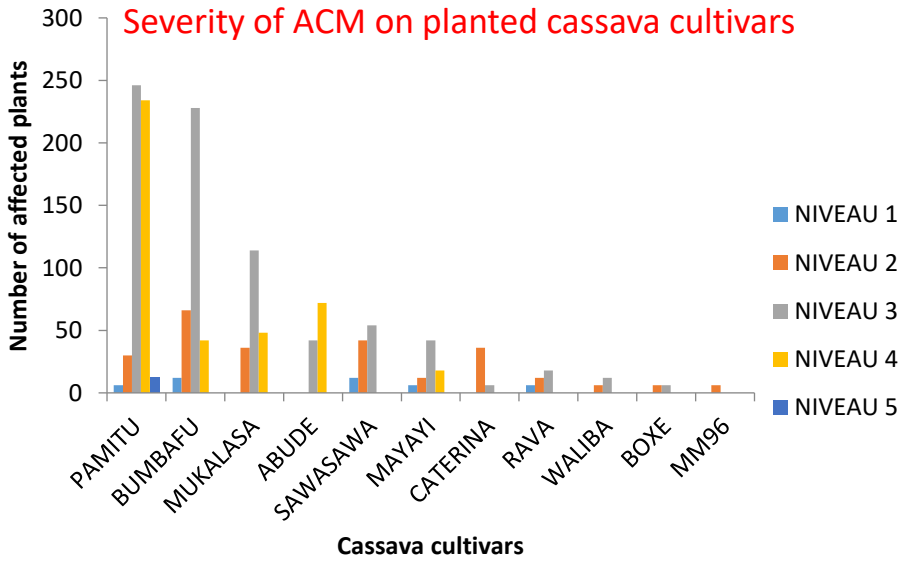

Figure 4. Severity of ACM on planted cassava cultivars

The figure indicates that, on average, under the eco-climatic conditions of Bunia and its surroundings, the Pamitu cultivar ranks highest among the planted cassava cultivars regarding various levels of ACM severity. The Bumbafu cultivar follows in second place, with Mukalasa, Abude, Sawasawa, Mayayi, Caterina, Rava, Waliba, and Boxe cultivars ranking subsequently, while the MM96 cultivar occupies the last position.
The cultivars Pamitu, Bumbafu, and Mukalasa(**the local cultivars**) are therefore the most affected by ACM in the study area.

IV. Conclusion and recommendations

The present study was conducted in Bunia and its surroundings, aiming to determine cassava farming systems and evaluate the incidence and severity of ACM in order to assess the state of this disease in the region.

To achieve this objective, an agronomic survey was conducted from March 15 to April 15 in Bunia town across its four areas: Bankoko, Kindia, Mudzi-Pela, and Simbilyabo, as well as in the surrounding areas.

The survey results indicate that in most cassava farms surveyed (62.5%), cassava is planted in association with other crops. The mean incidence rate of ACM in the study area approaches 62%, with average severity levels of 3 and 4.
Additionally, the results revealed that the Pamitu, Bumbafu, and Mukalasa cassava cultivars are particularly susceptible to ACM, with incidence rates of 22%, 14.5%, and 8.25%, respectively, and high severity levels between 3 and 4.

These findings confirm our working hypothesis that cassava cultivars grown in Bunia and its surroundings exhibit varying reactions to ACM. However, all cassava cultivars, whether local or improved, are susceptible to this disease, with high levels of incidence and attack rates observed in the study area.

We recommend that the Congolese government, through its national, provincial, and local services, provide effective support to farmers. This includes implementing preventive measures to control diseases affecting cassava crops, particularly ACM, and training farmers through extension services on disease management, which is a critical factor in cassava yield decline. Furthermore, it is essential to enhance support for research institutions in selecting cassava varieties that are resistant to ACM and adapted to the specific agroecosystems of the DR Congo.

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