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Study of the Growth Parameters of Twenty-Nine Sweet Potato Cultivars [*Ipomoea Batatas* (L.) Lam., 1793]: Collections in the Various Territories of Maniema Province, DR Congo

Lingot Buledi Amuri[1,2*], Brakus Yuma Brahimu[1,2], Salumu Djumaa[1], Défi Amuri Assani[1], Didier Luvengo Darabu[1], Florent Bondekwe[3], JC Mozenga Lokela[3], Jean-claude Esuka Alfani[3], Benjamin Dowiya Nzawele[3], Sylvain Solia Edondoto[3], Albert Okungo Lotokola[3]
[1]Department of Phytotechnics, Faculty of Agronomic Sciences of the University of Kindu, BP. 122/Kindu, DR Congo
[2]DES/Phytotechnics Program, Faculty of Agronomic Sciences, Faculty Institute of YANGAMBI, BP. 1232 Kisangani and BP 28 YANGAMBI, DR Congo
[3]Faculty of Agronomic Sciences, Faculty Institute of YANGAMBI, BP. 1232 Kisangani and BP 28 YANGAMBI, DR Congo

ABSTRACT

The main objective of this study was to evaluate the growth performance of 29 sweet potato cultivars [(*Ipomoea batatas* (L.) Lam., 1793] collected from different territories in Maniema Province. Twenty-nine cultivars were collected in five territories of Maniema province and the city of Kindu. To achieve this, we used an elongated plot design composed of simple rows. The results obtained showed that: the highest number of lobes was observed in cultivar C20 with eight lobes; the longest petiole was observed in cultivar C2 with 28.17 cm; the largest dimensions of the spreading leaves were recorded in cultivars C17 and C10 with 23.67 cm and 23.33 cm respectively; for the length of the main stem, the maximum values were recorded in cultivar C24 with 384.00 cm, followed by cultivar C3 with 330.00 cm; the shortest internodes were noted in cultivars C28 and C21 with 2.33 cm and 2.50 cm respectively. Hierarchical ascending classification (HAC) made it possible to establish a dendrogram illustrating the structuring of sweet potato cultivars into five distinct groups, defined on the basis of their growth characteristics, and another dendrogram illustrating the structuring of sweet potato cultivars into four different groups based on their morphological characteristics of the aerial parts of the plant.

Keywords: study, characterization, collection, morphological, sweet potato

INTRODUCTION

In sub-Saharan Africa, roots and tubers constitute the most important food crops (Chancelle, 2015). Sweet potatoes contain 10 times more vitamin A than white potatoes, and they also contain carotenoids (N'guessan et al., 2021; Afuape et al., 2014). After cassava, sweet potato ranks second among root and tuber crops in Africa in terms of production and quantity consumed (Loumana et al., 2022). Sweet potato is a high-quality food, rich in vitamins A, B, and C, and calcium (Ca) (Bell et al., 2016).

The sweet potato (*Ipomoea batatas* L.) is a tuberous crop of great economic importance in tropical and subtropical regions of Africa (Sihachakr et al., 1997). Its agronomic characteristics, such as broad adaptability, high productivity, a short growing cycle, and high nutritional value, make it a particularly important crop for food security in countries subject to intense human pressures and vulnerable to climate change (Bovell-Benjamin, 2007), but it is also subject to many constraints (Alain et al., 2019).

* Corresponding Author

Sweet potatoes are not always identical. They can differ in certain morphological attributes, such as the color of their leaves, stems, and petioles, and the shape of their leaves. It is therefore said that there are several sweet potato morphotypes (Bell et al., 2016). In production areas, sweet potato morphotypes are designated by vernacular names related to the phenotype, the name of their place of origin, or the name of the person who introduced them to a locality. This method of naming often leads to confusion, since the same morphotype can have different names depending on the production area (McKey et al., 2011; Emperaire et al., 2022).

Characterization not only allows us to identify existing morphotypes, but also to guide conservation and management methods for these genetic resources in varietal improvement programs (Nébié et al., 2013). The lack of characterization of a local sweet potato crop collection in Maniema province is a major concern for the promotion of this crop.

Thus, the main concerns of this study are as follows: How are the morphological and growth parameters of 29 sweet potato cultivars harvested in Maniema Province characterized? The specific questions are: - What are the morphological characteristics of each of the sweet potato cultivars collected from the different production areas of Maniema Province? - What are the distinctive growth characteristics of each of these different sweet potato morphotypes collected in Maniema?

To address this issue, we formulate the following hypotheses: The main hypothesis: There is significant variability between the 29 sweet potato cultivars collected in the different territories of Maniema Province with regard to growth parameters.

Specific hypotheses: The sweet potato morphotypes collected in Maniema Province have very different morphological and growth characteristics. Overall, our work aims to evaluate the growth performance of 29 sweet potato morphotypes collected in different areas of Maniema Province. The specific objectives of this work are as follows: to identify, collect, and establish a collection field for the different sweet potato morphotypes cultivated in Maniema Province; to determine the morphological and growth characteristics of all the collected morphotypes; and to compare their vegetative growth behavior.

MATERIALS AND METHODS

Medium

Our investigation was conducted in five territories of Maniema Province (Kasongo, Kibombo Pangi, Kabambare, and Kailo), including the city of Kindu, for the identification and collection of different sweet potato cultivars. This province is located in the center of the DRC (Makondambuta, 1997), but the woodlot and collection field were established in the city of Kindu, specifically at the University of Kindu campus in Lwama I. The study covered the period from April 25, 2024, to March 3, 2025.

The geographical coordinates of the experimental site are as follows: 02°56'32" East longitude, 025°53' 06.2" South latitude and 497m altitude (GPS, 2024).

The city of Kindu is located at an altitude of 497 meters. The average monthly temperature varies between 23°C and 28°C, and the average rainfall is 1650 mm; its coordinates are 25°55' longitude and 2°55' south latitude (Buledi et al., 2021).

According to the Koppen classification (Aw), the city of Kindu belongs to the humid tropical climate characterized by two seasons: The dry season, which runs from mid-May to mid-August and is accompanied by intense fog in the morning and scattered light rains and The rainy season, which extends from August to May, thus offers the opportunity for two growing seasons: Season B, from mid-August to January, and Season A, from January to mid-May (Buledi et al., 2021). The geographical coordinates of the experimental site are as follows: 02°56'32" East longitude, 025°53' 06.2" South latitude and 497m altitude (GPS, 2024).

Our study site has sandy-clay soil and a gently rolling landscape. It is bordered to the east by the Lwanonga River, with small streams flowing into it and feeding into fishponds, and to the south by the Mikelenge River. The collection field is located in a fallow area dominated by *Chromolena odorata, Pueraria javanica*, and *Panicum maximum*.

Equipment

The material used consisted of cuttings of different sweet potato morphotypes identified and collected in five territories of Maniema province and the city of Kindu. The vines were taken from farmers' fields, propagated in the woodlot, and after two months the cuttings, 30 to 40 cm long and bearing 3 to 4 nodes or buds, were used in our experimental or collection field.

Methods

Prospecting and collection of sweet potato cultivars

This phase was carried out in two sub-stages, namely the pre-survey and the survey itself: Pre-survey: This consisted of identifying the places where the population cultivates sweet potatoes and the survey itself: It involved going into the targeted territories, each sector and/or chiefdom to get to where the farmers practice sweet potato cultivation.

In each sweet potato production area, we formed a focus group (discussion group) of 8 to 12 people made up of fathers who talked about forms of different cultivars existing in the environment, places of origin, vegetative cycle, uses and type of useful products and we designated two people who accompanied us to the fields to make the identification and collection of different sweet potato cultivars grown in their environment.

Installation of the collection field

The vines were propagated and remained in the woodlot for two months, from June 1st to August 1st. Sweet potato characterization was carried out to identify there morphologically diverse.

Experimental setup

To conduct this field study, we used an elongated plot design composed of simple rows. Each row of a cultivar contained 12 mounds (replicates). The number of cultivars was 29, corresponding to the number of rows. The distance between rows or between two different cultivars was one meter, and the distance between mounds was 0.8 meters.

Conducting the test

Before installing the experimental field, we started by installing the wood park, which lasted two months from June 1st to August 1st, 2024.The preparation of the experimental field involved the following operations:

Site selection took place on June 15, 2024; site demarcation took place on June 20, 2024, using stakes and string; clearing took place from June 21 to 25, 2024, using a machete; plowing and harrowing were carried out from July 1 to 5, 2024, using a hoe; plot demarcation took place on July 10, 2024, using string and stakes; mound construction took place from July 25 to 27, 2024, using a hoe; staking took place on July 24, 2024, using stakes; labeling was done on July 29, 2024; cuttings were prepared on August 2, 2024; planting: Manual tilling was carried out before the mounds were made; four-node cuttings were cut and then planted on mounds. We planted on mounds 40 cm high, which were spaced 100cm x 80cm apart, with 3 cuttings per hole to ensure greater regularity of establishment. The operation took place on 03/08/2024; LRefilling of gaps took place two weeks after planting and two weedings spaced one month apart and harvesting began for some cultivars from six months, others seven months.

Images of different sweet potato cultivars (leaves and tubers) that are the subject of our study are shown in Figure 1 below.

Figure 1. Images of different sweet potato cultivars (leaves and tubers) during harvest

Parameters to observe

For this study, we observed morphological and growth parameters.

Morphological parameters: The predominant color of the stem, with macroscopic observation; the general appearance of the leaf, with macroscopic observation; the type of leaf lobation, with macroscopic observation; the color of the spread leaves, with macroscopic observation; the color of the immature leaves, with macroscopic observation; the pigmentation of the petioles, a macroscopic observation was made.

Growth parameters: The number of lobes on the leaf; we did the manual counting; the size of the spread leaves, we measured the length of the base lobes at the tip of the leaves (cm); the length of the internodes, we took this measurement with a graduated ruler (cm); the length of the petiole, with a graduated ruler (cm); length of the main stems, with the tape measure (cm).

Statistical analysis of data

The collected data was entered into an Excel spreadsheet. The analysis of morphological data was primarily descriptive. The structuring of morphological diversity in sweet potato cultivars was assessed using principal component analysis (PCA) based on quantitative cultivar traits to identify two main axes of variability with eigenvalues greater than 1, hierarchical clustering (HCA), and multiple correspondence analysis (MCA). The data collected on vegetative parameters composed of quantitative variables, were first subjected to verification of the conditions for applying analysis of variance (ANOVA). When the conditions were met, a on-way ANOVA was performed followed by the Tukey HSD test for understanding means. On the other hand, for variables not satisfying the conditions of normality or homogeneity, the non-parametric Kruskal-Wallis test was used, follow by the Dunn test with a Bonferroni correction for multiple comparisons. The attribution of significant letters of the averages was made according to the results of these tests. Multivariate analyses were conducted using R software version 4.5.1 (Ihaka & Gentleman, 1996).

PRESENTATION OF RESULTS AND DISCUSSION

The results are organized to show the characterization of the qualitative quantitative variables of different sweet potato cultivars collected by referring to the descriptor.

Results

Characterization of growth parameters

The results of different cultivars collected on growth parameters are presented in the summary table below.

Table 1. Summary of results on growth parameters

Cultivars	NL	LP (cm)	DF (cm)	LTP (cm)	LEN (cm)
C1	4.33 ± 0.47ab	18±1.191abc	10.50±2.57ab	135±9.57ab	8±0.82a
C2	5±0.58bd	28.17±2.03d	13.33 ± 0.94 b	280±12.91i	4.67±0.47c
C3	4±0.58bc	14.33 ± 1.11 hi	11.50±1.89bd	330±11.9k	4±0.82cd
C4	4.17±0.37ab	18.67±1.11bc	11.83±1.57bd	175±10.8gh	4.33 ± 0.75c
C5	5±0.0bd	12.5±0.96h	9.50±1;26ab	96.5±7.59ef	4.33 ± 0.75c
C6	4.17±0.37ab	14.5±0.96hi	10.83±1.46ab	107±11.94bf	4±0.08cd
C7	5.17±0.37ad	11.83±1.07h	21.33±3.54c	170.17 ± 8.55 dh	7.33 ± 1.11a
C8	7±0.0 gh	16.5±0.96ci	21.83±2.79c	89.67±2.69ef	4.17±0.69c
C9	6±0.58dh	16.5±0.76ci	10.17±1.34ab	87.83±7.49ef	4.5±0.5c
C10	4±0.58bc	27.5±3.1 of	23.33 ± 1.7c	223.83±25.24c	3.67 ± 0.47bc
C11	5±0.58bd	8.33±0.75f	10.83±1.34ab	138.33±5.53bd	4.67±0.47c
C12	5±0bd	20.83±3.76bg	8.67 ± 0.47 ad	133.33 ± 9.43ab	4.5±0.5c
C13	5±0.58bd	12.5±1.38h	11±0.82ab	85.5±6.55ef	4±0.58cd
C14	5±0bd	15±0.82ahi	12.17±1.07bd	82.83 ± 35.18 ef	4.83 ± 0.37c
C15	5±0bd	16±1.15cij	12.83±1.57bd	109.5±23.3abf	3.33 ± 0.47bc
C16	5±0.58bd	12.67±0.94hj	22.17±2.67c	226.17±21.71c	4.67±0.47c
C17	1±0e	18.67±1.11bc	23.67±1.37c	234.33±15.57c	4.83 ± 0.37c
C18	5±1bd	23.83 ± 1.07 gk	24±0.82c	141.67±7.74adg	3.67 ± 0.47bc
C19	2±0ef	14±0.82hi	10.17±1.34ab	185.5±7.14h	4.67±0.47c
C20	8±0.58g	23.67±1.37gk	12.5±1.26bd	137.67 ± 5.53 bd	3.5±0.5bc
C21	1±0e	14.5±0.76hi	13.33 ± 1.11 b	67.17±5.98e	2.5±0.5bd
C22	5±0bd	16.33 ± 1.25 ci	21.5±3.1c	137.5±7.72bd	4.5±0.5c
C23	5±0.82bd	23.33 ± 1.11 gk	20.5±2.63c	169.5 ± 14.48 dh	4.17±0.69c
C24	3±0cf	18.83±1.07bc	21.67±2.13c	384.5 ± 22.09 days	7.17±0.69a
C25	4±0.58bc	24.33 ± 1.6ek	13.17±1.07b	110.33±16.55abf	3.5±0.5bc
C26	5±0.58bd	26.33 ± 0.75 dk	11.17±1.07ab	243±7.19c	11.33±0.75e

C27	5±0bd	24.67±1.7ek	7±0a	280.17±9.37i	7.33 ± 1.25a
C28	4±0bc	16.67 ± 0.75 ci	9.17±0.69ab	83.33±11.59ef	2.33 ± 0.47 b
C29	5±0bd	15±1ahi	13.17±1.07b	135.17±9.51ab	3.33 ± 0.47bc

Legend: C1-C29: Cultivars; NL: Number of lobes per leaf; LP: Petiole length; DF: Dimension of spread leaves; LTP: Main stem length; LEN: Internode length.

The averages followed by the same letter in a column does not differ significantly at the threshold of 5% depending on the Turkey HDS test (for the data that has responded to the conditions of the ANOVA) or according to the Dunn test with the correction of Bonferroni for the data analyzed by Kruskal-Wallis test.

Analysis of Table 1 highlights a significant variability in growth parameters among the different cultivars studied. The results in Table 1 show the following: the highest number of lobes was observed in cultivar C20 with eight lobes, followed by cultivar C8 with seven lobes and cultivar C9 with six lobes. Conversely, the lowest number of lobes was recorded in cultivars C17 and C21, each with a single lobe, as well as in cultivar C19 with two lobes per leaf. The other cultivars exhibit intermediate values. Regarding petiole length, the highest values were recorded in cultivar C2 at 28.17 cm, followed by cultivar C26 at 26.33 cm, while the shortest lengths were observed in cultivars C27 and C28, measuring 7.00 cm and 9.17 cm respectively. The other cultivars exhibit intermediate lengths. The largest leaf sizes when fully extended were recorded in cultivars C17 and C10, at 23.67 cm and 23.33 cm respectively, while the smallest were observed in cultivars C27 and C28, at 7.00 cm and 9.17 cm. The other cultivars exhibited intermediate sizes. Cultivars with large leaf sizes can effectively cover the soil, protecting it from erosion.

Furthermore, the length of the main stem shows considerable variability among the different cultivars. The maximum values were recorded in cultivar C24 at 384.00 cm, followed by cultivar C3 at 330.00 cm, while the minimum values were observed in cultivars C14 (82.83 cm), C13 (85.50 cm), C9 (87.83 cm), and C8 (89.67 cm). The other cultivars are characterized by intermediate lengths, reflecting morphological heterogeneity within all the genotypes studied. Cultivars with long stems cover a large portion of the soil and protect it well, and the length of the internodes also shows marked variability: the highest values were observed in cultivar C26 at 11.33 cm, followed by cultivar C1 at 8.00 cm, while the shortest internodes were noted in cultivars C28 and C21 at 2.33 cm and 2.50 cm respectively. The other cultivars fall between these extremes.

The Kruskal-Wallis test revealed significant differences between cultivars in the number of lobes, petiole length, main stem length, and leaf length (p-value < 0.05). Furthermore, one-way analysis of variance (ANOVA) also showed statistically significant differences in internode length among the 29 cultivars studied (p-value < 0.05).

The results relating to the principal component analysis (PCA) of the growth parameters are presented in the table below:

Table 2. Results of the principal component analysis (PCA) on growth parameters

Component			**Comp1**	**Comp2**
Equity			1.751	1,158
Relative variance (%)			35,027	23,152
Cumulative variance (%)			35,027	58,179
No.	Quantitative morphological descriptor	Code		
1	Number of lobes per leaf	NL	-0.1523972	0.8261900
2	Petiole length	LP	0.6236521	0.3333157
3	Dimensions of the spread-out sheets	DFE	0.3746051	-0.4711881
4	Length of main stems	LTP	0.8663075	-0.1558941
5	Internode length	LEN	0.6696060	0.3428848

The results concerning the variability of growth parameters in sweet potato cultivars are presented in Table 2. Principal component analysis (PCA), performed on five growth traits, revealed two main axes of variability characterized by eigenvalues greater than 1. These two axes together explain 58.179% of the total variance observed in characterizing cultivar diversity. The first axis contributes 35.027% of the total variance, while the second explains 23.152%.

The first principal component, which accounts for the largest share of the variability (35.027%), is primarily determined by four variables: petiole length, leaf length, internode length, and main stem length. In contrast, the second component, explaining 23.152% of the variance, is essentially correlated with a single variable, the number of lobes, which thus constitutes the main discriminating factor along this axis.

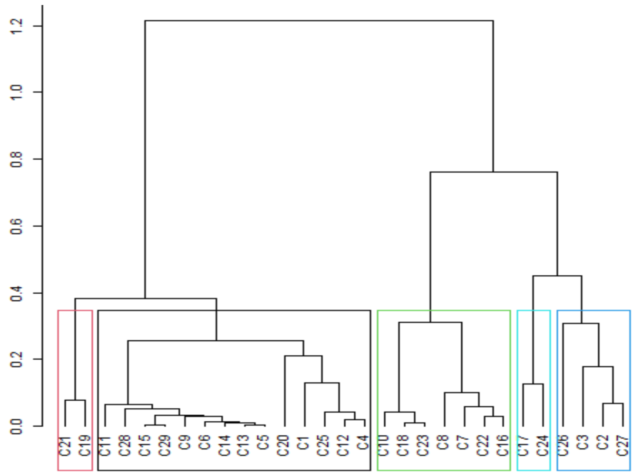

Figure 2. Dendrogram of cultivars in relation to growth parameters

Hierarchical cluster analysis (HCA) was used to construct a dendrogram illustrating the structuring of sweet potato cultivars into five distinct groups, based on their growth characteristics. This analysis highlights the following groupings:

Group 1 comprises 14 cultivars (C1, C4, C5, C6, C9, C11, C12, C13, C14, C15, C20, C25, C28 and C29) distinguished by high values of internode length, main stem and spreading leaves; Group 2 comprises only two cultivars (C19 and C21) characterized by a very low number of lobes per leaf compared to the other cultivars; Group 3 consists of seven cultivars (C7, C8, C10, C16, C18, C22 and C23) with particularly long leaves, which clearly differentiates them from the other groups; Group 4 includes two cultivars (C17 and C24) characterized by a long main stem and a high number of lobes per leaf; and Group 5 includes four cultivars (C2, C3, C26 and C27) which are distinguished by significant lengths of internodes and petiole compared to the other cultivars.

Characterization of morphological parameters

The results relating to the multiple correspondence analysis (MCA) on morphological traits are given in the table below:

Table 3. Results of multiple correspondence analysis (MCA) on morphological traits

Components			**Comp1**	**Comp2**
Equity			0.577	0.412
Relative variance (%)			13,927	9,949
Cumulative variance (%)			13,927	23,876
No.	Qualitative morphological descriptor	Code		
1	Flowering appearance	AF	0.1649122	0.1086210
2	Predominant stem color	CPT	0.9011130	0.3349619

3	General appearance of the leaf	AGF	0.2301640	0.6514484
4	Leaf lobation type	TLF	0.2197689	0.6072000
5	Colors of the spread leaves	CFE	0.8071663	0.1202075
6	Color of immature leaves	CFI	0.8016822	0.6399365
7	Petiole pigmentation	PP	0.9141556	0.4227206

Legend: AF: Flowering appearance; CPT: Predominant stem color; AGF: General leaf appearance; TLF: Leaf lobation type; CFE: Open leaf colors; CFI: Immature leaf color; PP: Petiole pigmentation.

The results concerning the morphological variability of sweet potato cultivars are presented in Table 4. Multiple correspondence analysis (MCA), performed on seven morphological traits, revealed two main axes of variability, each with eigenvalues less than 1. These two axes together explain 23.876% of the total variance observed in the morphological characterization of cultivar diversity. The first axis contributes 13.927% of the total variance, while the second explains 9.949%.

The first principal component, representing the largest share of variability (13.927%), is primarily influenced by four variables: the predominant stem color, the color of fully opened leaves, the color of immature leaves, and petiole pigmentation. Furthermore, the second component, explaining 9.949% of the variance, is mainly correlated with two variables: the overall appearance of the leaf and the type of leaf lobation, which constitute the main discriminating factors for this axis.

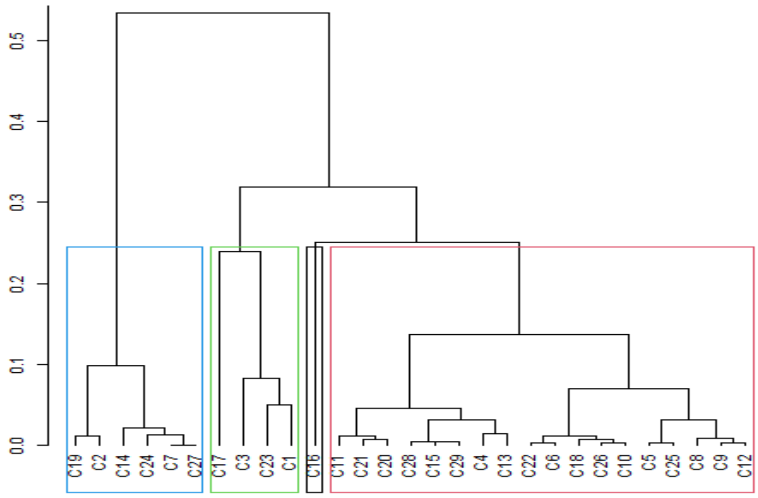

Figure 3. Dendrogram of cultivars in relation to morphological characteristics

Hierarchical cluster analysis (HCA) was used to create a dendrogram illustrating the structuring of sweet potato cultivars into four distinct groups, defined based on their morphological characteristics. This analysis highlights a clear differentiation between the groups, reflecting marked phenotypic diversity within the studied plant material. The following results emerge:

- Group 1 consists of a single cultivar, C16, characterized by leaves lacking lateral lobes and stems exhibiting predominantly purple pigmentation.
- Group 2 comprises 18 cultivars (C4, C5, C6, C8, C9, C10, C11, C12, C13, C15, C18, C20, C21, C22, C25, C26, C28, and C29), distinguished by a high degree of color variability in the stem, spreading leaves, immature leaves, and petiole pigmentation. Within this group, some stems exhibit a dark green or purple coloration, the spreading leaves are green or grayish-green, the immature leaves are green or purple, and the petioles have pigmentation ranging from green to intense purple.

- Group 3 comprises four cultivars (C1, C3, C17 and C23), characterized by green stems with some purple spots, green petioles with purple streaks and spreading green leaves with slightly purple margins.
- Finally, group 4 comprises six cultivars (C2, C7, C14, C19, C24, and C27), distinguished by strong pigment variability. The stems are green or uniformly dark purple, the spreading leaves are green or grayish-green, while the immature leaves are entirely purple or purple on both sides. The petioles show green pigmentation tinged with purple at the base of the leaf blade, or are predominantly purple.

Discussion

Regarding internode length, the shortest lengths were observed in cultivars C28 and C21, at 2.33 cm and 2.50 cm respectively. This allows the plant to produce numerous stolons capable of drawing sufficient water and nutrients from the soil. Short internodes also enable the plant to produce ample propagation material. This finding was confirmed by Allain et al. (2016) based on the characterization of 10 sweet potato cultivars in Burkina Faso. Mambokolo (2024) in Kisangani reported that two cultivars had very short internodes (3.02 and 3.22 cm), which closely matched our results.

Regarding flowering, some cultivars produced flowers while others did not until maturity. These results confirm those of Mambokolo in 2024 in Kisangani, where some of the nine collected cultivars did not flower until harvest. Concerning leaf shape, our twenty-nine collected cultivars grouped into five classes: cordate, triangular, lobed, nearly divided, and bean-shaped. Our results confirm those of Mambokolo (2024), who, with his nine collected cultivars, found that the cultivars grouped themselves according to leaf shape. In this respect, our results confirm those of Kouassi et al. (2029) in Ivory Coast, they found a very large variation in leaf shape. As for the number of leaf lobes, the number varied from 1 to 8, which is similar to the results of Alain et al. (2015) in Chad on the ten cultivars that were grouped together. For the number of lobes, our results showed significant differences between the cultivars, which confirms the results found in Ivory Coast in 2029 by Kouassi et al. (2019). This is also similar for the color of spread and immature leaves.

CONCLUSION

The main objective of this study was to evaluate the morphological and growth performance of 29 sweet potato morphotypes collected from different areas of Maniema Province. The results showed that: the highest number of lobes was observed in cultivar C20 with eight lobes; the longest petiole was observed in cultivar C2 at 28.17 cm; the largest dimensions were recorded in cultivars C17 and C10 at 23.67 cm and 23.33 cm, respectively. Cultivars with large leaf dimensions provide good ground cover, protecting the soil from erosion; the maximum length of the main stem was recorded in cultivar C24 at 384.00 cm, followed by cultivar C3 at 330.00 cm. Cultivars with long stems cover a large portion of the soil and provide good protection. The shortest internodes were observed in cultivars C28 and C21, measuring 2.33 cm and 2.50 cm respectively. This allows the plant to produce numerous stolons. Hierarchical cluster analysis (HCA) was used to create a dendrogram illustrating the structuring of the sweet potato cultivars into four distinct groups, defined based on their qualitative morphological characteristics. This analysis highlights a clear differentiation between the groups, reflecting marked phenotypic diversity within the studied plant material.

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