IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)
e-ISSN: 2319-2380, p-ISSN: 2319-2372. Volume 14, Issue 12 Ser. I (December 2021), PP 45-53
www.iosrjournals.org

Characterization of the 31 genotypes cultivated under the threat of cassava brown streak disease

Nakishuka Bitaisha Shukuru[1,2*], Sakshi Sharma[1], Jean-Claude Birindwa[3]
[1]*Department of Plant Pathology, School of Agriculture, Lovely Professional University (LPU), PO Box 144411 Phagwara, Punjab, India*
[2]*Plant Pathology Laboratory, Department of Crop Production, Faculté des Sciences Agronomiques, Université Catholique de Bukavu (UCB), PO Box 285 Bukavu, South Kivu, DR Congo*
[3]*Tissue Culture Laboratory, International Institute of Tropical Agriculture (IITA-The President Olusegun Obasanjo Research Campus), P.O.BOX:1222 Bukavu, DR Congo*
**Corresponding Author: NB Shukuru*

Abstract:
Background*: In areas like DR Congo where cassava leaves are eaten, leaf diseases "dispossess" farmers and other consumers of green vegetable. Cassava brown streak diseasediscolors leaves; mixed to the mosaic disease, the alteration of the shape and size of the leaves is observed. The fundamental objective of this work consists of studying vegetative parameters, especially cassava leaf yield potential, of the 31 genotypes cultivated under the threat of cassava brown streak disease.*
Materials and Methods*: The trial was set up according to the full randomized block design. At planting, 31 local and improved genotypes were selected as experimental materials. Observations focused more specifically on morphological characteristics of tested cassava cultivars.*
Results*: The results showed that the number of leaves per plant depend to each genotype regarding their intrinsic particularities. The decreasing in number of leaves and leaf area for many cultivars were observed during field experiment. The number of leaves of all cultivars varies from around 14leaves for Kanombe variety to 37 leaves for M'Bailo variety, 28 (Nabana) to 121 (Korengo), 25 (Kanyunyi) to 161.33 (Dorothea) and 7.03 (Kanyunyi) to 142.83 (Dorothea). This large variation in the number of leaves is justified by the fact that some cultivars have many branches (3 or more) and others do not, at 2, 4, 6 and 8 months after planting (MAP) respectively.*
Conclusion*: Some cultivars are even less susceptible to the disease. For most genotypes, cassava leaves become unattractive for consumption.*
Key Word*: Cultivars' screening, leaf production, agronomic characters, Cassava Brown Streak Disease*

Date of Submission: 06-12-2021 Date of Acceptance: 21-12-2021

I. Introduction

Cassava cultivation is threatened by the emergence of strong viral diseases expansion across the African continent. This poses a major security threat food, especially for children peasants practicing agriculturesubsistence.[1]. These latter unwillingly contribute to the spread of virus infections by the exchange of infected cuttings resulting in a constant reduction in yields.[2]. It results a gradual abandonment of cultivars premises in favor of improved varieties leading to the erosion of genetic resources of local cassava varieties. However, the safeguard of these local cultivars is an issue important for agricultural development sustainable in sub-Saharan Africa. In the current context of change climate, one of the strategies likely to fight against this erosion consists of collection, analysis, and organization of existing diversity in areas of production. This not only allows know the existing cultivars, but also to shed light on the importance of cassava leaves for most consumers.

Cassava is a heliophile plant, which requires abundant sunshine, therefore comprising an intermediate photosynthesis cycle between C4 and C3; a reduction in solar radiation leads to an increase in the length of the internodes and reduces the speed of production of new leaves, the lifespan of the leaves and ultimately the leaf surface. Cassava brown streak disease and mosaic disease discolor leaves; the mosaic alters the shape and size of the leaves.[3].The study is essential in regions exposed to chronic famines, this is the case in South Kivu, DR Congo where cassava cultivation is a solution, a crop serving as a reserve in the event of food shortage due to climatic

disturbances observing in those days in the province. Socially and scientifically, the study aims respectively to shed light on the choice of varieties to be used by farmers and to contribute to the literature on the extent and severity of cassava brown streak disease regarding its threat since no study in this context has been carried out so far in the study region.

II. Material And Methods

The field experiment was conducted in South Kivu, DR Congo between November 2017, and July 2018. The choice of the experimental site depended on several factors. These include the diversity of the crop on the site, i.e., where the cassava is most cultivated, the environment where the brown streak is present, the cultivated varieties being very sensitive and in which producers experience the greatest losses due to the said disease.

Study Design: Randomized block design

Study Location: The characteristic geographic coordinates of the study site, specifically the village of Kawizi, located in the Uvira territory, vary from 29 ° 10'45.138 " to 29 ° 10'47.496 " East longitude, 3 ° 17'9.804 " to 3 ° 17'12.924 " South latitude with varying altitude from 786 to 795 m.

Study Duration: November 2017 to July 2018.

Sample size: 31 genotypes of cassava.

Material

Only 31 local and improved cassava varieties were collected for the study: Nvulamingi, Kabunga, Nseke'elwa, Nambiyombiyo, Cintalula, Maombi, Musimwa, Kanombe, Cibongoyoka, Kamegere, Liyayi, Sawasawa, Dorothea, Siri (Amasi), M'Bailo, Nakarasi, Mvuama (Mukombe / Mama uwaki), Nabana, Nabwigoma, Muzungu, Ngoromane, Maguruyinkware (Kumigulu), Papayi, TMS 2001/1661, Kanyunyi, Mahungu, Obama (TME 419/V8), Rav, Korengo, Naunde and Mayombe.

Methods

Experimental apparatus

The randomized block design used includes three repetitions, each with 31 variations. The experimental field was 97 mx 104 m, or 10,088 m2 or 1.01 ha, and was divided into 93 plots of which 31 plots per block. The unit plot was 9 m long and 8 m wide, divided into 9 ridges, and had 72 plants, or 30 observable plants, the rest serving as a border. When planting, cuttings 20 to 25 cm long are inserted obliquely at an average angle of 45 ° on the ridges, at a spacing of 1m x 1m. At each observation period, 30 plants out of 72 are considered in a plot, previously chosen at random from the useful plot, consisting of only 7 ridges; the first plants at the ends of the sides of each log being excluded and limiting, together with the other two ridges at the ends, the edge effect.

Conduct of the study

The cuttings were taken from peasant fields during harvest; very often, some already normally infected with the diseases although the symptoms were not visible. This made it possible to apply heat therapy, disinfecting the prejudiced diseased cuttings. The following criteria for the removal of the cuttings were considered, including the health status (on healthy mother plants) and the age of the stems (8 to 18 months).

The tillage consisted of clearing, brushing, plowing, loosening the soil, and tracing ridges. The planting of the cuttings took place on November 17 and 18, 2017, and the procedure for setting up the culture took place manually. The maintenance work focused on relining the voids, the operation having coincided with the removal of the cuttings recovery rate between December 9 and 10, 2017, i.e. three weeks after planting, carried out manually, using the cuttings times placed at the end of each row of planting, and the weeding having been carried out seven times, given the importance of the weed species and their rapid proliferation in the experimental environment, precisely at the fifth, ninth, thirteenth, eighteenth , twenty-third, twenty-eighth, and thirty-third week after planting (SAP).

Observations

Data collection for most of the morphological and health parameters and characters was carried out every two months, except for the recovery rate in the third week after planting (3SAP), and observations on the roots which occurred in the sixth and eighth month after planting (6MAP and 8MAP).

The observation of the characters focused on the recovery rate, the canopy recovery rate (%), which consisted of an estimate of the recovery of the aerial part for each variety, this in the sixth and eighth month of the culture, the size of the plants (m), from the base to the top was estimated, the estimate of the number of leaves which

was the count of all the leaves for each plant, the leaf area (cm2), having concerned the estimation in taking into account the midlobe, its length, fully developed from each plant. The formula used is that of Hammer (1980): *Ln (LA) = -7.47 + 2.460 * Ln (MLL)*, with Ln, the natural logarithm; LA, being the leaf area in cm2 and MLL, the length of the main lobe or median lobe in mm. The measurement of the diameters of the rods (mm), laterally to the base (raised part) was considered.

Statistical analysis

Repeated measurements, between two and four times, except for the rate of recovery of the cuttings which was recorded once, were carried out for each variable to show the variability of the parameters measured over time and to overcome measurement and climatic variations. The data collected was encoded in an Excel matrix to constitute the database (BDD) and undergo processing before the appropriate analyzes. The data obtained for the variables recovery rate, canopy cover rate, plant size, estimate of the number of leaves, leaf area, and diameter of stems, intended for the analysis of variance were first used. object of the Shapiro-Wilk test in R to test the normality of the residuals in different variables. For ANOVA tests, the least significant difference test (lsd) at 95% confidence level was used to compare means whenever the differences were found to be significant.

III. Results

Monitoring the evolution of certain parameters of vegetative development is necessary because they determine the yield of tuberous roots.

Cutting's recovery rate

Figure 1 gives the recovery rate of cuttings from 31 cassava cultivars. The Coefficient of Variation (CV) is 3.5%, the lsd = 3.935 and the total mean is 95.22103%. The cuttings recovery rate of different cassava genotypes showed a highly significant variation *** (P <.001), according to Anova. It ranged from 78.24 to 100% for all cultivars.

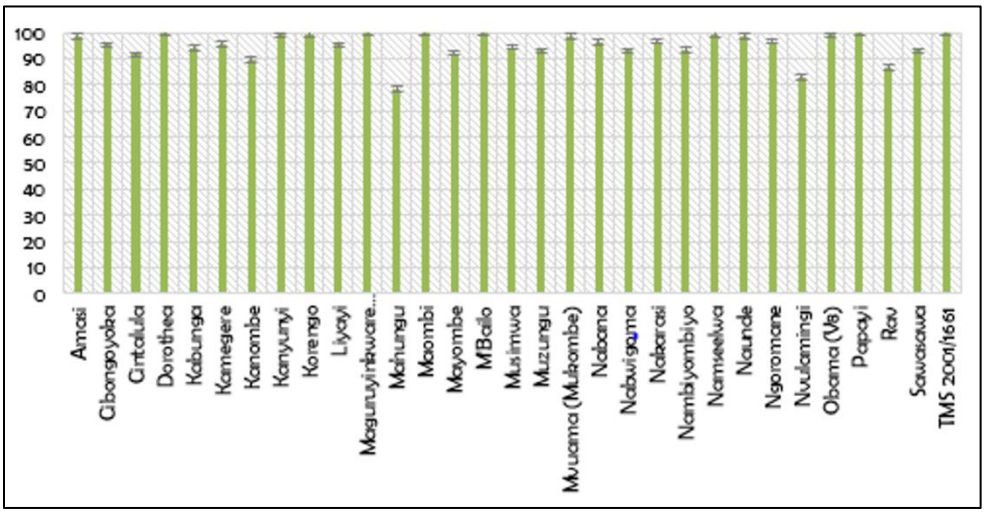


Figure 1. Recovery rates of cultivated varieties.

The varieties TMS 2001/1661, M'Bailo, Dorothea, Maombi, Maguruyinkware (Kumigulu), Papayi and Korengo showed the maximum recovery rate (100%) while the lowest rate is that of the Mahungu and Nvulamingi varieties for an average of 80% (Figure 3). This is explained by the drying out and loss of reserve material of the planting material during the transport and storage of the cuttings; the cutting of stems not considering the weight and number of nodes of the cuttings. In addition, for certain varieties where the number of stems was insufficient, by reducing the length of the cutting, this affected their recovery; threats to the crop from other diseases such as anthracnose and the distant provenance of cuttings influenced the recovery.

Distribution of genotypes according to vegetative characters

The measurements made show that at all stages of observation after the establishment of the culture, a highly significant difference was observed between the size of the plants, the diameter of the stems, the number of leaves and the rate of canopy coverage of all 31 cultivars studied, both improved cultivars and local cultivars (P <.001). It is the same for the leaf surface; except at 2MAP where there was a non-significant difference between the leaf area of cultivars taken together (P = 0.052) (Table 4). The means of the values obtained on these characters are presented in Tables 1-5. The standard error measurements with instructions ± in the table do not prove the contrary to us.

Growth in height and diameter

The different heights obtained with the cultivars under evaluation, local and improved, showed a considerable degree of dissimilarity between cultivars (Table 1). At 2 months of growth, the local cultivar M'Bailo grows faster in height than all the others (64.67cm), followed by two other local cultivars Nakarasi and Kabunga (56.67 and 55.00cm, respectively). However, it is among the varieties with an average height below 150cm, 4 months after planting, when the Korengo, Kanyunyi, Kabunga, Nvulamingi and Maombi varieties show an average height of 159.50cm, 158.50cm, 155.33cm, 154.00cm and 151.67cm, respectively. At 6 months, the varieties having shown an average height above 200cm are much more the improved cultivars Sawasawa (222.66cm) and Papayi (209.16cm), followed by three local culivars Kabunga (202.33cm), Cibongoyoka (201.67cm) and Cintalula (200.33cm). At this stage of vegetative growth, the local cultivars Maguruyinkware and Kanombe have lower heights (147.83cm and 155.33cm, respectively). Beyond this period, the local cultivar Dorothea bearing branches, elongates more quickly in height and overtakes all other cultivars, 8 months after planting the cuttings.

Table 1. Height of tested cassava genotypes.

Genotypes	Height (cm)							
	2MAP		4MAP		6MAP		8MAP	
Amasi (Siri)	46,83	±3.32	97,33	±6.65	195,33	±0.47	196,50	±5.78
Cibongoyoka	33,67	±4.75	120,17	±11.87	201,67	±4.75	187,00	±14.2
Cintalula	45,00	±5.70	101,83	±120.9	200,33	±3.32	201,50	±5.39
Dorothea	51,00	±1.42	130,00	±7.17	190,67	±3.80	242,00	±5.39
Kabunga	55,17	±3.80	155,33	±23.40	202,33	±3.32	206,50	±5.39
Kamegere	36,50	±0.00	105,67	±3.80	188,67	±0.47	199,00	±5.39
Kanombe	32,50	±0.00	66,67	±7.60	155,33	±8.07	165,00	±5.39
Kanyunyi	48,50	±0.00	158,50	±0.00	181,33	±1.90	211,00	±5.39
Korengo	41,00	±2.85	159,50	±19.65	199,00	±3.77	206,50	±5.39
Liyayi	36,50	±0.00	107,17	±6.17	171,33	±12.6	166,50	±5.39
Maguruyinkware	36,50	±0.00	80,83	±5.22	147,83	±53.9	121,50	±5.39
Mahungu	53,00	±5.70	130,00	±4.27	160,33	±18.1	184,50	±5.39
Maombi	45,00	±2.85	151,67	±14.72	188,67	±14.8	195,50	±5.39
Mayombe	35,00	±0.00	88,00	±0.00	192,67	±13.9	192,50	±5.39
M'Bailo	64,67	±8.07	137,00	±21.39	198,00	±2.85	231,50	±5.78
Musimwa	34,50	±2.85	144,17	±9.10	167,00	±4.27	176,50	±5.39
Muzungu	55,00	±0.00	121,50	±0.00	198,50	±5.14	210,50	±5.39
Mvuama	44,00	±0.00	144,50	±1.42	185,83	±9.81	194,50	±5.39
Nabana	37,33	±1.90	131,83	±5.22	215,50	±15.4	208,50	±5.39
Nabwigoma	23,50	±0.00	94,00	±9.97	191,00	±37.6	161,50	±5.78
Nakarasi	56,67	±6.65	147,00	±5.70	209,50	±1.42	207,50	±5.39
Nambiyombiyo	38,67	±1.90	148,83	±22.23	121,17	±12.2	129,50	±5.78
Nseke'elwa	45,00	±1.42	135,83	±13.40	164,33	±15.3	169,50	±5.39
Naunde	32,83	±1.90	104,33	±10.41	190,00	±9.70	232,50	±5.78
Ngoromane	46,50	±0.00	110,00	±0.00	197,00	±8.35	196,50	±5.39
Nvulamingi	52,67	±6.65	154,00	±13.46	187,55	±6.70	196,50	±5.78
Obama (TME 419)	37,50	±5.70	122,50	±0.00	208,50	±8.55	225,50	±5.78
Papayi	49,50	±0.00	128,50	±9.97	209,17	±2.37	209,50	±5.78
Rav	30,17	±2.37	97,67	±5.48	195,17	±3.71	195,00	±5.39
Sawasawa	41,67	±0.95	149,00	±1.42	222,67	±3.32	211,50	±5.78
TMS 2001/1661	42,50	±0.00	118,00	±0.00	167,17	±23.0	146,50	±5.39
P-value ; lsd ; CV	*<.001;3,171; 4,5%*		*<.001; 23,29; 11,5%*		*<.001 ; 14,393 ; 4,6%*		*<.001 ; 2,443 ; 0,8%*	

Stem diameter values ranged from 0.88 (Papayi) to 2.76 mm (Dorothea) at 2MAP, 1.22 (Kamegere) to 3.19 mm (Dorothea) at 4MAP, 1.97 (Obama or TMS 419) at 3.70 mm (Dorothea) at 6MAP, and 2.13 (Rav) at 3.92 mm (Dorothea) at 8MAP (Table 2). The local cultivar Dorothea grows rapidly, so it did not face competition from other cultivars for diameter growth. However, it is followed, in the second place, by the improved cultivar Papayi at 6 and 8MAP, when it is followed by Liyayi (2.05) and (2.65), respectively at the 2nd MAP and 4th MAP.

Table 2. Average stem diameter.

Genotypes	Stem diameter (mm)							
	2MAP		4MAP		6MAP		8MAP	
Amasi (Siri)	1,80	±0.27	2,21	±0.27	2,93	±0.58	3,03	±0.62
Cibongoyoka	1,12	±0.41	1,38	±0.42	2,13	±0.19	2,27	±0.19
Cintalula	1,34	±0.12	1,85	±0.14	2,40	±0.28	2,40	±0.28
Dorothea	2,76	±0.18	3,19	±0.15	3,70	±0.72	3,33	±1.01
Kabunga	1,37	±0.71	1,88	±0.71	2,60	±0.72	2,60	±0.59
Kamegere	0,95	±0.32	1,22	±0.03	2,11	±0.57	2,47	±0.74
Kanombe	1,01	±0.44	1,33	±0.24	2,02	±0.17	2,15	±0.35
Kanyunyi	1,63	±0.45	2,13	±0.45	2,90	±0.28	3,03	±0.34
Korengo	1,43	±0.13	1,93	±0.13	2,65	±0.30	2,88	±0.90
Liyayi	2,05	±0.70	2,65	±0.25	3,40	±0.00	3,30	±0.28
Maguruyinkware	1,08	±0.13	1,58	±0.13	2,30	±0.14	2,28	±0.13
Mahungu	1,00	±0.30	1,50	±0.30	2,30	±0.33	2,43	±0.68
Maombi	1,93	±0.05	2,37	±0.17	3,00	±0.16	2,93	±0.34
Mayombe	2,03	±0.25	2,53	±0.25	3,28	±0.33	3,27	±0.34
M'Bailo	1,21	±0.27	1,61	±0.27	2,42	±0.40	2,70	±0.66
Musimwa	1,18	±0.17	1,72	±0.17	2,50	±0.00	2,40	±0.28
Muzungu	1,29	±0.20	1,79	±0.20	2,52	±0.31	2,72	±0.75
Mvuama	1,95	±0.07	2,45	±0.07	3,17	±0.09	3,23	±0.25
Nabana	1,48	±0.09	1,98	±0.09	2,73	±0.09	2,80	±0.28
Nabwigoma	1,66	±0.05	2,16	±0.05	2,67	±0.66	2,57	±0.58
Nakarasi	1,67	±0.09	2,17	±0.09	2,70	±0.87	2,70	±0.87
Nambiyombiyo	1,45	±0.25	1,96	±0.22	2,63	±0.25	2,73	±0.53
Nseke'elwa	1,40	±0.87	1,90	±0.87	2,68	±1.07	3,03	±1.06
Naunde	1,17	±0.33	1,52	±0.50	2,23	±0.53	2,57	±0.09
Ngoromane	1,63	±0.31	2,13	±0.31	2,63	±0.41	2,47	±0.19
Nvulamingi	1,90	±0.96	2,60	±0.66	3,03	±0.09	3,00	±0.00
Obama (TME 419)	0,93	±0.34	1,28	±0.31	1,97	±0.09	2,07	±0.19
Papayi	2,24	±0.36	2,83	±0.17	3,40	±0.57	3,23	±0.53
Rav	0,88	±0.17	1,33	±0.05	2,03	±0.25	2,13	±0.53
Sawasawa	1,84	±0.41	2,24	±0.20	2,73	±0.89	2,53	±0.74
TMS 2001/1661	1,52	±0.38	2,02	±0.38	2,75	±0.22	2,65	±0.50
P-value ; lsd ; CV	*<.001 ; 0,383 ; 15,15%*		*<.001 ; 0,312 ; 9,6%*		*<.001 ; 0,430 ; 9,9%*		*<.001 ; 0,545 ; 12,3%*	

The number of leaves of all cultivars varies at 2, 4, 6 and 8MAP respectively from 13.50 (Kanombe) to 37.33 (M'Bailo), 28 (Nabana) to 120.50 (Korengo), 24, 87 (Kanyunyi) to 161.33 (Dorothea) and Kanyunyi 7.03 to 142.83 (Dorothea) (Table 3). This large variation in the number of leaves, the coefficient of variation ranging from 17.7 to 24.7%, is justified by the fact that some cultivars have many branches (3 or more) and others do not. Given the dry season, which the crop has passed through, the number of leaves is reduced due to the falling leaves, and during this season a weak regeneration of the leaves is observed by the plant following the absence rains.

Table 3. Number of leaves per plant.

Genotypes	Number of leaves							
	2MAP		4MAP		6MAP		8MAP	
Amasi (Siri)	20,83	±2.89	48,83	±6.85	32,63	±5.32	14,17	±12.59
Cibongoyoka	20,67	±2.51	38,17	±7.46	51,25	±1.79	32,75	±10.81
Cintalula	20,00	±10.69	42,67	±8.56	34,70	±1.99	16,00	±11.13
Dorothea	24,00	±6.58	88,17	±14.72	161,33	±3.32	142,83	±11.81
Kabunga	32,67	±7.77	56,83	±9.53	47,11	±4.15	28,61	±7.62
Kamegere	20,33	±1.90	29,67	±7.00	87,28	±19.42	68,28	±10.97
Kanombe	13,50	±5.14	42,67	±14.06	82,17	±100.7	63,67	±109.4
Kanyunyi	32,17	±9.24	51,50	±27.14	24,87	±3.23	7,03	±10.65
Korengo	32,33	±22.33	120,50	±43.08	98,00	±8.70	79,50	±15.76
Liyayi	20,00	±11.13	73,33	±13.99	138,49	±65.78	120,19	±56.49

Maguruyinkware	25,17	±4.53	71,50	±15.63	37,63	±1.04	19,13	±11.24
Mahungu	30,67	±19.21	86,00	±24.23	152,37	±1.04	134,17	±11.17
Maombi	22,67	±3.32	45,17	±14.72	54,18	±11.68	35,68	±22.04
Mayombe	27,50	±4.58	59,33	±6.39	79,07	±27.59	60,57	±30.25
M'Bailo	37,33	±8.56	46,17	±6.17	110,47	±4.94	91,97	±12.46
Musimwa	24,33	±8.87	67,67	±12.86	44,57	±1.95	26,07	±11.42
Muzungu	23,17	±13.12	42,83	±4.53	113,73	±11.53	93,40	±14.00
Mvuama	18,83	±8.87	69,00	±5.76	115,58	±7.24	97,08	±16.75
Nabana	18,50	±5.14	28,00	±4.58	66,08	±74.67	47,58	±74.76
Nabwigoma	21,00	±10.50	46,33	±13.22	45,31	±4.68	27,09	±12.32
Nakarasi	21,33	±8.64	26,33	±10.73	57,33	±3.80	38,83	±11.52
Nambiyombiyo	22,50	±15.10	50,83	±2.64	50,60	±15.66	32,10	±10.34
Nseke'elwa	22,67	±6.65	98,83	±45.90	141,43	±18.33	122,93	±20.82
Naunde	21,83	±4.68	49,67	±8.64	81,00	±7.85	62,67	±3.71
Ngoromane	26,00	±7.03	57,67	±5.48	89,78	±1.39	71,28	±10.89
Nvulamingi	13,33	±1.71	41,83	±4.53	61,50	±2.47	45,00	±7.54
Obama (TME 419)	20,33	±11.55	39,67	±3.11	113,17	±18.99	94,67	±21.39
Papayi	25,17	±6.28	71,67	±25.49	87,69	±5.46	69,13	±13.19
Rav	27,17	±4.82	68,33	±15.28	144,07	±5.80	125,57	±16.21
Sawasawa	34,50	±4.58	82,83	±10.86	102,77	±0.66	83,17	±11.99
TMS 2001/1661	21,83	±11.76	51,33	±9.35	135,45	±1.28	116,33	±11.17
P-value ; lsd ; CV	*<.001 ; 9,416 ; 24,1%*		*<.001 ; 16,716 ; 17,7%*		*<.001 ; 26,719 ; 19,2%*		*<.001 ; 26,865 ; 24,7%*	

The average leaf area values of cultivars over different periods of vegetative development range from 41.92 (Kamegere) to 148.61cm2 (Nabwigoma) at 2MAP, 141.19cm2 (Maguruyinkware) to 369.65cm2 (Muzungu) at 4MAP, 149.92 (Maguruyinkware) at 382.22 cm2 (Kamegere) at 6MAP and 67.94 (Maguruyinkware) at 189.71 cm2 (Sawasawa) at 8MAP (Table 4). At the end of the observation, we had observed this decrease in leaf area since the samples were taken from the leaves in place (young leaves remaining); unfortunately, the large leaves, at this stage of growth, were dry and fell under the effect of the wind, and especially of the age of the plants.

Table 4. Leaf area of cassava cultivars.

Genotypes	Leaf area (cm^2)							
	2MAP		4MAP		6MAP		8MAP	
Amasi (Siri)	141,33	±95.58	260,83	±0.00	334,09	±94.77	127,97	±15.55
Cibongoyoka	65,76	±68.30	391,56	±42.40	275,29	±221.1	91,67	±12.75
Cintalula	80,73	±39.52	307,59	±90.10	293,74	±56.86	104,10	±6.40
Dorothea	82,55	±22.35	234,92	±7.14	196,65	±48.13	75,38	±11.35
Kabunga	134,33	±152.7	348,70	±31.34	323,10	±54.35	138,74	±16.96
Kamegere	41,92	±8.90	401,58	±19.58	382,22	±74.75	144,59	±9.38
Kanombe	88,90	±41.80	260,83	±0.00	269,44	±112.6	87,03	±5.50
Kanyunyi	144,48	±51.31	384,69	±34.82	291,64	±115.3	100,53	±13.47
Korengo	124,02	±60.47	307,59	±90.10	214,58	±25.82	78,31	±40.48
Liyayi	69,62	±18.64	221,13	±56.56	183,59	±20.05	89,31	±8.49
Maguruyinkware	120,41	±86.16	141,19	±5.31	159,92	±37.37	67,94	±10.67
Mahungu	107,15	±19.44	250,52	±29.37	243,64	±44.50	74,49	±36.61
Maombi	102,61	±23.42	317,66	±17.22	205,12	±156.9	142,38	±12.97
Mayombe	139,81	±82.88	166,62	±11.76	253,51	±47.32	75,59	±61.49
M'Bailo	105,37	±8.82	294,09	±0.00	208,66	±51.88	91,67	±12.75
Musimwa	85,00	±15.34	306,77	±65.45	271,13	±8.71	135,22	±22.58
Muzungu	103,93	±50.89	394,65	±9.71	299,12	±214.4	91,67	±12.75
Mvuama	109,62	±40.14	229,91	±0.00	170,90	±90.56	37,36	±7.47
Nabana	54,76	±31.03	294,09	±0.00	257,65	±9.04	68,39	±9.53
Nabwigoma	148,61	±58.09	367,85	±0.00	254,77	±144.7	54,41	±9.35
Nakarasi	96,90	±31.16	234,92	±7.14	194,96	±11.15	75,38	±11.35
Nambiyombiyo	100,02	±89.45	339,09	±15.42	273,07	±34.87	130,08	±15.70
Nseke'elwa	119,76	±49.61	335,99	±17.80	272,45	±108.6	144,66	±55.28
Naunde	159,21	±145.6	246,44	±68.94	234,82	±54.32	86,71	±91.18
Ngoromane	97,88	±61.03	201,28	±0.00	200,36	±2.60	53,15	±9.22
Nvulamingi	73,41	±81.86	362,64	±79.99	348,70	±31.34	231,06	±22.18
Obama (TME 419)	136,42	±38.09	361,81	±48.55	281,75	±22.25	187,11	±21.89
Papayi	128,30	±97.41	250,72	±39.69	204,54	±144.7	164,26	18.04
Rav	111,08	±83.04	372,71	±87.45	306,96	±123.8	174,76	±41.78
Sawasawa	145,05	±15.94	296,99	±8.25	297,73	±102.7	189,71	±19.65

TMS 2001/1661	74,45	±77.05	256,54	±58.74	214,27	±128.12	52,57	±29.82
P-value ; lsd ; CV	*0,052 ; 66,177 ; 38,1%*		*<.001 ; 41,054 ; 8,5%*		*0,052 ; 91,824 ; 22,0%*		*<.001 ; 27,494 ; 15,5%*	

Regarding Table 5 presenting rate of canopy cover, all cultivars taken together, the rate of canopy cover varied increasing to 2, 4, 6MAP and almost decreasing at 8MAP.

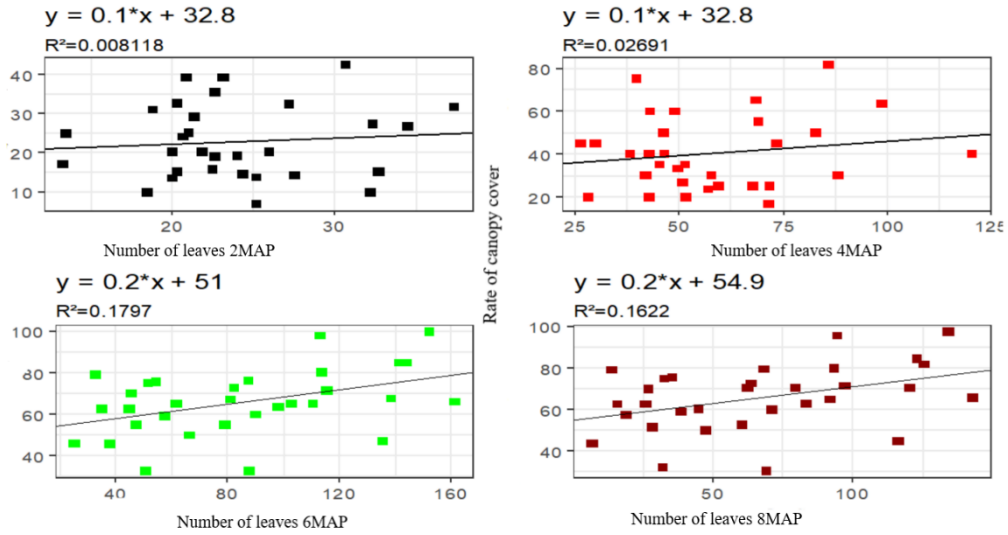
Table 5. Rate of canopy cover.

Genotypes	Rate of canopy cover (%)							
	2MAP		4MAP		6MAP		8MAP	
Amasi (Siri)	39,17	±2.37	60,00	±0.00	79,05	±1.35	79,05	±13.59
Cibongoyoka	24,00	±0.00	40,00	±0.00	75,00	±0.00	75,00	±13.74
Cintalula	13,35	±0.00	20,00	±0.00	62,50	±0.00	62,50	±13.74
Dorothea	19,17	±2.37	30,00	±0.00	65,75	±0.00	65,75	±13.74
Kabunga	15,00	±0.00	23,62	±3.18	55,00	±0.00	51,67	±11.87
Kamegere	15,00	±0.00	45,00	±0.00	76,07	±0.62	79,62	±16.06
Kanombe	24,83	±4.75	40,00	±0.00	72,50	±0.00	72,50	±13.74
Kanyunyi	9,73	±6.96	20,00	±0.00	45,75	±0.00	43,75	±15.67
Korengo	27,33	±7.22	40,00	±0.00	63,33	±2.37	70,50	±1.42
Liyayi	20,00	±0.00	45,00	±0.00	67,50	±0.00	70,67	±15.22
Maguruyinkware	6,72	±2.37	16,67	±4.75	45,50	±0.00	57,50	±34.81
Mahungu	42,50	±7.12	81,67	±4.75	99,67	±0.47	97,67	±15.44
Maombi	18,83	±4.75	35,00	±0.00	75,50	±0.00	75,50	±13.74
Mayombe	14,17	±6.28	25,00	±0.00	55,00	±0.00	53,00	±15.67
M'Bailo	31,67	±2.37	50,00	±0.00	65,00	±0.00	65,00	±13.74
Musimwa	14,33	±4.75	25,00	±0.00	62,50	±0.00	62,50	±13.74
Muzungu	39,17	±2.37	60,00	±0.00	80,00	±0.00	80,00	±13.74
Mvuama	30,92	±2.37	55,00	±0.00	71,50	±0.00	71,50	±13.74
Nabana	9,67	±2.37	20,00	±0.00	50,00	±0.00	50,00	±13.74
Nabwigoma	25,17	±2.37	40,00	±0.00	70,00	±0.00	70,00	±13.74
Nakarasi	29,17	±2.37	45,00	±0.00	59,00	±1.42	59,00	±12.66
Nambiyombiyo	15,65	±0.00	26,67	±4.75	32,50	±0.00	32,50	±13.74
Nseke'elwa	35,50	±0.00	63,33	±4.75	84,50	±0.00	84,50	±13.74
Naunde	20,00	±8.23	33,33	±4.75	67,03	±4.23	70,52	±22.35
Ngoromane	20,00	±4.11	30,00	±0.00	60,00	±0.00	60,00	±13.74
Nvulamingi	17,00	±1.42	30,00	±0.00	65,00	±0.00	60,50	±8.55
Obama (TME 419)	32,50	±7.12	75,00	±0.00	97,50	±0.00	95,50	±15.67
Papayi	13,67	±2.37	25,00	±0.00	32,50	±0.00	30,50	±15.67
Rav	32,33	±5.60	65,00	±0.00	84,67	±0.47	82,00	±16.51
Sawasawa	26,62	±2.37	50,00	±0.00	65,00	±0.00	63,00	±15.67
TMS 2001/1661	20,15	±7.12	35,00	±0.00	47,00	±4.27	45,00	±14.03
P-value ; lsd ; CV	*<.001 ; 2,709 ; 7,3%*		*<.001 ; 2,005 ; 3,0%*		*<.001 ; 1,169 ; 1,1%*		*<.001 ; 10,378 ; 9,7%*	

Relationship between number of leaves and rate of canopy cover

Figure 2 gives the relationships between the rate of canopy cover and the number of leaves of cassava cultivars during the development of the production cycle.

Figure 2. Regression lines between the rate of canopy cover of cultivars and the number of leaves during the cycle.



It emerges from these four graphs that there is a weak and positive correlation between the coverage rate and the number of sheets whose correlation coefficient is respectively 0.8118, 2.691, 17.97 and 16, 22% for the different periods 2, 4, 6 and 8 of vegetative development (Figure 2). This means that the varieties can have both a high recovery rate and a considerable number of leaves. The Mahungu variety presented the highest recovery rate at all observation periods, but also a greater number of leaves, occupying second place after the Dorothea variety (Table3) which unfortunately always shows a low recovery. The variety Nseke'elwa can serve as a good example in the correlation between these two variables (Table 5).

IV. Discussion

From the results of figure 3, it is the same for the studies carried out by Raffaillac and Second.[4,5,15,16], having found significant differences between the aptitude or not to cuttings, variations in the recovery rate between different genotypes. They show, respectively, that the primary objectives of breeding are to create varieties with high yields, which provide good quality cuttings to ensure 100% recovery and that the recovery rate varies according to the planting method used (number of nodes, dormant eyes kept by cutting in the ground or on the surface), and the position of the cutting during burial. Likewise, state Bulakali et al.[6]. that the losses occurring during cuttings can be partly attributed to heating of the twigs during transport. N'zué et al. and Mahungu et al.[7,8] being in fact in agreement, show that the reversal of the polarity of the buds of the cuttings at the time of planting and the attack of the cuttings by anthracnose negatively affects the resumption power of the cuttings. Kouakou et al.[9] admit it for conservation, and stipulate that the cuttings cut, i.e., one week before planting, must be stored in the shade, in a well-ventilated place, to ensure a homogeneous recovery, otherwise there will be variation between recoveries. Thus, Braima et al.[10], and Msikita et al.[3] agree with the desiccation. Fauquet and Fargette[11] stated that due to the low reserves in the material, the recovery of cuttings is difficult.The different heights obtained with the cultivars under evaluation, local and improved, showed a considerable degree of dissimilarity between cultivars. The branching variable has a positive correlation with the average height of the plants.[12].

In general (Figure 2), crops develop at variable rates depending on the species, and much more depending on the variety. Roose[13] noted the arithmetic progression of the recovery rate of some African plants as a function of time, including cassava. In the case of cassava, that is, all varieties end up reaching high rates for up to six months. For Neboit[14], they need the interval of one and five months, which makes all the difference. The time required for a cultivated stand such as cassava to reach its maximum recovery rate is as important as the quantified value of that rate.

V. Conclusion

The introduction of tolerant or resistant cultivars from breeding programs carried out in the province of South Kivu is not very satisfactory due to their current susceptibility to cassava brown streak disease, and the leaves that become unattractive for consumption.

Acknowledgements

The authors therefore directly thank the VLIR-UOS project team of Université Catholique de Bukavu (UCB) for funding this work. We thank in this regard, Prof. Dr. Ir. Espoir Bisimwa and PhD student Ir. Damas Birindwa for their technical support. In additional, many thanks to Dr Clerisse Casinga for supporting us morally.

Competing interests

The authors declare that no competing interests exist.

Author contributions

Conceptualization, methodology, set up the field, collection of data, data analysis, writing and preparation of the manuscript and produced the first format of the manuscript, incorporation all necessary corrections throughout the manuscript editing process until final submission, NB Shukuru; supervision, JC Birindwa and S Sharma.

Funding sources

This research received external funding from the VLIR-UOS project/UCB.

References

[1]. Segnou. Développement végétatif et potentiel de rendement chez le manioc. Institut de la Recherche Agricole pour le Développement (IRAD), Programme plantes à tubercules. TROPICULTURA. 2002; 20(4) :161-164

[2]. Singa I, Nguimalet CR, Lakouetene DP, Konaté G, Kosh Komba E, Semballa S. Les effets de la mosaïque africaine du manioc en République centrafricaine. Géo. Eco. Trop.2008; 32: 47-60.http://geoprodig.cnrs.fr/items/show/34672.

[3]. Msikita, W., Braima., Nnodu, E., Legg, J., Wydra, K., Ogbe, F.. Lutte contre les maladies du manioc, Guide de la pratique de lutte intégrée à l'usage des Vulgarisateurs, International Institute of Tropical Agriculture (IITA),2000; Cotonou, Bénin.

[4]. Raffaillac, J.P. et Second, G. Le manioc. AMEPLA.1997; 076 :429-455.

[5]. Lefèvre. Ressources genetiques et amelioration du manioc, en Afrique. Thesis, ORSTM ed., coll TDM Nejb57, 1989; Paris 186p.

[6]. Bulakali, B.P., Aloni, J., Palata, J.C. et Mergeai, G. Performances de trois variétés de manioc (Manihot esculenta Crantz) cultivées en association avec Stylosanthes guianensis (Aublet) Swartz dans les conditions du plateau des Batéké (ville-province de Kinshasa, RDC). TROPICULTURA.2014; 32(4): 158-167.

[7]. N'Zue, B., Zohouri, P. G., et Sangare, A. Performances agronomiques de quelques variétés de manioc (Manihot esculenta crantz) dans trois zones agroclimatiques de la Côte-d'Ivoire. Agronomie Africaine. 2005; 16 (2): 1-7.

[8]. Mahungu, N.M, Tata Hangy, K.W., Bidiaka, S.M. et 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),2014; Kinshasa, RDC.

[9]. Kouakou, J., Nanga Nanga, S., Plagne-Ismail, C., Mazalo, P.A., et Edoh, O.K. Production et transformation du manioc. Collection Pro-Agro, Institut international d'agriculture tropicale (IITA-Cameroun),2015; Yaoundé, Cameroun.

[10]. Braima, J., Yaninek, J., Tumanteh, A., Maroya, N., Dixon, A., Salawu, R. et Kwarteng J. Comment démarrer un champ de manioc, Guide de la pratique de lutte intégrée à l'usage des vulgarisateurs, International Institute of Tropical Agriculture (IITA-Bénin), 2000; Cotonou, République du Bénin.

[11]. Fauquet, C.M. & Fargette, D. La mosaïque africaine du manioc et son contrôle, Actes du séminaire proceedings, CTA, FAO, ORSTOM, IITA, CPI, Yamoussoukro 4-8/5/1987, Ministère de la recherche scientifique de côte d'ivoire, Collection de colloques et séminaires, 1988; Paris, France.

[12]. Maroya, N.G., 1997. Caractérisation morphologique des génotypes de manioc cultivés en Afrique de l'ouest et du centre (Bénin, Cameroun, Ghana et Nigéria). Bulletin de la Recherche Agronomique, Numéro 20 - Décembre 1997 : 32-54.

[13]. Roose, E.J. Erosion et ruissellement en Afrique de l'Ouest. Vingt années de mesures en petites parcelles expérimentales. Travaux et documents ORSTOM, 1977; no. 78, Paris, France.

[14]. Neboit, R. L'homme et l'érosion. 3è éd., 1991.

[15]. Bakayoko, S., Kouadio, K.K.H., Soro, D., Tschannen, A., Nindjin, C., Dao, D., Girardin, O. Rendements en tubercules frais et teneurs en matière sèche de soixante-dix nouvelles variétés de manioc (Manihot esculenta Crantz) cultivées dans le centre de la Côte d'Ivoire. Journal of Animal et Plant Sciences. 2012; 14(2): 1961-1977.

[16]. Ameu, M., Hire J., Kamalandua, D., Khisa, G., Nzeza, K.C., Ndoki, N.C. et Abangi, O.W. Champs-écoles paysans sur le manioc. Ressources à l'intention des facilitateurs d'Afrique sub-saharienne. Organisation des nations-unies pour l'alimentation et l'agriculture, FAO, 2014; Rome, Italie.

NB Shukuru, et. al. "Characterization of the 31 genotypes cultivated under the threat of cassava brown streak disease." *IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)*, 14(12), 2021, pp. 45-53.