International Journal of Agriculture Innovations and Research
Volume 6, Issue 3, ISSN (Online) 2319-1473
Manuscript Processing Details (dd/mm/yyyy):
Received: 07/11/2017 | Accepted on: 14/11/2017 | Published: 23/11/2017

Incidence of Viral Diseases on the Yield of Six Varieties of Cassava (Manihot Esculenta Crantz) Grown in the Localities of Adzope and Yamoussoukro (Cote d'Ivoire)

Assiri K.P.*, Djaratche B., Seka K., Yao K.F., Toualy M.N., Kra K.D., Fofana F. and ATTA D.H
Pole de Recherche Production Vegetale, Unite Sante des Plantes, Universite Nangui Abrogoua Abidjan. 02 BP 801 Abidjan 02, Cote d'Ivoire.
*Corresponding author email id: Kouamass@yahoo.fr

Abstract **– Cassava (*Manihot esculenta* Crantz) plays an important role in ensuring food security of the population in Côte d'Ivoire. However, its production is seriously threatened by the virus disease of cassava. The objective of this study is to evaluate the effect of viruses on the yield of cassava. For this study, six varieties of cassava, two improved and four local were used in two localities of the Côte d'Ivoire (Adzope in the south-east and Yamoussoukro in the Center). Parameters related to the viral disease which are the incidence and severity of symptoms were evaluated. In this study 4 types of virus disease symptoms were observed. It is of embossing; shoestring, mosaic and chlorosis. The study carried out showed that the incidence of the symptoms of virus diseases was higher in Adzope (60.12 %) than in Yamoussoukro (40.45 %). The viral disease symptoms were more severe on the local varieties than on those improved. Similarly, the results obtained showed a very significant difference between the yields of plants not showing symptoms of viruses and virus-infected ones. The performance of the not virus infected plants was higher (22.02 t/ha) compared to those of plants showing symptoms of virus diseases (18.74 t/ha). The yield loss due to viruses of cassava rose to 3.5 t/ha on average is 15. The incidence and severity of symptoms were higher on local varieties in the locality of Adzope. The study shows that yields were higher for plants exhibiting no symptoms of viral diseases than those with symptoms of viral diseases.**

Keywords **– Cassava, Côte d'Ivoire, Incidence, Severity, Virus Diseases, Yield Reduction.**

I. Introduction

Cassava is an important food crop for people living in the tropics, where it is the 4th major source of food energy [1]. Its tuberous roots constitute the staple food of more than 800 million people in the world, making it the sixth source of calories among foods [2]. World cassava production was 282 million tonnes in 2013 and 56 percent of this production came from Africa [3]. Cassava provides food security in several African countries [4], as it is easy to grow and its yields help to survive during famine [5].

In Côte d'Ivoire, cassava is the second largest food crop after yam, with an annual production estimated at 2.5 million tonnes [6]. It is one of the most consumed foods in the country because of its diversity of processing. The cassava tuber can be processed into flour, semolina, starch, etc. The most known form is the attieke.

Despite its many advantages, cassava production is affected by several diseases and pests, the incidence and severity of which affect tuberous root yields. Among diseases, African cassava mosaic is the most important threat to cassava cultivation especially in Africa. This viral disease is caused by a geminivirus of the family Geminiviridae. It belongs to the Genus called *Begomovirus*. This disease is spread by a whitefly *Bemisia tabaci* (Gennadius) or by the infected cuttings used for planting a new field [7]. This is one of the most severe diseases threatening cassava. It is reported wherever cassava is grown.

In recent years, the mosaic of cassava caused by East African cassava mosaic virus (EACMV) has spread rapidly to several countries in West Africa such as Togo and Burkina Faso [8]. The African Cassava Mosaic Virus (ACMV) alone can cause crop losses ranging from 30 to 40% while the EACMV induces losses reaching 68%. In the event of co-infection associating the CVMA and the CVMA, the losses reach 82% [9]. Six strains of this virus (ACMV, EACMV, EACMCV, EACMZV, EACMMV and EACMZV) are distinguished and are currently circulating in Africa [10].

In Côte d'Ivoire, some viruses responsible for viruses have been identified. *African Cassava Mosaic Virus* (ACMV) and *East African Cassava Mosaic Virus* (EACMV) a variant of the East African cassava mosaic virus discovered in Cameroon for the first time, called the *East African Cassava Mosaic Cameroon Virus* (EACMCV) has also been identified in Côte d'Ivoire [11], [12].

In Côte d'Ivoire, the prevalence of cassava viruses is increasing, which could lead to a considerable drop in yields. The objective of this work is to evaluate the losses of yield caused by these viruses.

II. Material and Methods Material

The plant material was made up of cuttings of different varieties of cassava. Improved and local varieties have been used. Concerning the improved varieties Bocou 1 and TMS4 (2) 1425 were used in the two localities. Local varieties varied according to locality. Thus in Adzope the varieties Mamawa and Melegbegbe were used while in Yamoussoukro, the varieties used were Yavo and Bonoua.

Methods

Preparation of Plots and Plant Material

The land was plowed by hand. Cuttings with 4 to 6 germinating nodes were used as seed. The plot was weeded 4 times throughout the study period.

Experimental Device and Test Set Up

International Journal of Agriculture Innovations and Research
Volume 6, Issue 3, ISSN (Online) 2319-1473

The experimental set up consists of a randomized 3-repeat Fischer block. Each block has 4 parcels. Each elementary parcel has an area of 6 m x 5 m and was made up of 24 plants. The separation between the plants was 1 m on the line and 1 m between the lines.

Symptomatology of Cassava Viral Diseases

Three (3) months after planting, cassava plants showing symptoms of viruses were labeled with ribbon and from this period (3 months), all cassava plants were visited to observe any symptoms of virosis. The symptoms were photographed and then described. The development of virosis was monitored on the basis of a visual diagnosis based on the observation of characteristic symptoms of virosis on the leaves of cassava plants.

Evaluation of the Incidence of Viral Diseases

Three (3), 5 and 7 months after planting, the percentage of symptomatic plants relative to the total number of plants in the plot was calculated by counting plants with symptoms of viral diseases according to formula below:

$$\text{Im}\ (\%) = \frac{\text{Pi}}{\text{NTP}} \text{ x } 100$$

Im = Mean incidence.
Pi = Number of plants showing symptoms of viral diseases at the visiting period.
NTP = Total number of plants in the plot.

Evaluation of Severity of Symptoms of Viral Diseases

To determine the severity of symptoms of viral diseases, the percentage of leaves with symptoms relative to the total number of leaves carried by the plant was calculated. A scoring scale ranging from 1 to 5 was used. The plants attacked were grouped into 5 classes classes [13] according to the following criteria: 1: Absence of visible symptoms; 2: 1-25% of attacked leaves; 3: 26-50% of attacked leaves; 4: 51-75% of attacked leaves; 5: more than 75% attacked leaves.

Evaluation of Yields

During harvest, 10 viral diseased plants and 10 non viral diseased plants were selected randomly, per elemental plot. After being unearthed, Cassava samples were weighed to determine their mass and to estimate their yield. The harvest was carried out 12 months after planting.

Statistical Analysis

Analysis of the variance with regard to one classification criterion (ANOVA 1) was used to compare the incidence and severity of cassava virus symptoms and the yield of viral diseased plants and those with no symptoms in the different varieties of cassava. For any significant difference observed between the averages of these parameters at the 5% threshold, a Fisher's LSD (Least Significance Difference Test) test was performed to distinguish homogeneous groups. Statistica 7.1 was used.

III. Results and Discussion

Results

Symptoms of viral diseases observed

Different types of symptoms of cassava viruses have been observed on all varieties of cassava grown, whether improved varieties (Bocou1 and TMS4 (2)1425) or local varieties (Bonoua, Yavo, Mamawa and Melegbegbe) in the localities covered by the study. In general, the symptoms observed were mosaic of different degrees, chlorosis, leaves deformation, shoestring and leaves embossing. Similar symptoms were observed in the two localities. As for TMS4 (2)1425 variety, three types of symptoms were observed. These are mosaic, chlorosis and embossing. The mosaic was characterized by alternating yellowish and greenish spots. Yellow spots have widened over time to occupy the entire surface of the limb. Increased yellow spots caused chlorosis on the aged leaves. Mosaic and chlorosis are accompanied by leaf distortion. Leaf embossing was observed on young leaves, giving an appearance of crumpled leaves. A complex of symptoms was also observed. The same symptoms were observed in the two study sites (Fig. 1).

Concerning Bocou 1 variety, observed symptoms were mosaic, embossing and shoestring. The embossing was more severe on young leaves. Severely-affected young leaves have collapsed. Different deformations were observed on the aged leaves: limb distortion, reduction of the leaf surface and stretching of the base of the leaf blade. The base of the leaves becomes tapered resembling a shoestring. Chlorosis was less intense on this variety (Fig. 1). Some cases of dwarfism and wilting have also been observed on this variety in the locality of Adzope (Fig.1).

Fig. 1. Viral disease symptoms observed on the leaves of improved varieties of cassava TMS(2)1425 et Bocou 1
a: embossing; b: chlorosis associated with deformation; c : mosaïc; d : complex of symptoms (observed on TMS4(2)1425); e : shoestring; f : deformation of young leaves (observed on Bocou1)

As for Yavo variety, the symptoms are manifested by a light mosaic and chlorosis marked by a pale yellow to white color, deformations such as embossing, shoestring, enrollment of the edge of the limb. Yellow spots widen over time to occupy the entire surface of the limb. The mosaic and the deformations become severe and are accompanied by a weakening of the plant (Fig. 2).

With regard to the Bonoua variety, the symptoms of deformation were more severe on young leaves. They have different deformations: blistering, distortion of the limb, reduction of size. The severely affected young leaves sag. The base of the aged leaves becomes tapered resembling a shoestring. Chlorosis is less intense on this variety. The severely affected leaves are reduced, deformed and curled, and are characterized by the presence of alternate yellowish portions of the normal green parts (Fig. 2).

Concerning Melegbegbe, symptoms of viral disease have been observed at all phonological stages and are characterized by deformations, windings, leaf area reductions, chlorosis and stunting of the plant (Fig. 2). Finally, for the Mamawa variety, the mosaic was the most dominant symptom. Plants severely affected by the mosaic have been observed for three months. The leaves presented different deformations that are the embossing, distortion of the limb and the reduction in the size of the leaves. The base of the older leaves becomes tapered, resembling a shoestring (Fig. 2).

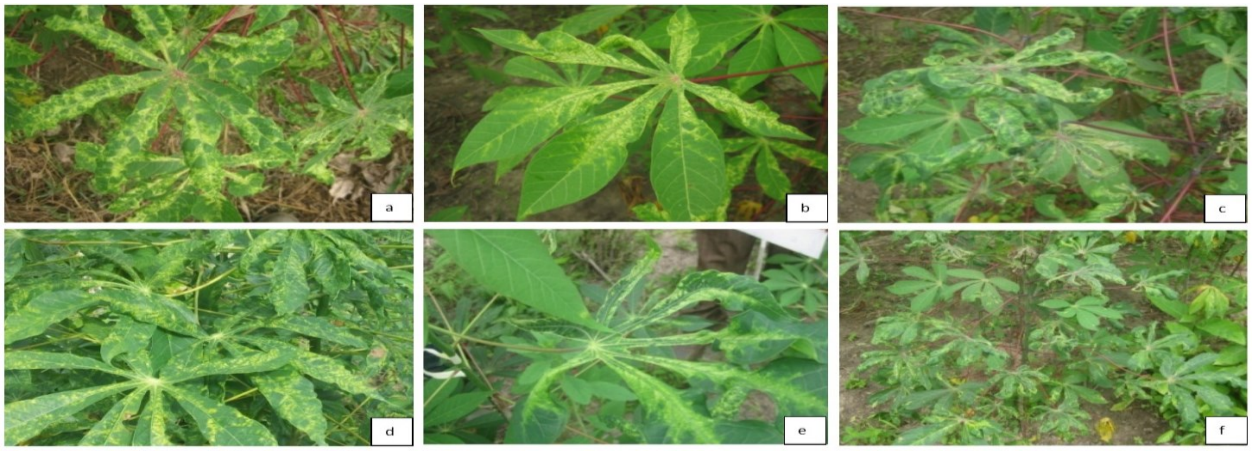
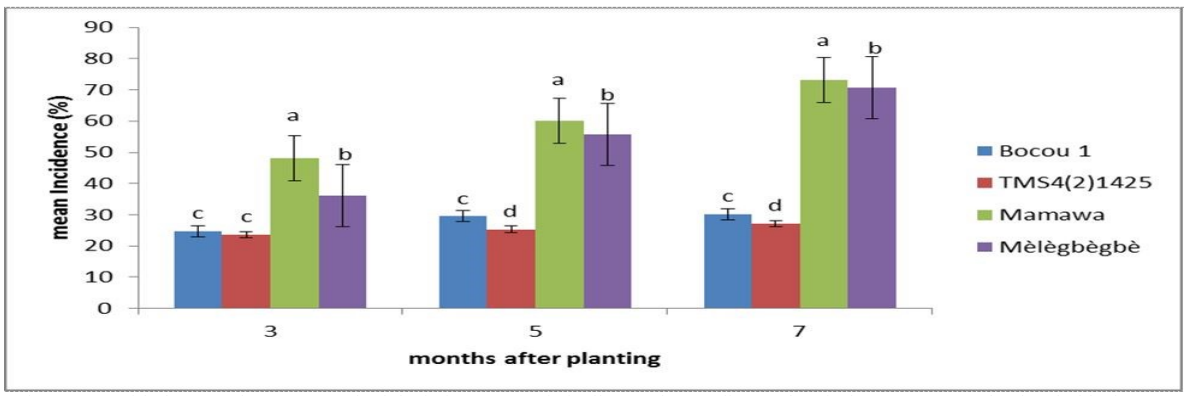


Fig. 2. Viral disease symptoms observed on the leaves of local varieties of cassava Bonoua, Mamawa, Melegbegbe et Yavo

a: mosaic ; b: chlorosis associated with deformation; c: complex of symptoms (observed on Bonoua, Yavo, Mamawa); d: chlorosis associated with mosaic; e: shoestring; f: leaves distortion and stunded plant (observed on Melegbegbe and Bonoua)

Incidence of Cassava Related Viral Diseases In the Locality of Adzope

In the locality of Adzope, the mean incidences observed on 3 month-old plants were inferior to 50 %. Thus, three (3) months after planting the incidence of viral disease symptoms varied from 23.55 % to 48.12 %. The highest incidence was observed on the local varieties: Mamawa and Mèlègbègbè. Five (5) months after planting, the incidences varied from 25.33 % to 60.12 %. The highest impacts were generally observed on the local varieties, Mamawa and Mèlègbègbè, while the lowest impact was observed on the improved varieties TMS4(2)1425 and Bocou 1. Sept (7) months after planting, the incidence was higher on the local varieties Mamawa (73.23 %) and Mèlègbègbè (70.65 %). In this locality the incidence of viruses on the improved varieties was less than 50 %. At 3, 5 and 7 months after planting, the statistical analyzes carried out showed a significant difference between the incidence of the symptoms of the different varieties (Fig. 3)



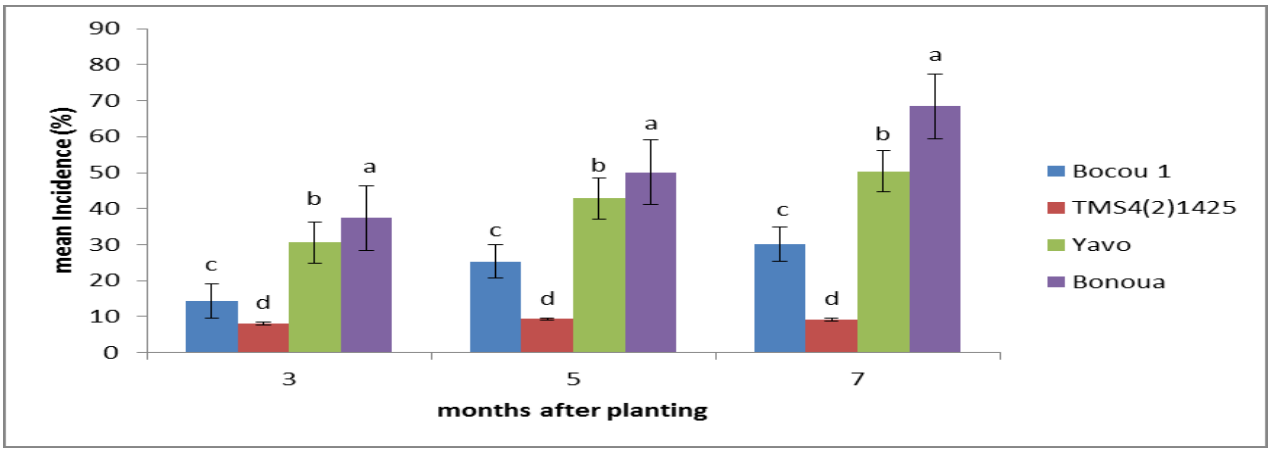
Histograms with the same letter on standard deviations are statistically equal according to the Fischer LSD test at the threshold of = 0.05

Fig. 3. Mean incidence of viral disease symptoms observed on cassava plants at different periods of vegetative cycle in the locality of Adzope.

In the Locality of Yamoussoukro

In the Yamoussoukro locality, according to mean incidences, phenological stages of plants varied. So, 3 months after planting, the incidence of virus symptoms varied from 8.12% to 37.35%. The highest incidence was observed on local varieties Yavo and Bonoua. Five (5) months after planting, the incidence varied from 9.31% to 50.12%. The highest incidences were also recorded on the local varieties Yavo and Bonoua while the lowest were observed on the improved varieties TMS4(2)1425 and Bocou 1, 7 months after planting, the incidences were highest on local varieties Yavo (50, 34%) and Bonoua (50.34 %). In this locality the incidence of viruses on the improved varieties is less than 40 %.

Regardless of the phenological stage of the plants, the statistical analyzes carried out showed a significant difference between the incidence of the symptoms of the different varieties (Fig. 4).



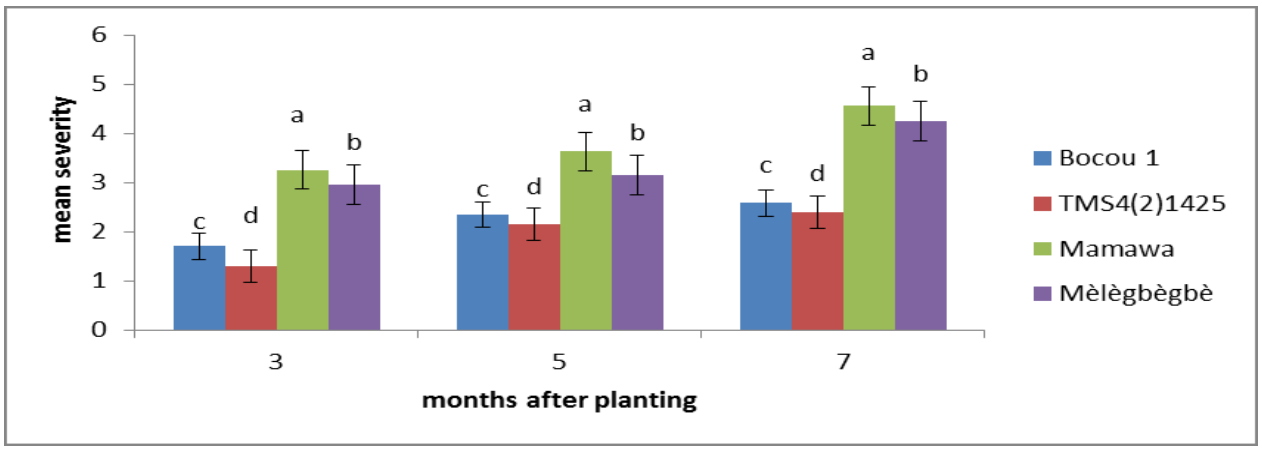
Histograms with the same letter on standard deviations are statistically equal according to the Fischer LSD test at the threshold of = 0.05

Fig. 4. Mean incidence of viral disease symptoms observed on cassava plants at different periods of vegetative cycle in the locality of Yamoussoukro

Viral Diseases Symptoms Severity

In the Locality of Adzope

In Adzope the average of severity of viral diseases symptoms varied from 1.30 to 4.5. Thus, 3 months after planting, mean symptom severity ranged from 1.30 to 3.25. The disease was more severe for the local varieties Mamawa and Mèlègbègbè. Five months after planting, the severity of symptoms varied from 2.15 to 3.63. The disease has always been more severe on local varieties. Seven (7) months after planting, the highest severity was observed on the Mamawa variety (4.5), while the lowest was observed on the TMS4(2)1425 variety (2.4). Regardless of the phenological stage of the disease, statistical analyzes showed a significant difference between the average severity of the symptoms of viral diseases in the different varieties of cassava (Fig. 5).



Histograms with the same letter on standard deviations are statistically equal according to the Fischer LSD test at the threshold of = 0.05

Fig. 5. Mean severity of viral disease symptoms observed on cassava plants at different periods of vegetative cycle in the locality of Adzope

In the Locality of Yamoussoukro

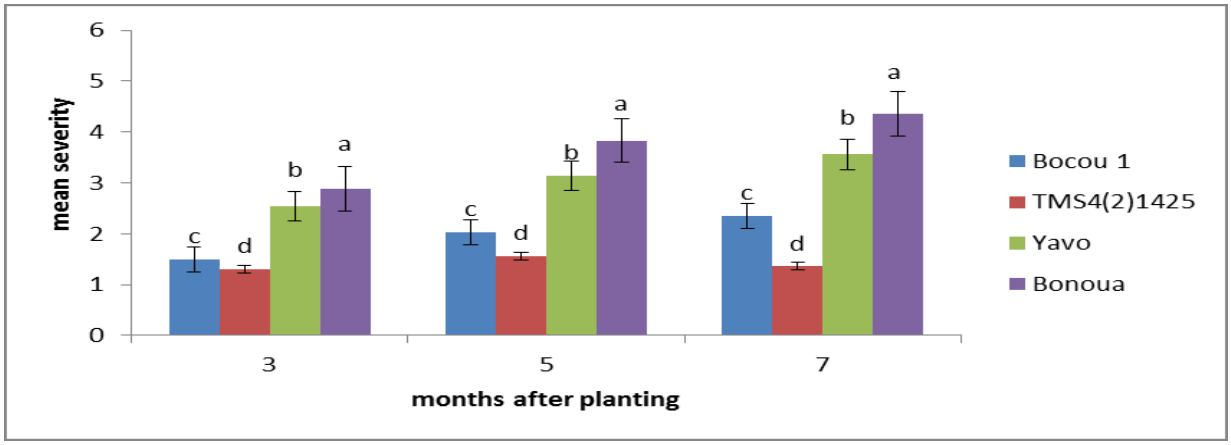
Concerning the locality of Yamoussoukro, the average severity of symptoms of viruses also varied from 1.31 to 4.5. Three (3) months after planting, mean symptom severity ranged from 1.31 to 2.95. The disease was also more severe for local varieties Yavo and Bonoua. Five (5) months after planting, the severity of symptoms ranged from 1.56 to 3.83. Concerning the Yavo variety, the

severity was 1.56 and 3.33 on the Bonoua variety. The disease was more severe on local varieties. Seven (7) months after planting, the highest severity was observed on the Bonoua variety (4.5) while the lowest was observed on the TMS4(2)1425 (1.36).

Whether at 3, 5 or 7, the statistical analyzes showed a significant difference between the average severity of the symptoms of viral diseases in the different varieties of cassava (Fig. 6).

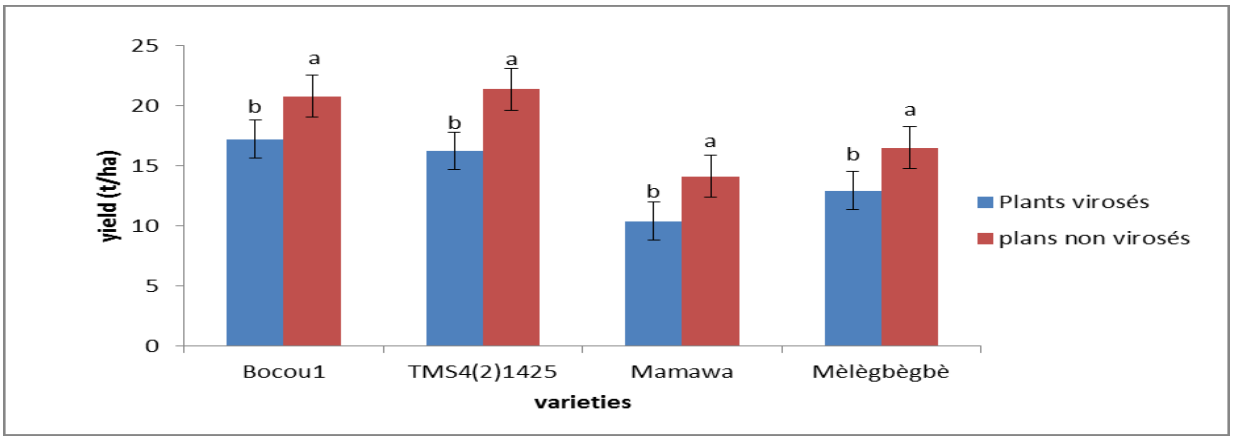
Root Yields of Each Cassava Variety

In general, yield of plants showing no symptoms of viral disease was significantly higher than those showing symptoms of viral disease. Thus in the locality of Adzope, this situation was observed on all varieties, both improved (Bocou 1 and TMS4(2)1425 and local (Mamawa and Mèlègbègbè). In this locality, the non-viral diseased and viral diseased plants of the TMS4(2)1425 variety recorded the highest yields. Non-viral diseased and viral diseased plants of Mamawa recorded the lowest yields (Fig. 7).



Histograms with the same letter on standard deviations are statistically equal according to the Fischer LSD test at the threshold of = 0.05

Fig. 6. Mean severity of viral disease symptoms observed on cassava plants at different periods of vegetative cycle in the locality of Yamoussoukro



Histograms with the same letter on standard deviations are statistically equal according to the Fischer LSD test at the threshold of = 0.05

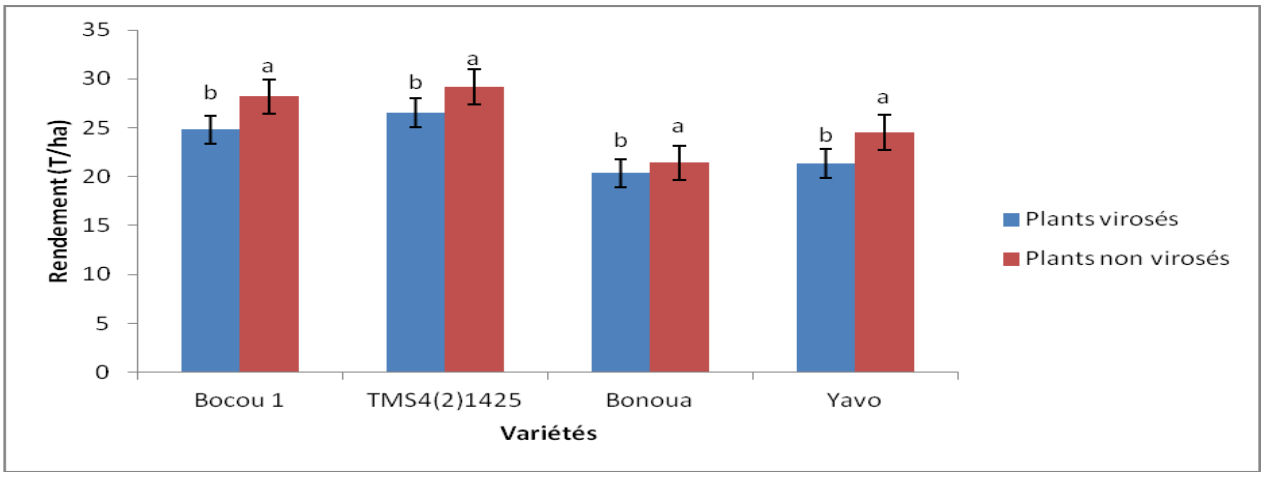
Fig. 7. Comparison of yield of cassava plants with viral symptoms and asymptomatic plants in the locality of Adzope.

In Yamoussoukro, the yield of non-viral diseased plants was statistically higher than those showing symptoms of viral disease for the Bocou 1 varieties, TMS4(2)1425, Bonoua and Yavo (Fig. 8). Whether at 3, 5 or 7, the statistical analyzes showed a significant difference between the average severity of the symptoms of viral diseases in the different varieties of cassava (Fig. 9).

IV. Discussion

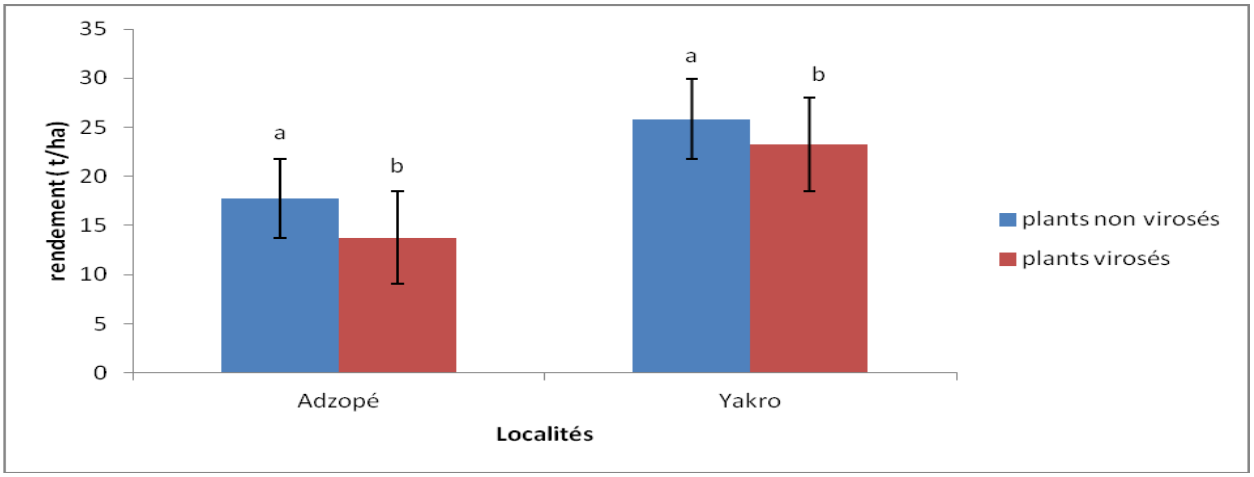
Different types of viral disease symptoms were observed on both improved varieties of cassava and on local varieties, in the localities of Adzope and Yamoussoukro. These different types of viral disease symptoms were also observed on 14 varieties of cassava by [12] in all cassava growing areas in Côte d'Ivoire.

These symptoms varied depending on the variety and phenological stage of the plant. According to [14], this variability in symptoms is often attributed to different strains of virus, host susceptibility, plant age, solar radiation, and temperature. Local varieties Mamawa, Mèlègbègbè and Bonoua have been more susceptible to viral diseases. This result is in agreement with those of [9] who showed that these cultivars express more the symptoms of



Histograms with the same letter on standard deviations are statistically equal according to the Fischer LSD test at the threshold of = 0.05

Fig. 8. Comparison of yield of cassava plants with viral symptoms and asymptomatic plants in the locality of Yamoussoukro



Histograms with the same letter on standard deviations are statistically equal according to the Fischer LSD test at the threshold of = 0.05

Fig. 9. Yield comparison of cassava plants with viral symptoms and asymptomatic by locality

viral disease and were considered very sensitive to the virus of the African mosaic. The symptoms of viral diseases have been expressed on the improved varieties. This could be explained by the tolerance of these two varieties. Indeed, according to [15], the multiplication of viral particles is slowed down or attenuated throughout the plant which limits the metabolic disturbances, thus allowing the plant to develop despite the expression of various symptoms.

The results of our studies have shown that the incidence of symptoms of viral diseases have varied from one variety to another and also at the local level. Indeed, the varieties TMS4(2)1425 and Bocou 1 were more tolerant towards viral diseases with a low incidence. However, local varieties were more susceptible to viruses with incidences up to 73 %. Indeed, 3 months after planting, the Bonoua, Mamawa and Mèlègbègbè plants already showed a high level of infection, indicating that these cuttings were contaminated before they were put in place, thus confirming the results of [16] showed that most of the cuttings used for cassava planting by farmers in West Africa already carry viral infections. The susceptibility to viral diseases of the varieties depends on both the environmental conditions and especially on their genetic inheritance. The level of infection of the improved varieties diffused is lower than that of the local varieties, which is in agreement with the results of [1] on the behavior of cassava varieties in relation to viral diseases. This spatial variation in the incidence of viral disease could be explained by the difference in vegetation, which is denser in Adzope (dense forest zone); which would favor the development of vectors for disease agents of viral diseases, than in Yamoussoukro which is located in savannah zone. Indeed, according to [14], the incidence of viral diseases may depend on various environmental conditions that influence more or less the success of transmissions. The appearance of symptoms is the result of the intensity of the reaction of the plant to the attack of a virus which may be different according to the environment as [17] reports.

The severity of the symptoms varied from 2 to 4.5 indicating that the symptoms of viruses are either moderate or severe. The highest mean severity was observed on the local varieties while the lowest on the improved varieties. The sensitivity to viral diseases of cultivated cassava varieties depends both on the conditions

of the environment and especially on their genetic inheritance. According to [17], [2] and [18], these mean symptom severity scores on improved varieties are partly explained by the fact that the onset of symptoms is the result of the intensity of the plant's response to a virus attack which may be different depending on the medium. According to the author, the severity of the symptoms and the way in which they spread can be greatly altered by the temperature of the ambient air in which the plants are infected. In addition, [12], add that symptoms due to the virus in plants can vary and take on different aspects depending on environmental conditions.

Regarding yields, our study showed that the yield of the viral diseased plants was the lowest. The yields recorded at Adzope were on the whole lower than those obtained in the localities of Yamoussoukro. The low level of yield observed in the viral diseased plants could be explained by depigmentation, reduction of the leaf area and leaf rolling, which considerably reduces the photosynthesis of the plant, in particular by the destruction of chlorophyll [19], [20]. The reduction of photosynthesis thus has a direct impact on the development of cassava tubers by inhibition of starch synthesis [16].

V. Conclusion

The studied showed that cassava varieties are susceptible to the viral infection. Four types of symptoms, mosaic, chlorosis, embossing and shoestring, were observed on cassava varieties. The incidence and severity of symptoms were higher on local varieties in the locality of Adzope. The study shows that yields were higher for plants exhibiting no symptoms of viral diseases than those with symptoms of viral diseases.

Acknowledgments

The authors wish to thank the West Africa Agricultural Productivity Program (WAAPP) for the grant.

References

[1] Muengula-Manyi M, Kabwe KN, Bragard C, Tshilenge-Djim P, Winter S, Kalonji-Mbuyi A 2012. Incidence, Severity and Gravity of Cassava Mosaic Disease in Savannah Agro-Ecological Region of DR-Congo: Analysis of Agro-Environmental Factors. *American Journal of Plant Sciences*, 3:512-519.

[2] Alvarez E, Liano GA, Mejia JF. 2012. Cassava diseases in Latin America, Africa and Asia. in R.H. Howeler, ed. The cassava handbook. A reference manual based on the asian regional cassava training course, held in Thailand. Cali, Colombie, *CIAT*. pp. 258-304.

[3] FAO. 2014. Crop Production data 2013. FAOSTAT. Food and Agriculture Organization of the United Nations, Rome, Italy. http://www.fao.org.

[4] Ntawuruhunga PG, Okao-Okuja A, Bembe M, Obambi JC, Mvila A, Legg JP .2007. Incidence and Severity of Cassava Mosaic Disease in the Republic of Congo. *African Crop Science Journal*, 15(1):1-9.

[5] N'zue B, Zohouri PG, Sangare A. 2004. Performances agronomiques de quelques variétés de Manioc (some varieties of cassava) (*Manihot esculenta* Crantz) dans trois zones agro climatiques de la Côte d'Ivoire. *Agronomie Africaine,* 16 (2):1-7.

[6] Zohouri GP, N'zue B, Kouassi K, Wahounou P J, Brou KG, Tahouo O. 2013. La lutte contre la pourriture du manioc en Côte d'Ivoire (The fight against cassava rot in Ivory Coast). Le CNRA en 2013. P 15-16.

[7] Calvert LA, Thresh JM. 2002. The viruses and virus diseases of cassava. In: Hillocks RJ, Bellotti AC, eds. *Cassava: Biology, Production and Utilization*. Wallingford, UK: CAB International, 237-60.

[8] Tiendrebeogo F, Lefeuvre P, Hoareau M, Traore VSE, Barro N, Reynaud B, Traore AS, Konate G, Traore O, Lett J-M. 2009. Occurrence of East African cassava mosaic virus-Uganda (EACMV-UG) in Burkina Faso. *Plant Pathology,* 58:783.

[9] Owor B, Legg JP, Okao-Okuja G, Obonyo R, Ogenga-Latigo MW (2004). The effect of cassava mosaic gemini viruses on symptom severity, growth and root yield of a cassava mosaic virus disease-susceptible cultivar in Uganda. *Annals of Applied Biology*, 145(3): 331-337.

[10] Were H.K, Winter S, Maiss E. (2004). Occurrence and distribution of cassava begomoviruses in Kenya. *Annal of Applied Biololgy*, 145(2):175-184.

[11] Ndunguru J, Legg JP, Aveling T AS, Thompson G, Fauquet CM. 2005. Molecular biodiversity of cassava Begomoviruses in Tanzania: evolution of cassava geminiviruses in Africa and evidence for East Africa being a center of diversity of cassava geminiviruses. *Virology Journal,* 422: 22-221.

[12] Toualy MNY, Segun AA, Seka K, Diallo AH, Kumar PL (2014). Incidence and distribution of cassava mosaic begomoviruses in Côte d'Ivoire. *International Journal of Agronomy and Agricultural Research* 4(6):131-139.

[13] IITA (International Institute of Tropical Agriculture) 2000. Report, the assessment of cassava pests and diseases in Kinshasa and Bas Congo. IITA, Edition, Ibadan, 56 p.

[14] Hillocks RJ, Thresh JM. 2002. Les viroses de la mosaique et de la Striure brune du manioc en Afrique: Un guide comparatif des symptômes et de l'etiologie (Viruses of mosaic and cassava brown streak in Africa: A comparative guide to symptoms and etiology). *Roots*.7 p.

[15] Kummert J, Semal J 1996. Les virus et viroides phytopathogenes (Phytopathogenic viruses and viroids). In : Traité de pathologie vegetale (Treaty of plant pathology). Semal J. (collection). Les presses agronomiques de Gembloux (The agronomic presses of Gembloux), pp 85-142.

[16] Fargette D, Fauquet C, Thouvenel JC. 1988. Yield losses induced by African cassava mosaic virus in relation to the mode and the date of infection.. *International Journal of Pest Management*, 34(1): 89-91.

[17] Ambang Z, Akoa A, Bekolo N, Nantia J, Nyobe L, Ongono Bouquet YS. 2007. Tolerance de quelques cultivars de manioc (Tolerance of some cassava cultivars) (*Mahinot esculenta Crantz*) et de l'espece sauvage (and wild species) (*Mahinot glaziovii*) à la mosaique virale africaine et a la cercosporiose du manioc (with African viral mosaic and Sigatoka disease). *Tropicultura,* 25 (3):140-145.

[18] Bisimwa E, Walangululu J, Bragard C. 2015. Cassava Mosaic Disease Yield Loss Assessment under Various Altitude Agroecosystems in the Sud-Kivu Region, Democratic Republic of Congo. *Tropicultura,* 33(2):101-110.

[19] Costa C. 2003. Watermelon mosaic virus de la mosaïque de la pastèque : Étude de la variabilite du virus et epidemiologie moleculaire (Watermelon mosaic watermelon mosaic virus: Study of the variability of the virus and molecular epidemiology). Memoire pour l'obtention du diplôme de l'Ecole Pratique des Hautes Etudes : *Science de la vie et de la terre (Memory for graduation from the Ecole Pratique des Hautes Etudes: Science of Life and Earth)*, France. 46 p.

[20] Moundzeo L, Mvoulatsieri M, Foahom B & Sonwa M (2012). Date de plantation et de recolte des varietes de manioc dans la vallee du (Date of planting and harvesting of cassava varieties in the valley of the) NIARI (CONGO). *African Crop Science Journal*, 20(2): 603-612.