Scientific Research Publishing

American Journal of Plant Sciences, 2025, 16(10), 1121-1132
https://www.scirp.org/journal/ajps
ISSN Online: 2158-2750
ISSN Print: 2158-2742

Quantitative and Health Evolution of National Yam Genetic Resources under *Ex Situ* Conservation in Côte d'Ivoire

Brice Sidoine Essis*, Konan Evrard Brice Dibi, Adou Emmanuel Ehounou, Kinampinan Adelphe Hala, Kouassi Thiégba Kouame, Sika Madeleine Odjé, Amani Michel Kouakou

Centre National de Recherche Agronomique (CNRA), Research Station for Food Crops (RSFC), Root and Tuber Plant Program (TTPP), Bouake, Côte d'Ivoire
Email: *Sidoine.essis@cnra.ci

How to cite this paper: Essis, B.S., Dibi, K.E.B., Ehounou, A.E., Hala, K.A., Kouame, K.T., Odjé, S.M., and Kouakou, A.M. (2025) Quantitative and Health Evolution of National Yam Genetic Resources under *Ex Situ* Conservation in Côte d'Ivoire. *American Journal of Plant Sciences*, **16**, 1121-1132.
https://doi.org/10.4236/ajps.2025.1610073

Received: April 2, 2025
Accepted: October 24, 2025
Published: October 27, 2025

Abstract

Yam, of the genus Dioscorea, is an important crop grown mainly in tropical West Africa. In Côte d'Ivoire, yam is the most important food crop and contributes to food security with an annual production of 8 million tonnes. To preserve the genetic variability of the national yam collection, a series of selection and breeding projects have been carried out at the Centre National de Recherche Agronomique (CNRA). This study involved analysing quantitative evolution and assessing the incidence of diseases and pests in the yam accessions in the collection. After analysis, it was found that of the 441 accessions in 2022 (214 *Dioscorea alata*, 178 *Dioscorea rotundata*, 8 *Dioscorea esculenta*, 2 *Dioscorea bulbifera* and 2 *Dioscorea dumetorum*), 303 came from Côte d'Ivoire (69%), 108 from IITA in Nigeria (24%) and 30 accessions (7%) from various origins. The number of yam accessions in the national collection varied from 513 in 2011 to 441 in 2022. A loss of 72 accessions was observed in 2022. This shows that the national yam genetic resources come from different origins and have undergone a discontinuous evolution marked by the loss of 72 accessions between 2011 and 2022. However, these losses were compensated for by the collections and varietal creations carried out during these years. From a health point of view, there were two diseases: anthracnose and Yam Mosaic Virus. These diseases had a negative impact on genetic resources.

Keywords

Genetic Resources, Dioscorea, Health, Accessions, *Ex Situ* Conservation

1. Introduction

Yam of the genus Dioscorea, is an important crop cultivated in many countries around the world, particularly in West Africa in tropical zones [1]. Yam is the most important food crop in Côte d'Ivoire and contributes significantly to the food security of Ivorians, with an annual production of about 8 million tonnes [2]. Optimum yields range up to 60 - 70 t/ha, but the national average yield is 8 - 10 t/ha for the yam species *Dioscorea rotundata* and 10 - 15 t/ha for the yam species *Dioscorea alata* [3].

Yam is consumed in boiled, pounded, fried or braised form [4]. With a production of 4.2 million tonnes, *i.e.*, 60% of national production, the *D. alata* yam species remains the most important yam species in Côte d'Ivoire [5]. However, 75% of the yam trade is dominated by the *D. rotundata* species, whereas D. *alata* is mainly self-consumed by producers [6].

Despite its importance, this foodstuff faces several difficulties, particularly in collecting genetic resources with a view to increasing both genetic variability and yields, as well as combating the various diseases and pests affecting this crop. To limit the extent of the harmful effects of climate change, it is essential to conserve genetic resources derived from studies, collections, introductions and creations. The conservation of genetic heritage forms the basis of all work in genetic improvement, agronomy and crop protection.

With a view to preserving the genetic variability of the national yam collection of the Centre National de Recherche Agronomique (CNRA), several research and collection projects have been carried out with funding from the CNRA, West Africa Agricultural Productivity Program (WAAPP), RTB Breeding-Yam (formerly AfricaYam) and RTB Breeding-Quality (formerly RTBfoods) projects. These projects have enriched yam collection through new collections of traditional varieties, the introduction of IITA hybrids and, above all, the ongoing creation of hybrids (715 cloned *D. rotundata* and 177 *D. alata* hybrids in G1; 762 cloned *D. rotundata* and 183 *D. alata* hybrids in G2, and 34 cloned *D. alata* and 30 *D. rotundata* hybrids in G3) since 2011.

The aim of this study is to take stock of the collection by analysing the composition, origin and quantitative and sanitary trends of yam genetic resources from 2011 to 2022, and to assess the incidence and severity of diseases (anthracnose, Yam Mosaic Virus) of yam accessions in the national collection of the Centre National de Recherche Agronomique (CNRA) from 2016 to 2022.

2. Materials and Methods

2.1. Materials

2.1.1. Study Site

The study was carried out in Bouake, in central Côte d'Ivoire, at the Food Crops Research Station (FCRS), located at 7˚4'N and 5˚2'W. The region has a typical Baouleen climate. The rainfall pattern consists of two rainy seasons, from April to July and September to October, and two dry seasons, from August and November to March [7]. The average annual rainfall is between 826.1 and 1396.8 mm (**Figure 1**). The soils at the Research Station for Food Crops are ferralitic, gravelly, branched, shallow and derived from granitic material [8].

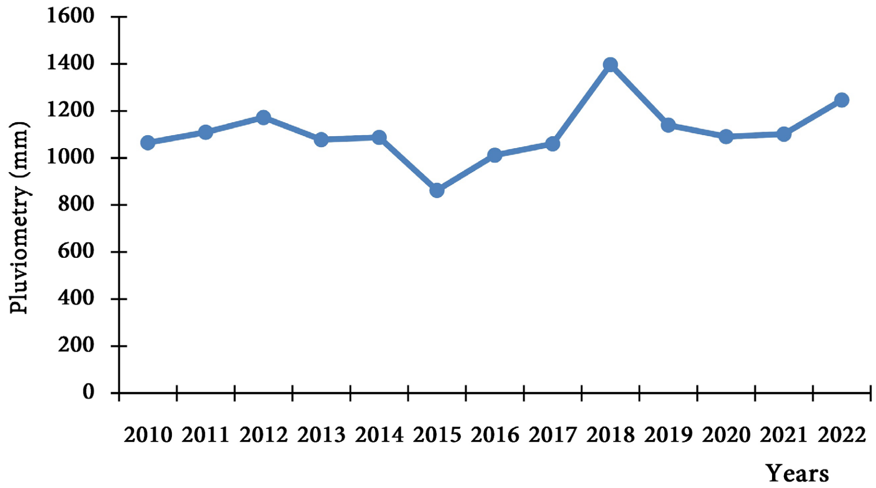

Figure 1. Annual pluviometry of the study site from 2010 to 2022.

2.1.2. Plant Material

The material used in this study consists of yam accessions of the genus Dioscorea, comprising the species *Dioscorea alata*, *Dioscorea rotundata*, *Dioscorea esculenta*, *Dioscorea bulbifera* and *Dioscorea dumetorum* from the national yam collection. This collection consists of local or traditional varieties and improved varieties (hybrids) of various origins and varietal creations through intraspecific crosses.

2.2. Method

2.2.1. Experimental Design

The accessions were arranged in 7 blocks of 38 lines. Each accession consisted of 5 mounds. The dimensions were as follows:

- 2 m between rows
- 1.5 m between accessions
- 1 m between plants per accession

The accessions are replanted each year on a plot at the CNRA's Food Crops Research Station in Bouake, Côte d'Ivoire.

2.2.2. Observations and Measurements

The yam accessions in the collection were counted each year after the harvests. This was done from 2011 to 2022. It is possible to determine the loss or increase in accessions of each type of yam from one year to the next by using this count. This was achieved by subtracting the number of accessions planted from the number harvested.

Observations and measurements were made 3, 5 and 7 months after planting.

The average incidence and severity indices for each disease were calculated for anthracnose and mosaic virus.

They focused on the incidence and severity of anthracnose and Yam Mosaic Virus. Incidence of diseases (*I*) is defined as the proportion of diseased plants in each population. It is used to assess the development or spread of the disease. The incidence of each disease is determined by each microplot using the following formula:

$$I(\%) = \frac{\text{Number of plants with symptoms}}{\text{Total number of observed plants}} \times 100$$

Disease severity is the overall degree of damage (disease symptoms) caused to the plant or part of the plant (leaf, stem or root). Disease severity levels are assigned to each plant based on the observation of the characteristic symptoms of each disease under investigation. This is done on a scale from 1 to 5 [9]. Healthy plants have a score of 1 and diseased plants have a score from 2 to 5, *i.e.*, from the least severe to the most severe (**Table 1**).

The severity index (or Symptom Severity Index, SSI) estimates by summing severity scores > 1 in a plot divided by total number of symptomatic plants. It is estimated by the following formula:

$$\text{SSI} = \frac{\sum \text{severity scores} > 1}{\text{Total number of symptomatic plants}}$$

Table 1. Disease symptom severity rating scale [9].

Rating score	Proportion of leaf area and stems showing symptoms
1	Not present (healthy)
2	<25% (mild)
3	25% - 50% (moderate)
4	50% - 75% (severe)
5	>75% (very severe)

2.2.3. Data Analysis

The various data (from 2011 to 2022) were analysed using Excel software. This included the number of accessions per year and health data on anthracnose and Yam Mosaic Virus. Averages were calculated and curves and histograms were plotted.

3. Results

3.1. Origin of Yam Accessions in the Collection in 2022

Of the 404 accessions in the collection in 2022, 303 accessions were of local origin, representing 69%. 108 accessions came from International Institute of Tropical Agriculture (IITA) 24%, 8 accessions from Puerto Rico (2%), 8 accessions from Cameroon (2%), 7 accessions from India (2%) and 2 accessions from Brazil (0.4%). The remaining 5 accessions came from New Caledonia, the Philippines, Martinique, Trinidad and Haiti (1%), *i.e.*, 1 accession per origin (**Figure 2**).

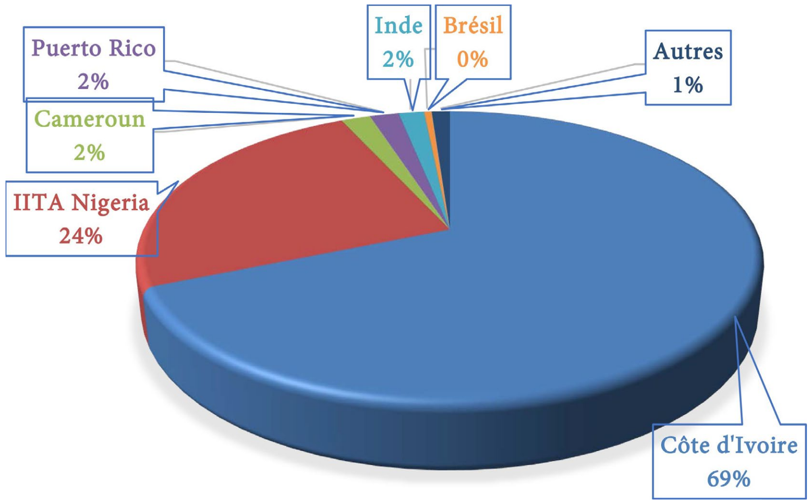

Figure 2. Origin of yam accessions in the collection in 2022.

3.2. Evolution of the Number of Accessions in the Yam Collection from 2011 to 2022

The number of yam accessions in the national collection varied from year to year and from species to species. Between 2011 and 2022, it decreased from 513 to 441 accessions. Losses and gains were also observed during the period of this study. Between 2011 and 2013, the number of *D. alata* yam accessions decreased from 284 to 200, a loss of 84 accessions, while the number of *D. rotundata* accessions decreased from 220 to 158, a loss of 62 accessions. This loss was very high for *Dioscorea alata* and *Dioscorea rotundata* yams, with 148 accessions lost each. An increase in the number of accessions was observed in 2014, with 67 accessions for *D. alata* and 42 accessions for *D. rotundata*, before a decrease in 2015 (36 accessions). From 2015 to 2017, a slight alternation of increase and decrease was observed, until the number reached 240 accessions for *D. alata* and 186 for *D. rotundata* in 2017. In 2018, the number increased to 281 accessions before oscillating between 281 and 283 until 2020, an increase of 43 accessions compared to 2017. A loss of 23 accessions was observed in 2021.

For *D. rotundata*, the number increased by 54 accessions in 2019 and 2020-2022, with a slight alternation between an increase and a loss of accessions. For the other 2 species, there was an increase in the number of accessions from 2011 to 2022. For *D. esculenta*, the number of accessions increased from 7 to 11 and for *D. bulbifera* from 2 to 3. The number of accessions for *D. dumetorum* remained constant at 2 from 2016-2022 (**Table 2**).

Table 2. Evolution of the number of accessions per type of yam from 2011 to 2022.

Year	Different types of yams				
	D. rotundata	*D. alata*	*D. esculenta*	*D. bulbifera*	*D. dumetorum*
2011	220	284	7	2	0
2012	180	210	7	1	0

Continued

2013	158	200	7	1	0
2014	200	267	7	1	0
2015	182	243	7	1	0
2016	208	247	10	1	2
2017	186	240	11	2	2
2018	161	281	10	2	2
2019	215	283	11	3	2
2020	183	283	11	3	2
2021	208	251	11	3	2
2022	184	241	11	3	2

3.3. Health Status of *Dioscorea alata* and *Dioscorea rotundata* Accessions

3.3.1. Incidence of Yam Mosaic Virus and Anthracnose *Dioscorea rotundata*

Figure 3 shows the average incidence of anthracnose and Yam Mosaic Virus. For Yam Mosaic Virus, the incidence varied between 46.8% and 100% from 2016 to 2022, with the highest incidence (100%) before a resurgence in 2021, when 46.8% of the accessions in the collection were infected. For anthracnose, the infection rate varied between 28% and 100%, with the highest rate of 100% observed for 2 consecutive years from 2016 to 2018, and a decrease from 2018 to reach the lowest rate (28%) in 2020 (Figure 3).

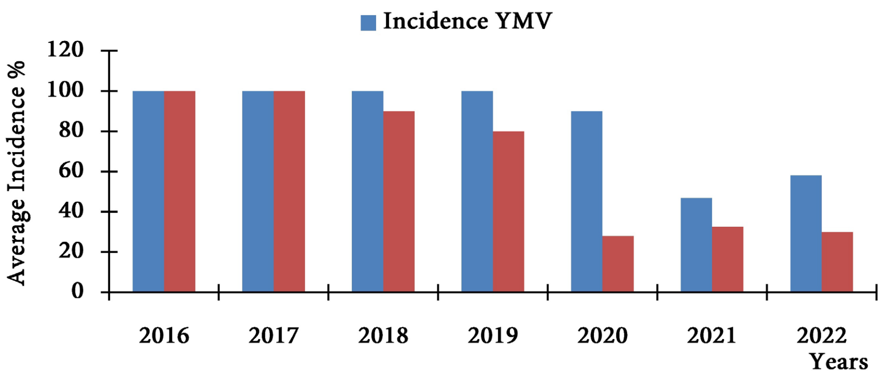

Figure 3. Average incidence of anthracnose and Yam Mosaic Virus in *D. rotundata* accessions in the collection from 2016 to 2022.

3.3.2. Incidence of Yam Mosaic Virus and Anthracnose *Dioscorea alata*

The histograms below show the average incidence of Yam Mosaic Virus and anthracnose on *Dioscorea alata* accessions in the collection. In all years, the rate of Yam Mosaic Virus decreased over time, with the highest value of 100% in 2016 and the lowest value of 38.2% in 2021. As for anthracnose, a slight variation in the infection rate of the accessions was observed, ranging from 90.51% to 100% between 2016 and 2022 (Figure 4).

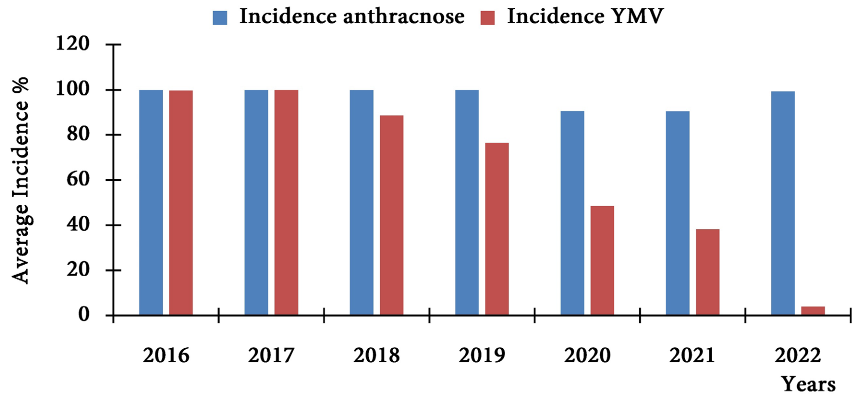

Figure 4. Average incidence of anthracnose and Yam Mosaic Virus in *D. alata* accessions in the collection from 2016 to 2022.

3.4. Degree of Symptoms of Yam Mosaic Virus and Anthracnose in the Accessions of *D. alata* and *D. rotundata* in the Collection

3.4.1. *Dioscorea rotundata*

From 2016 to 2022, the average severity varied between 2 and 4. However, the average severity of Yam Mosaic Virus was constant from 2016 to 2017, before decreasing from 4 to 2 from 2017 to 2018. A slight variation in average severity was observed from 2018 to 2022, with an increase followed by a constant phase and a decrease (**Figure 5**). The average severity of anthracnose also fluctuated. From 2016 to 2017 there was a slight increase from 2 to 3, followed by a decrease in 2018, with the value 2 remaining constant until 2022 (**Figure 5**).

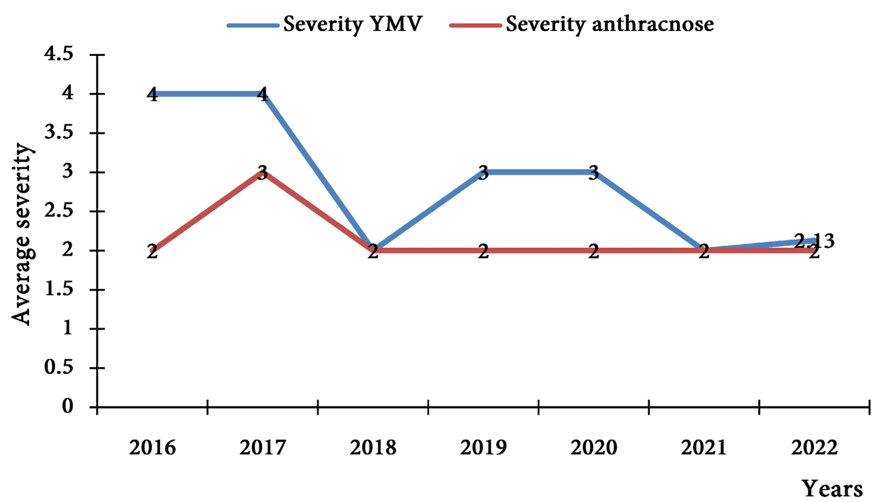

Figure 5. Average severity of anthracnose and Yam Mosaic Virus in *D. rotundata* accessions in the collection from 2016 to 2022.

3.4.2. *Dioscorea alata*

Variations in the average severity of Yam Mosaic Virus and anthracnose in the *D. alata* collection from 2016-2021 are shown in **Figure 6**. The average severity of Yam Mosaic Virus developed from 3.5% in 2016 to a peak of 4.3% in 2017. From 2018 to 2021 a decrease in severity was observed, from an average of 4.3% to the lowest severity of 1.6% in 2021. For anthracnose, the average severity varied between 4.5 and 2.3 for all *D. alata* yam accessions in the collection. Apart from 2017, when the accessions had a high anthracnose severity of 4.5, it was less severe in 2016 (3.8), 2018 (3.6), 2019 (3.4) and 2020 (3.3). The lowest anthracnose severity was observed in 2021 with a score of 2.3 (**Figure 6**).

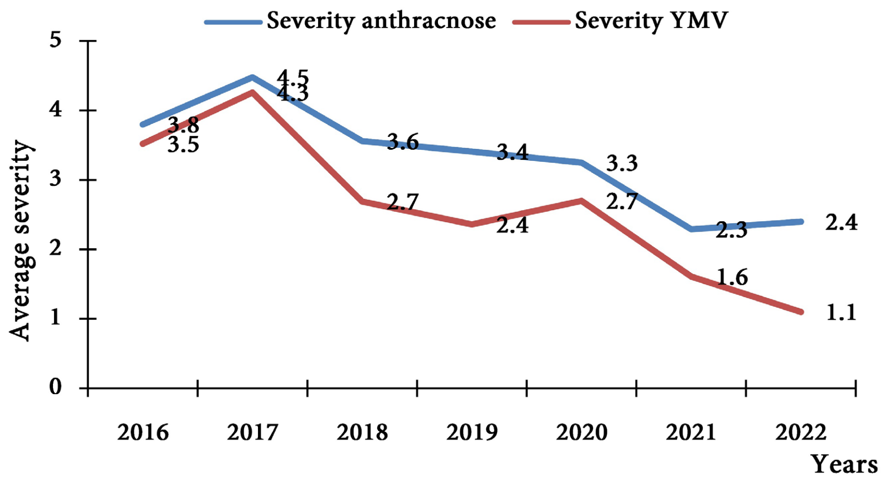

Figure 6. Average severity of anthracnose and Yam Mosaic Virus in *D. alata* accessions in the collection from 2016 to 2022.

4. Discussion

The national genetic resources of yam of the genus Dioscorea have diverse origins. It is essentially composed of 5 species, namely *D. alata*, *D. rotundata*, *D. esculenta*, *D. bulbifera* and *D. dumetorum* enriched over the years by the various introductions of yam cultivars and and species of yam over the years from institutes such as: Overseas Office of Scientific and Technical Research (ORSTOM) and Institute of Savannahs (IDESSA), which has enabled the genetic resources of yam conserved *ex situ* at the RSFC of the CNRA of Bouake to have several provenances. Yam accessions and to increase their number. These results are in with those obtained by Kouakou in 2010 [6]. They indicated several parallel collections and introductions from countries in the sub-from countries in the sub-region, South America and the West Indies.

In 2011, following the post-election crisis, the genetic resources in Abidjan were transferred to Bouake to continue research. The samples collected in 2008 and 2009 were used to enrich the different yam species, bringing the total number of accessions to 502. The increase in the number of accessions is also due to the surveys and collections carried out in 2013. In addition, *D. alata* and *D. rotundata* clones from IITA were introduced in 2018 and evaluated at the Food Crops Research Station Bouake. As shown by the work of Dumont *et al.* (2010), important collections have been made in Côte d'Ivoire [10].

The decline in the number of accessions during this study was observed mainly in two species, *Dioscorea alata* and *Dioscorea rotundata*. This decline is thought to be due to post-harvest losses caused by poor harvesting and transport techniques, resulting in wounds and bruises, which are the main entry points for diseases and insects in the tubers. According to Nteranya and Adiel (2005), the high rates of tuber loss are due to poor agricultural practices at harvest, during transport from farms and during storage, which cause tubers to rot [11]. The susceptibility of certain cultivars to storage pests, as pointed out by Foua-bi in1982, means that certain cultivars, such as those of the *D. alata* species, are more susceptible to pest attack than those of the *D. rotundata* species, depending on the thickness and hardness of the tuber periderm, which has led to enormous losses in the *D. alata* species [12].

The *ex-situ* conservation method for genetic resources is limited by the repeated replanting of infected seeds in the same or neighboring fields. This leads to an accumulation of pathogens in the soil, creating increasing disease pressure over time [13], resulting in losses of accessions, as observed in our study. The same applies to annual changes in rainfall and temperature, which can favor or hinder the growth of specific pathogens. For example, humid conditions can promote the development of fungal rot, while dry seasons can stress plants and make them more susceptible to nematode attacks [14].

The prevalence of yam anthracnose in the *D. alata* collection was 100% for four consecutive years and varied from 100% to 20% in the *D. rotundata* collection. The severity varied from year to year for the *D alata* species and remained constant for the *D. rotundata* species from 2018 onwards. These results can be explained by the cultivation practices and the contaminated plant material used to establish the collections. Most of the cultivars used have not been improved and are often susceptible to diseases [15]. In 2005, George *et al.* showed that anthracnose is present in all regions of the world where yams are intensively grown, with *D. alata* species being more susceptible than other species [16]. The disease was more severe in 2017 due to heavy rainfall during the six months after planting, from June to September. Contrary to the results of the 2017 study by Yao *et al.*, which showed that anthracnose severity varied by agroecological zone, it varied over the years in the same zone [17].

The prevalence of Yam Mosaic Virus was most pronounced in *D. rotundata*, with an incidence of 100% for four consecutive years, before decreasing to 46% in 2021, with a severity ranging from 4 to 2.13. The prevalence of Yam Mosaic Virus decreased over the years, reaching a low of 3.9% in 2022 in *D. alata*, with a severity ranging from 1.1 to 3.5. In fact, many cultivars, especially new improved cultivars, have shown some tolerance to viruses. As a result, improved varieties have a capacity for disease resistance that limits the effect of the virus on accessions [18]. Our results showed that all collections were 100% infected, which may be justified using plant material affected by Yam Mosaic Virus for the conservation of these genetic resources. In 2009, research by Séka *et al.* highlighted the strong presence of yam Yam Mosaic Virus in Bouake, with an incidence rate of over 80% and very high severity scores [19].

However, the environment can affect the virulence of mosaic and anthracnose, as well as the effectiveness with which they are transmitted. Extreme weather conditions, such as heatwaves and heavy rainfall, can create conditions conducive to disease outbreaks, even in resistant varieties, as observed in our study [14].

Therefore, we must continue to record yam accessions in the collection. This will lay the groundwork for future research focused on selecting and developing promising yam species, creating chemical composition tables, developing preservation techniques to produce enriched flour for children, processing compounds derived from these species to ensure their sustainability, and effectively managing natural resources to reduce pressure on wild species while increasing agricultural diversity [20].

The conservation method employed in our study is more restrictive than *in vitro* conservation, which is less space- and time-intensive. However, our goal is to distribute virus-free *in vitro* plants to farmers, researchers, and other interested parties both nationally and internationally [21].

5. Conclusion

Yam genetic resources under *ex situ* conservation in Côte d'Ivoire are composed of 5 species of the genus Dioscorea, of which the alata comprises 241 accessions, the rotundata 181 accessions, the esculenta 11 accessions, the bulbifera 3 accessions and the dumetrium 2 accessions to date. These genetic resources have undergone a discontinuous evolution, with loss of 72 accessions between 2011 and 2022. However, these losses have been minimised thanks to local and external collections and introductions during these years. In terms of health, two diseases have affected genetic resources: anthracnose and Yam Mosaic Virus. These diseases have had a detrimental effect on the various collections, especially anthracnose, which is highly prevalent in *D. alata*, and Yam Mosaic Virus in *D. rotundata*. This increase in the prevalence of anthracnose and Yam Mosaic Virus, particularly in these two species, is of concern to the CNRA, which could use existing biological control program to clean up yam genetic resources.

Acknowledgements

The authors would like to express their gratitude to the Centre National de Recherche Agronomique (CNRA).

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Adoukonou-Sagbadja, H., Missihoun, A.A., Sedah, P., Dagba, R.A., Kinhoegbe, G., Ahanhanzo, C. and Agbangla, C. (2014) Variabilité génétique des accessions d'igname *Dioscorea alata* L. introduites au Bénin à partir des îles du Sud-Pacifique. *Journal of Applied Biosciences*, **73**, 5966-5978

https://www.ajol.info/index.php/jab/article/view/111654

[2] Faostat (2021) FAO Statistical Database. http://www.fao.org/faostat/fr/#data

[3] Ettien, D.J.B. (2004) Intensification de la production d'igname (*Dioscorea* spp.) par la fertilisation minérale et l'identification de nouvelles variétés en zones forestière et savanicole de Côte d'Ivoire. Thèse de Doctorat, Université de Cocody,187 p.

[4] Kouakou, A.M., Zohouri, G.P., Dibi, K.E., N'zué, B. and Foua-Bi K. (2012) Emergence d'une nouvelle variété de l'espèce *Dioscorea alata*, la C18, en Côte d'Ivoire. *Journal of Applied Biosciences*, **57**, 4151-4158. https://www.m.elewa.org/JABS/2012/57/2.pdf

[5] Kouamé, B., Ehounou, J., Kassin, K.E., Dekoula, C.S., Yao, G.F., N'goran, E.K., *et al*. (2018) Caractérisation des paramètres agroclimatiques clés de la saison culturale en zone de contact forêtsavane de côte-d'ivoire. *European Scientific Journal ESJ*, **14**, Article No. 243. https://doi.org/10.19044/esj.2018.v14n36p243

[6] Kouakou, A.M. (2010) Diversité génétique des ignames *Dioscorea alata* L. en Côte d'Ivoire. Thèse de Doctorat, Université Félix Houphouët-Boigny, 7-18.

[7] Anonyme (2023) Bulletins agro climatiques des stations du CNRA. Janvier-mars; avril-juin; juillet-septembre et octobre-décembre de 2011 à 2022.

[8] N'Cho, B.S. (1991) Modélisation de l'accès des racines de maïs (*Zea mays*) à l'azote. Expérimentation au champ en Centre Côte d'Ivoire. Mémoire de DIAT-ESAT, Montpellier, 22 p.

[9] Asfaw, A. (2016) Standard Operating Protocol for Yam Variety Performance Evaluation Trial. IITA. https://cgspace.cgiar.org/server/api/core/bitstreams/769b16d5-2ed3-4035-8bdc-0e90ec387424/content

[10] Dumont, R., Zoundjihekpon, J. and Vernier, P. (2010) Origine et diversité des ignames Dioscorea rotundata Poir. *Cahiers Agricultures*, **19**, 255-261. https://doi.org/10.1684/agr.2010.0411

[11] Nteranya, S. and Adiel, M. (2015) Root and Tuber Crops (Cassava, Yam, Potato and Sweet Potato). *Feeding Africa Conference*, Senegal, 21-23 October 2015, 26 p.

[12] Foua-Bi, K. (1982) Effet des piqûres *d'Aspidiella hartii* (Homoptère-Coccidae) sur la levée, le développement de l'appareil végétatif et la productivité de l'igname. Oxford University Press, International Foundation for Science, 265-273.

[13] Dumet, D. and Ogunsola, D. (2008) Directives pour la régénération: Igname. In: Dulloo, M.E., Thormann, I., Jorge, M.A. and Hanson, J., Eds., *Crop Specific Guidelines* [*CD ROM*], CGIAR System-Wide Genetic Resource Programme (SGRP), 8 p.

[14] Zohouri, P. (1995) Les maladies des plantes à racines et tubercules (Igname et manioc); biologie, identification et lutte: Guide de Recherche et de Formation IDESSA, Part 13. IITA, 28. https://hdl.handle.net/10568/97222

[15] ITRA (2003) Institue togolaise de recherche agronomique, culture vivrieres. rapport annuel 2003. Ministère de L'agriculture et de L'élevage et de la Pêche, 64 p.

[16] Georges, A., Jean, G. and Pierre, M. (2005) L'igname *D. Alata*, la génétique et l'anthracnose. Contribution de L'inra: Passage de la Collecte-Introduction à la créAtion de Variétés Résistante Phytoma, 4 p.

[17] Yao, K.F, Assiri, K.P., Seka, K. and Diallo, A.H. (2017) Distribution et prévalence de l'anthracnose de l'igname dans quatre zones productrices de la Côte d'Ivoire. *International Journal of Innovation and Applied Studies*, **19**, 463-474.

[18] Denis, F. (1987) Epidémiologie de la mosaïque Africaine du manioc en Côte d'Ivoire. Institue Française de Recherche Scientifique pour le Développement en Coopération. Éditions de l'orstom, Collection Études, Thèses, 191 p.

[19] Séka, K., Diallo, A. H., Kouassi, N. K. and Aké, S. (2009) Incidence du Yam mosaic virus (YMV) et du Cucumber mosaic virus (CMV) sur des variétés de Dioscorea spp. cultivées dans les régions de Bouaké et de Toumodi en Côte d'Ivoire. *International Journal of Biological and Chemical Sciences*, **3**, 694-703. https://doi.org/10.4314/ijbcs.v3i4.47179

[20] Lombe, M.R., Bekomo, J.I., Ngandu, O.K. and Ngbolua, K.T.N.J.P. (2024) Les espèces du genre Dioscorea (Ignames) en Afrique tropicale et subtropicale. *Revue Marocaine des Sciences Agronomiques et Vétérinaires*, **12**, 240-251.

[21] Faure, Y., Gelabale, S. and Gomez, R.-M. (2022) Culture *in vitro*, assainissement et indexation de la collection Igname du centre de ressources biologiques plantes tropicales des antilles. *NOV'AE-Ingénierie Et Savoir-Faire Innovants*, No. 2, 90-98.