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SHORT REPORTS

Current Status of Plant Genetic Resources Conservation and Use in the National Genebank, Nigeria

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Abstract

The aim of this paper is to expound the current status of the conservation and management system of plant genetic resources (PGRs) in the National Genebank of Nigeria. National Centre for Genetic Resources and Biotechnology (NACGRAB) created in 1987 is referred to as National Genebank. It holds one of the most comprehensive collections of PGR in the form of seed, plantlets, live plants in Nigeria and provides a major contribution to the prevention of Genetic Resources erosion.

The genebank currently conserved about 10,200 accessions of more than 25 crops species *viz* 5,464 accessions of cereals, 2,193 accessions of pulses/legumes, 556 accessions of oilseeds, 1,674 accessions of vegetables while about 160 accessions of various tree species are conserved *ex-situ*. Diversity mapping, characterization and evaluation of PGRs, duplicate identification, diversity study, pre-breeding and landrace enhancement are the major research works of NACGRAB, and its management strategies such as conservation method, types, characterization, and evaluation are very essential for strengthening utilization of the PGRs.

Keywords: Conservation, Characterization and evaluation, *Ex-situ*, Genebank, PGRs, Utilization.

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Introduction

Nigeria is a country that is physically and ecologically diverse; and greatly endowed with natural resources. The country can be divided into 3 distinct ecological regions: a humid forest region, a sub-humid region with highland and a semi-arid region with an annual rainfall of about 250 to 3000 mm in Sahelian north and southern coastal areas, respectively (FAO, 2008). There are 7, 895 plant species from 338 families and 2,215 genera that have been identified in Nigeria (FMEnv, 2006). However, about 0.4 and 8.5% of the plant species are said to be threatened and endangered according to the International Union for Conservation of Nature (IUCN) list of the threatened species.

Nigeria, rich in plant genetic resources and their wild relatives in their natural habitats, is endowed with rich and is the epicenter of diversity for many crops/taxa such as cowpea, West Africa okra, West African rice, yams, bambara groundnut, Africa yam bean and wing bean (FMEnv, 2006).

PGRs Management System in Nigeria

Plant Genetic Resources (PGRs) or germplasm refers to all materials that can be used for improvement of cultivated plant species (Becker, 1993). According to the International convention for biodiversity, genetic resources is defined as all living materials that include genes of present and potential value for human use and needs (IPGRI, 1993).

Genebanks (*ex-situ* conservation) were created in the mid-twentieth century to conserve indigenous cultivated biodiversity

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when modern varieties replaced landraces. This idea was accepted generally as a necessary step to safeguard the future (Van de Wouw *et al.,* 2009 and Khoury *et al.,* 2014). Genebanks were created to preserve genetic material for immediate use and posterity (Fowler and Hodgkin, 2004), either directly or as genetic material in breeding programs to face challenging situations in environmental conditions or societal needs.

The national centre for genetic resources and biotechnology was established in 1987 with a mandate to conduct research, gather information/data and disseminate technological information on matters relating to genetic resources, conservation, utilization and biotechnology applications. It is the focal point for Plant genetic resources conservation and maintenance in Nigeria and is thereby referred to as the National genebank. In line with her mandates, it has four major departments/units, namely, Plant Genetic Resources Department (Seed Genebank and Field genebank), Animal Genetic Resources, and biotechnology (Tissue culture and molecular biology units) In addition, the Centre also has 3 Zonal Stations Research Farms located in different geo-political zones viz: Bagauda in Kano state; Badeggi in Niger state and Benin in Edo state.

National Centre for Genetic Resources and Biotechnology (NACGRAB) has adopted various strategies in order to manage the rich genetic resources available in the country. The strategies include: *Ex-situ* conservation which comprises of seed genebank, *in-vitro* bank, field genebank and medicinal garden. Types and groups of germplasm available in the genebank for conservation are as follows: Landraces, modern/improved varieties, obsolete varieties, breeding lines, inbred lines, exotic lines, and wild relatives. The PGRs are also grouped based on economic values, such as cereals, pulses, vegetables, fruits, fibers, oil crops, spices etc. Based on the biology of the seeds/germplasm, all germplasm are divided into: orthodox seeds, recalcitrant seeds and vegetatively propagated plants. The centre also adopted geographical information system (GIS) application, characterization, regeneration and evaluation of PGRs, identification of duplicates, diversity study, and pre-breeding, among others.

The facilities available in the center include:

- Medium-term storage (initially Long term storage with vacuumed sealed material used for base collection but has been converted to medium storage due to the present condition the genebank) with 2 to 10°C and 15% RH. This facility can store for 15 to 20 years;
- Short-term storage (for active collection) with 20–25°C and 15% RH. It can store for 2 to 5 years for orthodox seeds;
- *In-vitro*/tissue culture laboratory: for *in-vitro* conservation of recalcitrant, apomictics and vegetatively propagated plants.
- Seed testing and processing laboratory,
- Seed health laboratory
- Field genebank: for conservation of various tree spp.
- Molecular laboratory: for genetic analysis at DNA level e.g., DNA extraction, PCR amplification etc.
- Database management: to document all the information pertaining to the conserved germplasm.

Exploration, Collection, Conservation and Utilization of Germplasms

NACGRAB has been collecting/exploring PGRs from different parts of the country since 1987 either alone or in collaboration with other institutes. More than 10,200 accessions of indigenous cultivars and wild relatives have already been collected through over 25 crop-specific and region-specific explorations (Table 1) and they are being maintained at the centre's storage facilities. These represent wide variability in crops like maize, sorghum, rice, wild vigna, okra, chochorus, amaranthus, and pearl millet. The areas already explored include the North-East, North-West, North-Central, South-West, and South-East regions of Nigeria. However, some of the preserved germplasm is constantly lost due to poor storage conditions due to power outages or unstable power supply. However, gap analysis is regularly done before embarking on explorations in order to explore some of the old site where the lost germplasm were collected. Under *ex-situ* conservation, the genebank holds about 10,200 accessions of more than 65 crop species with their passport data (collected through over 25 crop specific and region-specific explorations). Among them are, 5,464 accessions of cereals, 2,193 accessions of pulses/legumes, 556 accessions of oilseeds, 1,674 accessions of vegetables while about 160 accessions of various tree crop species are being conserved in the field genebank facility of the centre (Figure 1).

A total of 3,266 accessions of 26 crops species representing about 30% of total germplasm maintained in the facility were regenerated during 2015-2019 in Ibadan

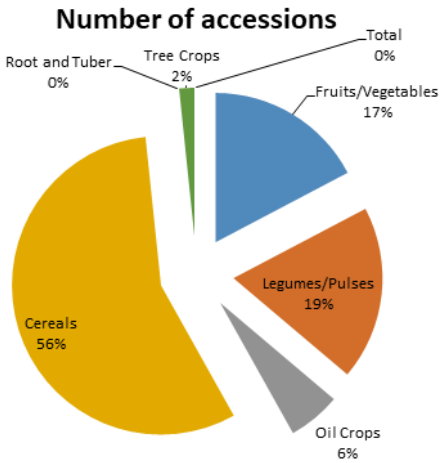

Figure 1: Crop class and number of accessions in storage.

Table 1: Number of crop species and accessions in storage at NACGRAB's genebank as at 2020

S. No.	*Crop*	*Genus*	*Species*	*Seed Genebank*	*Field Genebank*	*In-vitro Genebank*
1	Amaranthus	*Amaranthus*	*Hybridus*	252		
2	Celosia	*Celosia*	*Argentia*	248		
3	African Spinach	*Basella*	*Alba*	12		
4	Cabbage	*Brassica*	*Oleraceae*	3		
5	Roselle	*Hibiscus*	*Spp*	12		
6	Basil	*Ocimum*	*Basilicum*	6		
7	Saint Leave	*Ocimum*	*Graticinum*	3		
8	Bambara Nut	*Vigna*	*Subterra*	42		
9	Soybean	*Glycine*	*Max*	424		
10	Lima/Butter Bean			92		
11	Phaseolus	*Phaseolus*	*Spp*	52		
12	Pigeon Pea	*Cajanus*	*Cajan*	50		
13	Sword Bean	*Canavalia*	*Gladiata*	3		
14	African Yam Bean	*Sphenostylis*	*Stenocarpa*	100		
15	Groundnut	*Arachis*	*Hypogea*	368		
16	Wild Vigna	*Wild Vigna*	*Species*	1062		
17	Pumpkin	*Curcubita*	*Spp*	27		
18	Cucumber	*Cucumis*	*Sativus*	6		
19	Melon	*Cucumis*	*Spp*	444		
20	Egg Plant	*Solanum*	*Spp*	114		
21	Pepper	*Capsicum*	*Spp*	214		
22	Tomato	*Solanum*	*Lycopersicum*	144		
23	Rice	*Oryza*	*Sativa*	492		
24	Millet	*Pennisetum*	*Spp*	1467		
25	Wheat	*Triticum*	*Aestivum*	212		
26	Sorghum	*Sorghum*	*Bicolor*	1808		
27	Maize	*Zea*	*Mays*	1375		
28	Fonio/Acha	*Digitaria*	*Exillis*	110		
29	Onion	*Allium*	*Cepa*	9		
30	Okra	*Abelmoscus*	*Esculentus*	506		
31	Corchorus	*Corchorus*	*Olitorius*	118		
32	African Apple	*Chrisophyllum*	*Albidum*	3		
33	Sesame	*Sesamum*	*Indicum*	97		
34	Morogbo (Sesame Vegetable)	*Sesamum*	*Indicum*	12		
35	Castor Seed	*Ricinus*	*Communis*	3		
36	Cotton	*Gossypium*	*Hirsutum*	12		
	TOTAL SEED			9902		
37	Acacia	Acacia	*Albida*		1	
38	Acacia	Acacia	*Nodosa*		8	
39	Acacia	Acacia	*Biflora*		7	
40	Baobab	*Adansonia*	*Digitata*		4	
41	Afzelia	Afzelia	*Africiana*		2	
42	Agava	Agava	*Spp*		5	

43	Albizia	Albizia	*Odoratisswima*	20	
44	Albizia	Albizia	*Saman*	3	
45	Albizia	Albizia	*Lebbeck*	16	
46	Alstonia	Alstonia	*Boonei*	2	
47	Cashew	*Anacardium*	*Occidentale*	7	
48	Anogeisus	Anogeisus	*Leocardpus*	2	
49	Sweet Sops	*Anona*	*Squamosal*	3	
50	Anthonotha	Anthonotha	*Macrophylla*	6	
51	Sour Sop	*Anonas*	*Muricata*	2	
52	Bread Fruit	*Artocarpus*	*Altilis*	8	
53	Avocado Pear	*Persea*	*Americana*	3	
54	Neem	*Azadiracthta*	*Indica*	37	
55	Bauhina	Bauhina	*Monandra*	5	
56	Bixa	Bixa	*Orellana*	5	
57	Ackee Apple	*Blighia*	*Sapida*	12	
	TOTAL			157	
58	Plantain/Banana	*Musa*	*Spp*		2
59	Pineapple	*Ananas*	*Comosus*		3
60	White Yam	*Dioscorea*	*Rotundata*		3
61	Water Yam	*Dioscorea*	*Alata*		1
62	Ginger	*Zingiber*	*Officinale*		2
63	Bitter Leaf	*Vernonia*	*Spp*		1
64	Passion Fruit	*Passiflora*	*Edulis*		1
65	Cocoyam	*Colocasia*	*Esculenta*		2
66	Eucalyptus	*Eucalyptus*	*Spp*		1
	Total				16
	Grand Total				10,075

(Oyo state), Bagauda (Kano state) and Badeggi (Niger State) stations (Table 2). Moreover, a total of 310 accessions of 6 crop species were characterized and evaluated i.e., 100 accessions of maize, 50 accessions of rice, 20 accessions of cowpea, 40 accessions of okra, 40 accessions of Jute mallow and 60 accessions of tomato (Table 3).

One of the mandates of genebank is utilization by providing access to PGRs and databases. The genebank has distributed PGRs to national research institutes, students, scientists, breeders, hobby breeders and farmers majorly for utilization in crop improvement programmes. 9888 accessions of 40 different crop species were distributed to various users (Table 4).

Links and Collaboration with International Organizations (CGIAR), NARIs and Private Organizations

In order to fulfill its national mandate, the centre maintains links and collaboration with all National crop/Animal based institutes of the Agricultural Research Council of Nigeria (ARCN), Agricultural Universities and also have effective links with many crop based) since the inception of the genebank in 1987. The Centre collaborates with CGIAR centres, including Genetic Resources Centre (GRC) housed in International Institutes under the CGIAR system, include Centre for Genetic Resources (CGR) housed in the International Institute for Tropical Agriculture (IITA), Ibadan managing the world plant genetic resources and ICRISAT works on the management of wheat, millet, pearl millet plant genetic resources. In addition, there are other NGOs involved in Agro biodiversity management e.g., Centre for Environment, Renewable Natural Resources Management, Research and Development (CENRAD), Justice Development Movement (JDPM), Oyo, Nigeria etc. and many other working on seed business. As part of mandates of NACGRAB in the conservation of safety duplicates of germplasm held by National Agricultural Research Institute (NARIs) in Nigeria, the under-listed germplasm were deposited at the National Gene bank.

Duplicates Samples Deposited at International Genebanks

In accordance with the provision of treaty of Conventional Biological Diversity of 1992 which mandated all genebanks

Table 2: Total number of accessions per crop species successfully regenerated at Ibadan from 2015 - 2019

S. No.	*Type of Crops*	*Number of Accessions*
1	Okra	215
2	Corchorus	153
3	Amaranthus	100
4	*Bassella alba* (Red And White)	17
5	Tomato	140
6	Melon	50
7	Pepper	82
8	Ife Bimpe Minor Legumes	10
9	Maize	36
10	Sorghum	100
11	Celosia	58
12	Yam	34
13	Rice	50
14	Snake Tomato	2
15	Roselle	5
16	Sesame	8
17	Groundnut	40
18	Soybean	20
19	Bambara Nut	18
20	Pearl Millet	240
21	Cowpea	59
22	African Yam Bean	6
23	Phaseolus	3
24	Pigeon Pea	10
25	Egg Plant	40
26	Wild Vigna	20
	Total	1516

in the world to deposit duplicate samples in Svalbard Global Seed Vault, Norway. A total of 423 sorghum accessions, 176 accession of cowpea and 34 accessions of sesame were deposited in Svalbard Genebank, Norway (Annual Report, 2012). In collaboration with the Institute of Agricultural Research (IAR), Zaria, Lake Chard Research Institute (LCRI), Maiduguri and National Roots Crops Research Institute (NRCRI), Umudike supported by Global Crop Diversity Trust, additional 423 accessions of sorghum and I67 accession of pearl millet were deposited in ICRISAT Sahelian Centre, Niamey for safe keeping (Figure 2).

Documentation and Information

Significant advances have been made in terms of documentation and publicly making information on ex situ germplasm available. The genebank has upgraded from using the Ms Excel application for data management to using Genesys as an information management system. Passport data of more than 51 accessions of crop wild relatives (CWR)

Table 3: Accessions of crop characterized

S. No.	*Crop spp*	*Number of accessions*
1	Maize	100
2	Rice	50
3	Cowpea	20
4	Okra	40
5	Jute mallow	40
6	Tomato	60
7	Total	310

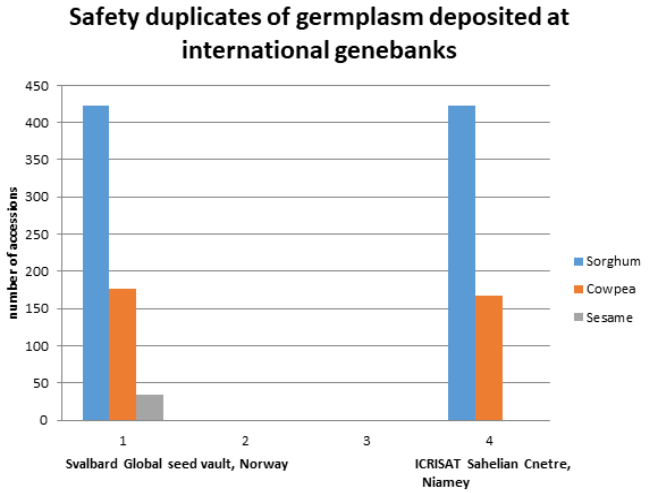

Figure 2: Four crop species safely duplicated in CGIAR banks.

and 4000 landraces were submitted to the *genesis* and FAO database (Figure 3). Figure 2 explained the number of accessions conserved in different facilities in NACGRAB. 98% of the total accessions which represent 9902 accessions are stored in the seed genebank while only 2% representing 157 accessions are in the field genebank. The figure revealed that only 16 accessions are stored *in-vitro*.

Links and Collaboration with International Organizations (CGIAR), NARIs and Private Organizations

In order to fulfil its National mandate, NACGRAB has a strong synergy and collaboration with international, regional and local organizations (Institutes and Universities that are crop based) since the inception of the genebank in 1987. The Centre collaborates with CGIAR centres, including Genetic Resources Centre (GRC) housed in International Institute for Tropical Agriculture (IITA), Ibadan managing the world plant genetic resources and ICRISAT working on the management of wheat, millet, and pearl millet plant genetic resources. In addition, The centre maintains a linkage with FAO for support to promote the conservation and sustainable use of PGRFA In addition, there are other NGOs involved in Agro biodiversity management e.g. Centre for Environment, Renewable Natural Resources Management, Research and Development (CENRAD), Justice Development Movement

Table 4: Seed Distribution From 2010-2019

Crop spp	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*Total*
Amaranth	113	44	136		69	195	127	114	82	204	1084
African yam bean			5		2	12	25	2	13	9	68
Acha					1	2	2		2	19	26
African spinach								4	1	2	7
Basil											
Bambara nut	36				5	30	5	7			83
Butter bean						5	3				8
Black bean											
Celosia			11		16	40	15	57	58	96	293
Castor											
Cowpea	10	42	98		109	143	97	123	71	36	729
Cabbage											
Cotton					5	7			1		13
Cucumber									1	3	4
Egg plant			34		36	56	45	32	50	42	295
Eleucine									1		1
Groundnut	47		14		21	11	17	18	21	19	168
Jute mallow	20	29	43		71	45	61	55	101	168	593
Kenaf					8	6	`12	36	22	15	87
Lima bean			3				5				8
Millet		7	2		5	25	11	3	41	41	135
Melon	20	34	30		37	42	32	4	14	45	258
Maize	145	39	22		14	103	179	136	59	28	725
Okra	100	66	96		145	89	73	166	155	242	1132
Onion						1			3		4
Pepper	40	31	25		31	60	66	104	58	145	560
Pumpkin	11					5			1		17
Pigeon pea	3				1	39	14	7	25		89
Phaseolus						2			1		3
Roselle					5	1		2	1	3	12
Rice					12	51	46	71	18	107	305
Sesame	5		42		45	42	112	32	76	9	363
Sword bean											
Sorghum	36	165	178		62	249	96	56	154	91	1087
Soybean	6		15		28	56	19	39	28	89	280
Sunflower						10			1		11
Tomato	52	30	61		194	137	286	155	98	151	1164
Water melon										4	4
Wheat					4	2		6	10	9	31
Wild vigna					140	91			10		241
Total	644	487	815		1066	1557	1336	1229	1177	1577	9888

(JDPM), both in Oyo state, Nigeria and many other working on seed business.

With support of WAAPP-Nigeria, the genebank rehabilitated the cold storage facilities and kept it functional during phase 1 of the project from 2013-2015. A technical consultant was also hired to ensure the genebank work perfectly at all

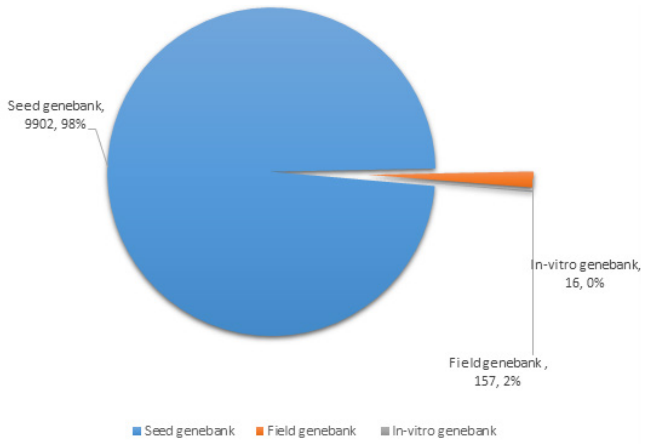

Figure 3: Percentage of crop accessions in different storage type.

times. The International Institute of Tropical Agriculture in Ibadan has been a major partner for NACGRAB. Recently, IITA and the centre jointly sampled Kersting's groundnut from Oyo, Ondo and Ekiti farms in October 2018, and groundnut and African Yam bean in January-February 2019.

The Global Crop Diversity Trust (GCDT), through the Royal Kew Botanical garden, in the U.K funded the collection of wild relatives of crops which includes: rice, garden egg, bambara groundnut, millet, and wild *Vigna*. Two hundred and six accessions of 20 species of wild relatives of crops. The materials collected with their herbarium specimen were processed at the NACGRAB and deposited in the gene banks of NACGRAB and Royal Kew Botanical garden for further classification and characterization. The GCDT through the crop wild relative project also provides support to NACGRAB to strengthen its genebank information systems. This project upgrades the computer hardware equipment for document management systems.

A research project on Wild Vigna, funded by the GCDT through the International Institute for Tropical Agriculture (IITA) was carried out in NACGRAB for two years. In 2017, (174) wild vigna lines were evaluated for seedling stage drought, the experiment identified thirty of the wild vigna accessions to be highly tolerant to seedling stage drought. The result obtained prompted the second stage of the experiments in 2018, out of the 162 accessions screened for seedling stage drought, 68 accessions were selected as tolerant to seedling stage drought based on their level of recovery after drought.

Crop Research Institute for the semi-arid tropics (ICRISAT) in the year 2017 and 2019. The germplasm collection activity was an extensive exploration activity designed to collect maximum diversity of different crops, some of which were on the verge of extinction and located in difficult terrain, hostile environments and harsh conditions. Major crops of focus during the collection activity included: sorghum, pearl millet and groundnut which have high economic importance and are tagged worldwide as crop for the future. In 2017, a total of 144 accessions were collected; in 2019, a total of 223 accessions were collected. The centre has also successfully supervised the collection and regeneration of four crops, cowpea, sorgum, pearl millet and yam. The project was funded by the Global Crop Diversity Trust and had 3 Research Institutes, the Institute of Agricultural Research, Samaru (IAR), Lake Chad Research Institute (LCRI) and National Root Crops Research Institute (NRCRI) as collaborators. As part of the requirement of the project, safety duplicate of the materials collected have been sent to Svalbard Global Seed Vault and ICRISAT Sahelian centre, Niamey for safe keeping.

Training

The centre also impart training in all facets of PGR activities. It has conducted short term training at the national level on tissue culture molecular techniques. It has also trained several students from Universities, Polytechnic and colleges of agriculture on SIWES and industrial training. PhD students from different universities within the country and outside have also been regularly made use of the centres facilities for their experiments/research with an emphasis of training such students with a view to producing more specialists in field of plant genetic resources management. The centre has also been relevant in information dissemination on PGR activities in Nigeria. It published annual reports, newsletters (quarterly) and the National Varietal Release catalogue. The centre has well over 100 research papers, reports, catalogues, proceedings of seminar/symposia, etc. with focus on conservation and management of plant genetic resources research.

Many of the centre's scientists and technologists have received training both at national and international levels on different aspects of plant genetic resources conservation and utilization.

Gaps and Challenges Facing PGR Management in Nigeria

Technical Know-how

Crop wild relatives are related to our food crop plants and contain useful diversity for adapting food crops to climate change. Ironically, little effort and priority has been given to this class of germplasm. Technical capacity for management (evaluating and characterizing) of CWR is still lacking as there are few personnel with technical knowledge on collecting and managing CWR in the country.

Limited Financial Resources/Fund

Exploration, collection and characterization of PGRs needs a lot of funds but due to limited financial resources, collection, characterization, seed health, and regeneration activities are not effective and efficient.

Farmer's Unwillingness to Provide Information

During collections and exploration of germplasm, farmers don't always give enough information/knowledge associated with PGR. Also, they don't provide enough seed sample that warrants diversity within a landrace.

Lack of Infrastructures

The two facilities for germplasm storage (Long term and short-term) has been in existence since the inception of the genbank in 1987. Due to long-term of use, they are no longer efficient especially the long-term storage room. In addition, epileptic power supply also pose a problem to the efficiency of the cold room and threatens the longevity of the germplasms.

Gaps in PGRs Management among NARIs, NGOs and Private Organizations

Weak coordination existed among NARIs, NGOs and private organizations as regards germplasm management, exchange and information sharing. There are situations whereby these organization are not willing to provide information and samples of germplasm in their custody to the National genebank.

Assessment Genetic Erosion and Community Genebank

Knowledge of existing crop diversity, its distribution and evolution over time, is an essential pre-requisite for developing and implementing effective and efficient management strategies of crops and their genetic diversity. One of the mandates of genebanks is to assess and monitor genetic erosion and arrest the situation. The centre has recorded little achievement in the area of genetic erosion assessment.

Recent Developments

Recently (2021), the centre being the focal point for PGRs conservation and management in Nigeria with FAO prepared the country report on the state of PGRFA in preparation for the third report on the state of PGRFA in the world. The centre has instituted the National Committee on PGRFA to strengthen the linkages among different stakeholders as part of the implementation of the second world report.

Nigeria recently approved Nigeria's ratification of Plant Treaty in January, 2021. This ratification would change the status of the country from observer to full member of the treaty.

Moreover, the Centre organised a National summit and conference on Genetic Resources Conservation and Utilization held on 23-24 March, 2021 with a representation of international organisations such as IITA, FAO, ICRISAT and NEXTGEN CASSAVA. The centre has initiated action to implement the recommendations of this summit.

Conclusion

This paper discussed the current exploitation status of plant genetic resources conservation in NACGRAB, Nigeria. It briefly discussed on the activities such as collection, storage, utilization, research, collaboration and management. The paper also identifies gaps in the area of genetic erosion assessment, limited funding, lack of synergy and network among organization managing Plant Genetic Resources.

In future, NACGRAB has to improve on the monitoring of Genetic erosion In addition, there should be a strong communication network established among public, private, community based organizations, NGOs and international organizations for PGRs management. There should be awareness about the importance of plant genetic resources conservation among farmers and local people to establish community genebank and Link to National Genebank for proper plant genetic resources management.

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