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Information of Plant Gene banks in the World

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Abstract—*Plants endure the primary source that converts solar energy into chemical energy and provide the first link in the food chain. Human beings have used plants in innumerable ways for their food, nutrition, health, clothes, shelter and other needs. Diversity over the years have been nurtured, utilized, and enhanced by mankind for different purposes. It has been affected or lost by calamities such as drought, flood, cyclones, changes in land use patterns and with the advent of technologies. Conservation of the diversities of plants holds essential parts of today's life. Gene banks work as a biorepository which preserves genetic material. Major Gene banks dwell in China, Russia, Japan, India, South Korea, Germany and Canada (in that order) as well as those operated by the Centers of the Consultative Group on International Agricultural Research (CGIAR). Here an effort is made to compile information of a few of the far-reaching Gene banks of the world and also to find gene banks holding maximum germplasm. Gene banks are storing genes of new plant varieties that will be better suited to our needs and to the constraints of our ecosystems. In the early 1970's there were few gene banks with half a million of sample accessions. But today, there are approximately 1300 Gene banks consisting of around more than 6 million of accessions stored for future (although there is a possibility of duplicates). These ganebanks store 40% of cereals, 15% of food legumes and less than 10% of vegetable, roots, tubers, fruits and forages. Svalbard Global Seed Vault stores nearly 1.5 million of seed germplasms however It has the capacity to store 4.5 million germplasms. ICAR-NBPGR is second largest genebank in world with the capacity of more than 4.25 lakhs of germplasm stored. With so many advantages associated with gene banks, there are some disadvantages also. For eg: there is possibility that germplasm kept under optimal condition may decline its viability, which indicates that it needs to be regenerated. Seed germplasm needs to be replenished by regeneration after a certain period of time. "FAO estimates that as many as one million accessions may now be in need of replanting in order to generate new seeds for storage. Regeneration itself is fraught with difficulties and can promote genetic erosion" (Breese,EL, 1989 [15]). Hence, to safeguard crop varieties for future usage, they need to be conserved in Gene banks as well as need to regenerate from time to time to retain the quality and viability of germplasms.*

1. INTRODUCTION

Plants endure the primary source that converts solar energy into chemical energy and provide the first link in the food chain. Human beings have used plants in innumerable ways for their food, nutrition, health, clothes, shelter and other needs. There persist an amazing diversity and forms of plants used by us. Diversity over the years have been nurtured, utilized, and enhanced by mankind for different purposes. It has been affected or lost by calamities such as drought, flood, cyclones, changes in land use patterns and with the advent of technologies. Conservation of the diversities of plants holds essential parts of today's life. During the last decades, it has been observed extinction of crop varieties is prevailing. Of the several plant species used in the past for food, only about 150 survive in cultivation today and just three –rice, wheat and maize supply nearly 60% of the calorie and protein derived from plants. To safeguard plant diversity for longer usage large number of gene banks has been established in developing nations. Gene banks abides the facility for conserving and storing germplasm. Conservation of germplasm is done by conserving seed, tissues, pollen-grains and plant itself. There exists 5 types of gene banks. Gene banks work as a biorepository which preserves genetic material [1]. According to Food and Agriculture Organization (FAO)wol of United Nation, there outlast nearly 1400 gene banks in the World. Major Gene banks dwell in China, Russia, Japan, India, South Korea, Germany and Canada (in that order) as well as those operated by the Centers of the Consultative Group on International Agricultural Research (CGIAR) [2]. According to "Gene bank." *Wikipedia: The Free Encyclopedia.* Wikimedia Foundation, Inc. 12 September 2014. Web. 24 September 2014. <http://en.wikipedia.org/wiki/Gene_bank>, there are five types of gene banks. Table 1 elucidates these gene banks. In this article an effort is being made to compile information of a few of the far-reaching gene banks of the world.

Table 1: Types of Gene banks

1.	Seed Genbank	They are developed to store germplasms in seed form. Seeds of plants are completely dried and stored at an ideal low temperature in the seed Gene bank. The Millennium Seed Bank is largest seed bank. It is situated in Wellcome Trust Millennium Building (WTMB), located Wakehurst Place in West Sussex, near London[1].
2.	Tissue bank	They represent for storing germplasms of seedless plants. In tissue bank germplasms in the form of buds, merismetic cells and protocarm are stored. They are supplied required amount of light and temperature for nutrient [1].

3.	Cryo bank	They are intended to store seed or embryo of a plant at an ideal low temperature. These germplasm are preserved in liquid nitrogen at -196°C. Cryo banks are helpful in conserving those species of plants which are in the process to be extinct [1].
4.	Pollen Bank	They are meant to store pollen grains. Storage of pollen grains as a germplasm will be useful to generate a brand-new plant with one set of chromosome in future, if needed [1].
5.	Field Gene bank	Field gene banks abide to conserve plants in the fields. For that purpose a desired ecosystem is developed artificially. Adequate amount of water, soil and manure is provided, to grow plants in the fields. The basic purpose is to store the genes of the plants in the fields. Central Rice Research Institute in Orissa has conserved 42,000 varieties of rice [1].

2. IMPORTANT GENEBANKS

1. Svalbard Global Seed Vault

According to "Svalbard Global Seed Vault." *Wikipedia: The Free Encyclopedia*. Wikimedia Foundation, Inc. 16 November 2016. Web. 16 November 2016. <http://en.wikipedia.org/wiki/Svalbard_Global_Seed_Vault> the Svalbard Global Seed Vault is a protected seed bank positioned on the Norwegian island of Spitsbergen neighboring Longyearbyen town in secluded Arctic Svalbard islet. It resides about 1,300 kilometers from the North Pole. The seed vault is an effort to safeguard seeds in gene banks and to preserve the seeds in case of any crisis. Seed Vault's construction was started on 19 June 2006. The first stone of the vault was laid down by the Prime Minister's of Norway, Sweden, Finland, Denmark and Iceland. It resides 120 meters inside a sandstone mountain on Spitsberg island. Officially it was opened on 26 February 2008. A tripartite agreement between the Government of Norway, Nordic Genetic Resource Centre (NordGen) and The Global Crop Diversity Trust takes care of the seed vault. Management of Seed Vault is executed by the Nordic Genetic Resource center. On an average vault store nearly 1.5 million of seed germplasms however It has the capacity to store 4.5 million germplasms. Much before the existence of seed vault in 1984, Nordic Genbank (NGB) was storing a backup of Nordic plant germplasms in the form of frozen seeds in a secluded coal mine in Svalbard. In addition to that, for some period of time, NGB has duplicated seed germplasms of the Southern African Development Community. At present all the Nordic and African collection have been transferred to the new Svalbard Global Seed Vault facility. The Nordic gene bank has been integrated part of NordGen since 1 January 2008 [2].

2. Consultative Group on International Agricultural Research (CGIAR)

According to "Consultative Group on International Agricultural Research." *Wikipedia: The Free Encyclopedia.* Wikimedia Foundation, Inc. 16 November 2016. Web. 16 November 2016. < http://en.wikipedia.org/wiki/Consultative_Group_on_International_Agricultural_Research> CGIAR is a global research organization in agricultural sector. Its goal is to reduce poverty in rural areas, increased food security, improvement in human health and nutrition and establishing imperishable natural resources. It provides financial support and coordinate research in crop breeding programs worldwide. CGIAR consists of 15 research centers called as 'CGIAR Consortium on International Agricultural Research Centers'. According to "Genebanks: investing in biodiversity for future generations." Consortium News. CGIAR. 11 July 2013. 16 November 2016. < http://www.cgiar.org/consortium-news/genebanks-investing-in-biodiversity-for-future-generations/ > around 710,000 accessions of crops *via:* Cereals, legumes, roots and tubers, trees and other significant crops are stored in CGIAR collections. CGIAR gene banks not only preserve seed germplasm for future use, but also renders direct support to farmers, such as re-establishing of extinct varieties and landraces, providing seeds for crop breeding purposes etc.

3. Agriculture Research Service of the United States Department

According to "Agricultural Research Services."*Wikipedia: The Free Encyclopedia*. Wikimedia Foundation, Inc. 14 July 2014. Web. 16 November 2016. < http://en.wikipedia.org/wiki/Agricultural_Research_Service > Agricultural Research Services (ARS) is the primary research agency of the United States Department of Agriculture (USDA). USDA has four research agencies and ARS is one of them. It was formed on 2 November 1953 with its headquarter in Washington DC. The objectives of ARS lies in promoting scientific knowledge and solving problems arising in agricultural sector. [5]. Website of "Brazilian Gene Bank Becomes World's Seventh Largest." SciDev.Net. 6 December 2006. 16 November 2016. <http://www.scidev.net/global/biotechnology/news/brazilian-gene-bank-becomes-worlds-seventh-larges.html?stay=full > specifies that Agriculture Research Service of the United States Department of Agriculture is a world's largest seed bank and it holds 460,000 seed samples, however, its capacity is to store germplasm up to 1 million[6].

4. China National Genebank

China National Genebank is a non profit organization funded by Govt. of China. This gene bank stores germplasm of human origin, plants, marine organisms, animal and microorganisms. In case of plant germplasm in the form of tissues, seeds are stored. Gene bank was built in 1983 with the mission of the collection and consevationof biological resources of national importance. Presently it is holding 374,627 accessions of 898 species in long term storage (Zhang J. *et.al*)[20].

5. National Bureau of Plant Genetic Resources

In 1976, Indian Council of Agricultural Research (ICAR) has inaugurated an Indian National Gene Bank entitled as "National Bureau of Plant Genetic Resources (NBPGR)". It is majorly involved in the activities of collection, conservation and evaluation of plant genetic resources. NBPGR has played

a great role in the green revolution by providing required genetic stocks to desired location. It consists of colossal infrastructure. In the current scenario, It is one of the topmost gene banks (germplasm accession holdings wise) in the World. After 25 years of research and services towards plant genetic resources collection, conservation and evaluation, the institute has emerged as the spearhead of the Indian national plant genetic resources management system. It consists of 11 regional stations/base centers spread in different geographical zones of the country. It is connected with 40 national active germplasm sites. Germplasm holdings of 4,04,945 accessions have been conserved in the national gene bank [8].

6. CIMMYT Gene bank

CIMMYT is spanish acronym of *Centro Internascional de Mejoramiento de Maíz y Trigo.* It is an International Maize and Wheat Improvement Center and is a non profit organization for research and training [18]. According to the website of "CIMMYT International Maize and Wheat Improvement Center". 16 November 2016. <www. Cimmyt.org/en/where-we-work/Americas.> gene bank of CIMMYT is located in Mexico and stores 27,000 accessions of maize and 170,000 accessions of wheat, with a total of 197,000 accessions [19].

7. German e*x situ* Gene bank

German ex situ Gene bank is situated in Germany. It is one of the largest global collection of germplasms. In this Gene bank about 150,000 accessions are maintained, including cereals, legumes, vegetables, forage crops, oil crops, potatoes and medicinal and spice plants (Borner *et al.* [7]). *Ex situ* gene bank collections of plants consist of seed gene bank, in-vitro collections and field gene banks. Crop varieties, or landraces whose seeds is dried up to lower moisture content are stored in a seed gene bank. However, varieties or landraces, whose seeds lose their viability quickly and plants which are vegetatively propagated are conserved in a field gene bank or *in vitro* gene banks.

8. International Center for Agricultural Research in Dry Areas (ICARDA)

ICARDA is global organization working in dry areas. It was established in 1977, and is one of the CGIAR supported center. It is dedicated for collection, conservation and characterization of barley, wheat, lentil, chickpea, fababean, vetch and grasspea. Website of "ICARDA Science for Better Livelihoods in Dry Areas." 16 November 2016 <http://www.icarda.cgiar.org/mission-and-vision> unveils establishment of gene bank in 1983, consisting of 135,000 accessions of mandated crops from 110 countries. Within the stored accessions, about 65 % accessions are unique landraces and wild species of forages, legumes and cereals. ICARDA's offices are running in West Asia, South Asia and China, North Africa, Nile valley and sub- Saharan Africa, Central Asia and Caucasus, Arabian Peninsula and highland regions of Afganistan, Iran, Pakistan and Turkey.

9. The International Rice Gene bank

A document on "The International Rice Genebank." 16 November 2016. <http://cropgenebank.sgrp.cgiar.org/images/file/learning_space/IRRI_genebank_manual.pdf> mentions holdings of 117,000 germplasms of rice, which includes the latest, wild and traditional varieties of rice. The International Rice Genebank, is managed by the International Rice Research Institute (IRRI). It is a significantly large collection of rice genetic stocks [9].

10. Brazilian gene bank

From the website of **"**Brazilian gene bank becomes World's Seventh Largest" SciDevNet. 6 December 2006. 16 November 2016. <http://www.scidev.net/global/biotechnology/news/brazilian-gene-bank-becomes-worlds-seventh-larges.html?stay=full > it is clear that the Brazilian gene bank is seventh largest gene bank in the world. It has a collection of around 102,000 seed samples of 500 diverse plant species. This genebank not only stores germplasm of plants, but also germplasms of animals, spores or eggs [10].

11. AVRDC - The World Vegetable Center

AVRDC is a research organization committed to improving quality of nutrition through improvement in vegetables and fruits. It is a world's largest gene bank for vegetables." AVRDC The World Vegetable Center." 26 June 2014. **16 November 2016** <http://avrdc.org/about-avrdc/new-locations/#.VCqD5lcXK0r> specifies, AVRDC Genebank consists of 61,177 accessions of vegetables of germplasm of 440 species from 156 countries. Researchers from Asia, Africa, Central America and Oceania are engaged in AVRDC program. Its Headquarter is in Shanhua, Taiwan City in Southern Taiwan [11].

12. International Potato Center

The International Potato Center is also known as CIP, which is Spanish acronym. This center was established in 1971 for root and tuber research. CIP is an international center with its headquarters in Lima, Peru. It has 20 regional offices in Asia, America and Africa. In addition to that it is part of CGIAR consortium [12]. It has the world's largest *in vitro* gene bank consisting of 4500 varieties of potato as mentioned in the website "The gene bank at the International Potato Center." Rural. < http://www.abc.net.au/news/2013-12-04/international-potato-center-peru-gene-bank/5109964 > From the website of "The gene bank at the International Potato Center." 16 November 2016. < http://cipotato.org/conserving-diversity-for-the-future/ > mentions active collections of more than 21,000 accessions of potato, sweetpotato and Andean root. For the purpose of security and safety in germplasm movement, this gene bank

has obtained an International Standards Organization (ISO) accreditation [12].

13. Greek Gene Bank

By the year 1981, Greek gene bank (GGB) was entrenched in Thessaloniki, Greece with the financial support of FAO. During the last 50 years, there was an increase in the downfall of various crop varieties. To safeguard left out germplasm GGB was established. From the website of "Evaluation of Greek Gene Bank."Athens, December 2012. <http://www.latsis-foundation.org/files/meletes2012/04.pdf>
It is found that (GGB) gene bank consists of 12,000 samples of germplasms of cultivated wheat, legumes, grasses, posters, beets, Brassica and grapes. In addition to that it stores tissue germplasms, through which a new plant can be germinated. Further, It extends its facility to store a collection of grapevine species [14].

3. FINDINGS AND CONCLUSIONS

Among all the Gene banks listed above Svalbard Global Seed Vault stores maximum no. of germplasms followed by Gene banks of CGIAR Institutes. They are the major sources to protect biodiversity for future usage. Table 2 and Fig. 1 depicts no. of germplasm collected by all of the above gene banks.

Table 2: Germplasm Holdings in Genebanks

S. no.	Gene Bank	No. of Germplasm
1	Svalbard Global Seed Vault	8,40,000
2	CGIAR Institutes	7,20,000
3	Agriculture Research Service of the United States Department	4,60,000
4	National Bureau of Plant Genetic Resources	4,04,945
5	China National Genebank	3,74,627
6	CIMMYT	1,97,000
7	German *Ex situ* Genebank	1,50,000
8	ICARDA	1,35,000
9	The International Rice Genebank	1,17,000
10	Brazilian gene bank	1,02,000
11	AVRDC Genebank	61,117
12	International Potato Center	21,000 (approximately)
13	Greek Gene Bank	12,000

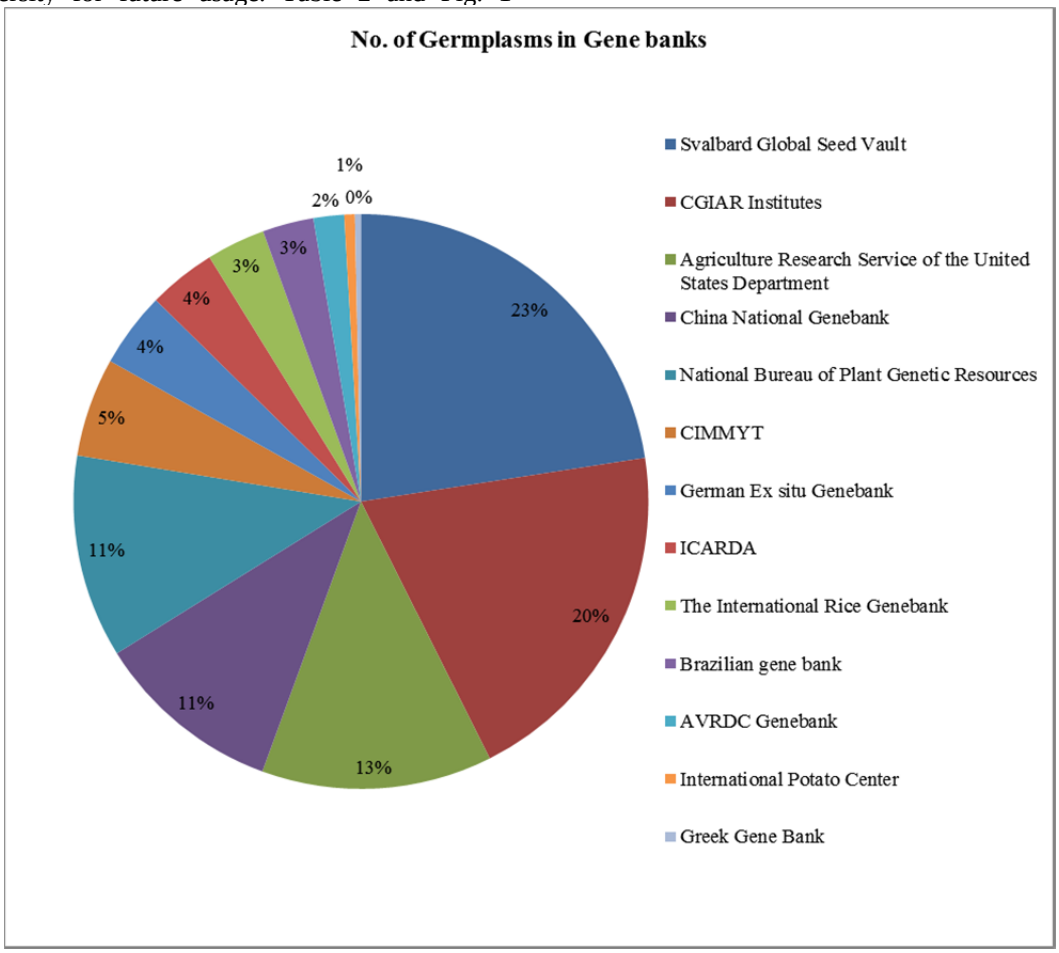

Fig. 1: Pie chart depicting germplasm holdings in various genebanks

Food production depends on agricultural biodiversity, which is declining due to environmental factors, the increase in population and extensive modernization of agricultural resources. Therefore, it is essential to conserve plant biodiversity in our gene banks. These gene banks are storing genes of new plant varieties that will be better suited to our needs and to the constraints of our ecosystems.

In the early 1970's there were few gene banks with half a million of sample accessions. But today, there are approximately 1300 Gene banks consisting of around more than 6 million of accessions stored for future (although there is a possibility of duplicates). These ganebanks store 40% of cereals, 15% of food legumes and less than 10% of vegetable, roots, tubers, fruits and forages. For easy access of resources to farmers, plant breeders and researchers, major gene banks have signed agreement with "International Treaty on Plant Genetic Resources for Food and Agriculture"[15].

With so many advantages associated with gene banks, there are some disadvantages also. For *eg:* there is possibility that germplasm kept under optimal condition may decline its viability, which indicates that it needs to be regenerated. Seed germplasm needs to be replenished by regeneration after a certain period of time. "FAO estimates that as many as one million accessions may now be in need of replanting in order to generate new seeds for storage. Regeneration itself is fraught with difficulties and can promote genetic erosion" (Breese,EL, 1989 [15]). Hence, to safeguard crop varieties for future usage, they need to be conserved in Gene banks as well as need to regenerate from time to time to retain the quality and viability of germplasms.

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