Forage Genetic Resources in Brazil

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Abstract
To maintain the largest herd in the world, 214 million heads of beef cattle grazing exclusively on pastures (only 14% finished in feed-lots), Embrapa (Brazilian Agricultural Research Corporation) in Brazil, has intensely invested on forage breeding programs since the 1980s. Nowadays, there are circa thirteen forage grass and legume species being bred at different Embrapa Units around the country and other six Units focusing on collection and research of regional native forages. Breeding depends on good germplasm sources. Therefore, breeding activities in Brazil will remain highly dependent on exotic and native genetic basis maintained in the Germplasm Banks. Despite the importance of forages to the country, genetic resources have still not received the attention they deserve. Most of the forage germplasm banks at Embrapa are maintained by breeders, who are also responsible for cultivar development activities, from germplasm evaluation and breeding to cultivar release to the market and thereafter. Thus, breeders lack the time to manage the banks adequately. Conservation is a challenge, since forage grass seeds usually lose viability quickly even under good conservation conditions and some accessions produce very low seed thus are being maintained vegetatively. Accessions maintained in the field impose problems of accession identity and varietal purity, and loss of plots due to invasive weeds or harsh climatic conditions. Although resources have been continuously available for maintenance, investments for evaluating and using are scarce. In general, accessions need to be better characterized, conserved and exchanged among researchers and institutions. Collection expeditions, mainly in Africa, are still imperative, since many genera, as *Melinis* and *Hyparrhenia* have not been collected and sexual forms in several apomictic species are not available or the sexual pools need broadening. Some important regions in Africa have not been assessed, as well as marginal areas to find sources of resistance to abiotic stresses.

Introduction
The area of pastures in Brazil totals 162.5 million hectares (Abiec 2020) including cultivated and native pastures. The continental dimensions of Brazil, with a favourable climate for the growth of forage plants and livestock, allowed Brazil to achieve a prominent position in the world scenario in recent years. Currently, Brazil has the largest commercial beef cattle herd in the planet, which corresponds to 14.7% of the world total, and is the second largest producer of beef and largest beef exporter.

Of this area, around 60 to 70% are occupied by cultivated pasture grasses of exotic species, introduced from the African continent, which, due to their apomictic reproduction, are of limited genetic variability and offer the danger to be decimated by disease outbreaks or pest attacks, demonstrating the vulnerability of our livestock system under grazing. The rest of the areas are occupied with a few grasses and legumes introduced from Africa or from the Mediterranean, or from native Brazilian species. In addition to animal nutrition, forage plants have great importance in maintaining productivity in crop rotation schemes, in fallow areas and in protecting the soil of sloping areas, which do not allow for sustainable use with agricultural crops.

Tropical forages are still little explored when compared to other crops, and account for practically all animal production (meat and milk) in Brazil, with only a few cultivars, specifically *Panicum* and *Brachiaria*, covering over 60 million hectares of pasture and accounting for more than 70% of the marketed seeds. The search for new cultivars is essential for the sustainability of the production and agribusiness processing of meat and milk in the country, either by new introductions or collections, or by the development of new cultivars in genetic improvement programs. For this reason, Embrapa maintains forage germplasm banks spread throughout the country and coordinated by Embrapa Genetic Resources and Biotechnology in Brasilia, DF.

The germplasm banks are organized in four-year renewable projects pertaining to a macroprogram which includes all the plant, animal and microorganism germplasm banks of Embrapa. The objective of the project is to maintain, in an organized manner, Embrapa's Forage Germplasm Banks through correct identification of accessions, maintenance of viability, genetic integrity, quality and availability of passport

data, management and characterization through the Alelo System for access to basic information by the general public and users of germplasm banks.

Methods and Study Site

The Project of Forage Active Germplasm Banks is coordinated by Embrapa Beef Cattle, and involves 12 germplasm banks, of which, eight of specific forages, and four regional banks. The specific forages active banks and collection contemplate 10 genera and are: Azevem (*Lolium multiflorum*) germplasm bank of Embrapa Temperate Agriculture in Pelotas, RS; *Brachiaria*, *Panicum maximum* and *Stylosanthes* at Embrapa Beef Cattle in Campo Grande, MS; elephant grass (*Pennisetum purpureum*) and collections of *Cynodon* and *Setaria* at Embrapa Dairy Cattle in Coronel Pacheco, MG; buffel grass (*Cenchrus ciliaris*) at Embrapa Semi-Arid in Petrolina, PE; *Desmanthus* at Embrapa Coastal Tablelands in Aracaju, SE; *Paspalum* at Embrapa Southeast Livestock in São Carlos, SP. The four regional banks are of importance to the regions: Mid-North Region at Embrapa Mid-North, in Teresina, PI; South Region at Embrapa South Livestock in Bagé, RS; Cerrados Region at Embrapa Cerrados, in Planaltina, DF and Pantanal at Embrapa Pantanal, in Corumbá, MS.

Four activities are developed in this project: collection and/or introduction, germplasm characterization, germplasm conservation and documentation. The genebanks that may have collection activities because they are native forages are *Paspalum*, Mid-North Region, South Region, Cerrados Region and Pantanal Region. Characterization involves mainly morphological characterization of the accessions, but also cytogenetic and chemical, and agronomic performance, insect and disease tolerances etc. Conservation involves the regeneration of plants from seeds, maintenance of the accessions in the field, seed multiplication, conservation of the seeds in cold chambers at the Embrapa Units (temperature less than 10ºC and humidity between 20 and 30%) and conservation of the seeds in long-term chambers at Embrapa Genetic Resources (humidity between 3 and 7% and -20ºC temperature) in Brasilia, DF. Documentation consists of placement of passport as well as other data, such as morphological, agronomic, seed quantity and availability for exchange into Embrapa's Alelo System (http://alelobag.cenargen.embrapa.br/AleloConsultas/Home/index.do).

Results

Until 2020, the germplasm banks were required to turn public the passport data of their banks in the Embrapa Alelo system. Thus, the number of official accessions in these banks are: Azevem – 240 accessions; *Brachiaria* – 213 accessions and *Urochloa* collection - 17 accessions; *Panicum maximum* – 429 accessions; *Stylosanthes* – 201 accessions; elephant grass – 145 accessions; collections of *Cynodon* and *Setaria* – 21 and 83 accessions, respectively; buffel grass – 116 accessions; *Desmanthus* – 445 accessions; *Paspalum* – 488 accessions; Mid-North Regional Bank – 72 accessions; South Region – 388 accessions and exotic legumes – 206 accessions; Cerrados Region – 2085 accessions and Pantanal Region – 94 accessions.

Specific characterization and conservation results are not the purpose of this paper, thus are not here presented.

Discussion [Conclusions/Implications]

Embrapa has been investing in increasing germplasm since it was founded in the 1970s (Nass et al. 2012). Genetic resources have always been an important issue in Brazil, because it is the foundation of any breeding program. Brazil is essentially an agricultural country, and the genetic improvement of crops is fundamental to meet the productivity, quality and adaptation to the country´s conditions. Embrapa has 47 research centres, and one of them next to the main headquarters in Brasília, DF, was constructed to enable research, development and innovation solutions in genetic resources for the sustainability of Brazilian agriculture and has acted strongly in the exchange and quarantine of plant germplasm, ensuring the continuity of Embrapa's genetic improvement programs (Nass et al. 2012).

Most of the forage germplasm banks at Embrapa are maintained by breeders, who are also responsible for cultivar development, from germplasm evaluation and breeding to cultivar release in the market and thereafter. Embrapa maintains eight important different genera of forage grasses in their banks with over 1600 accessions and these are all managed by breeders. If on the one hand this is excellent because the breeder will ensure the use of the accessions in their breeding programs, on the other hand, the banks cannot be as well managed and conserved since the breeders cannot fully dedicate themselves to manage the banks adequately. To define, systematize and integrate all activities essential to the management, conservation and use of

germplasm, through a coordinated management of the germplasm banks, the Embrapa Germplasm Curator System was created (Burle 2019), and the curators are the breeders.

Legumes are also represented in the banks of *Stylosanthes* and *Desmanthus*, forage *Arachis* (not included in this project) and exotic legumes in the South Bank, totalling over 800 accessions. However, there are many native legumes included in the Cerrados Bank which are not part of any breeding initiative. A few years ago, there were breeding programs of *Cratylia* and *Leucaena*, but these have been discontinued. Embrapa maintains in the long-term storage in Brasilia, 2537 accessions of 214 different species of legumes (Rocha 2014).

Forage grass seeds lose their viability very quickly, even under adequate storage conditions, so conservation is a challenge. To ensure viability, many banks maintain their accessions in the field, which imposes problems of accession identity and varietal purity, and loss of plots due to invasive weeds or harsh climatic conditions. Another particularly important issue is the lack of government investment in personnel to maintain the plots in good shape in the field.

Although resources have been continuously available for maintenance, investments for evaluating and using are scarce. In general, accessions need to be better characterized, conserved and exchanged among researchers and institutions. Once again, breeders do not always have the time to invest fully in germplasm bank activities.

From 1980 to around 2000, Embrapa invested much in germplasm collection in the country. However, new policies and cutback of resources have affected collection expeditions in general. Forage germplasm also depends on collection expeditions, mainly in Africa, since many genera, such as *Melinis* and *Hyparrhenia* have not been collected and sexual forms in several apomictic species are not available or the sexual pools need broadening. Some important regions in Africa have not been assessed, as well as marginal areas to find sources of resistance to abiotic stresses.

Thus, efforts are made to ensure the availability of forage genetic resources for the future of Brazil, but much still needs to be done and investments are necessary.

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