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Full Length Research Paper

Genetic resources of *Faidherbia albida* (DEL.) A. Chev. in the Sudano-Sahelian region of Cameroon

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Germplasm is the genetic material that is used for reproduction, selection and creation of variation in breeding programs. An investigation was carried out on the genetic resources or germplasm of *Faidherbia albida* (DEL.) A. Chev. in the Sudano-Sahelian regions of Cameroon to facilitate its use. Data were collected through literature reviews, formal and informal discussions with local people, non governmental organizations and scientists, as well as from field visit and administration of semi-structured questionnaires to communities around the forest. Genetic resources of *Faidherbia albida* were found throughout the Northern (Sudanian and Sahelian) regions of Cameroon and observed at different conservation levels: - gene banks, domesticated and natural stands. Majority of respondents (91%) indicated that trees in parklands resulted from natural regeneration and were protected by local communities. The domesticated populations are used by the local communities for agroforestry practices i.e. integrating maize, sorghum, groundnut, cotton and cowpea in rotation during the planting seasons. Loss of genetic resources resulted from both natural factors such as drought or climate change (mentioned as the most important factors) and anthropogenic activities. Destructive harvesting through intensive pruning by cattle rearers (*Mbororo*) to feed livestock was very common in the Tokombere parklands. Pruning affects seed production and seed establishment which is detrimental to the sustainability of the species. Consequently, there is an urgent need to conserve this important species for the benefit of the rural poor who is highly dependent on it. Conservation activities should be carried out at all levels including the government, scientist, non governmental organizations (NGOs) and village communities and government policy on forest management should be implemented and intensified.

Keywords: *Faidherbia albida*, distribution, **c**onservation, domestication, germplasm, management, threats

INTRODUCTION

Faidherbia albida (Del.). A. Chev. is mainly a species of the Sudanian and Sahelian zones of Africa. It belongs to the family Leguminoseae subfamily Mimosoidae. It is the unique member of the Acacieae tribe with nevertheless,

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some differences in botanical and phytochemcal features which make it a genus apart from the *Acacia*, which comprises about 1200 species. The Acacieae tribe is characterized by the presence of stamens free from each other or united only at the base (CTFT, 1989).

The origin of this species is not well known Chevalier (1934) considered it as native to the Sahara before its desertification and has been domesticated in the current area of Sudanian zone. The latter is contrary to Aubreville (1950) who considers this tree species to be spontaneous in Eastern and Southern Africa along the rivers and introduced in the Northern part of its range in West Africa through agriculture. The natural distribution of *F. albida* in Africa is from Senegal to the Red sea (Egypt, Sudan, Ethiopia, Somalia, and Kenya). Further south, it is distributed through eastern and central Africa as far as Natal in South Africa, and westwards to Lesotho, Angola, and Namibia, but absent from the corridor in the eastern parts of the last two countries. Spontaneous occurrences of the species are found in Yemen, Israel, Jordan, and Lebanon, where the northernmost is 30 km north of Beirut. The species was introduced to Ascension Island, the Cape Verde Islands (Wickens, 1969), Cyprus and Pakistan (Brenan, 1983). More recent introductions have been made to other countries notably, Peru and India. In India, it is of interest as occupying an ecological niche similar to that of the indigenous *Prosopis cineraria*. Its distribution corresponds precisely with the Guinean forest zone of Africa. The species has a discontinuous distribution in areas where ground water is present and includes sites in the mountain massifs of the Sahara.

Faidherbia albida a tree of size 31 m in height and 1.5 m in diameter has been observed in Cunene River on the Namibia-Angola border (NAS, 1975). More generally, it reaches 15 to 20 m in height and 1 m for a diameter at breast height with rounded crown, more or less dense. Average life is 70 to 90 years but individuals of over 150 years old have been reported in Zambia. The bark is deeply cracked, characterized by dull brown to whitish grey, with a pale brown edge in older trees and smooth when young. It is mostly found on sites with deep sandy soils that allow the development of an extensive root system to obtain water from deep down the water table. *Faidherbia albida* being a legume has nodules on roots containing *Rhizobium* that can fix atmospheric nitrogen. The reverse phenology in the species makes it excellent for agroforestry as it does not compete with crops during the raining season (FAO, 1999; Roupsard et al., 1999). Farmers use the tree as forage for their animals during the dry season when other sources of food are absent (World Agroforestry Center, 2009). The species was selected as a priority species for domestication by the World Agroforestry Center (Franzel, 1994) and the Food and Agricultural Organisation (FAO) Panel of Experts on Forest Genetic Resources (FAO, 1974). However, the region is under constant threat of desertification due to climatic constraints and degrading anthropogenic actions. The safeguarding of this fragile ecosystem necessarily involves the implementation of measures to combat desertification. Studies on the importance of the species indicate that it can be used in the future for many purposes or to solve the several environmental and social problems faced in the region. Farmers adopted the *Faidherbia albida* agroforestry parkland system introduced in the 1990s by the Rural Development and Management Project (DPGT) (Gautier, et al., 2003) to improve soil fertility in the regions. Several of these parklands were established and have been shown to improve yield in sorghum and cotton (Harmand and Njiti, 1992; Liber and Eyog Matig, 1996; IRAD, unpublished reports).

There are previewed reforestation projects in the pipeline for Africa and Cameroon in particular, the Operation Green Sahel and the African Forest Landscape Restoration initiative AFR100 (WRI, 2015). Which species will be planted and where will the germplasm come from? Several literatures have cited the importance of local seed source for reforestation because of its adaptive potential to the environmental condition (Afreen et al., 2011; Broadhurst et al., 2008). In addition, appropriately sourced germplasm and the use of high quality seeds should be an urgent consideration to improve planting success. When breeders need to improve plants for reforestation or plantation development, they have to find a source of germplasm that would supply the genes needed to undertake the breeding project. Plant genetic resources are all genes, gene combinations or genotypes found in cultivated, landraces and wild relatives available for plant breeding (Gepts, 2006). The West African collection of genetic resources of *F. Albida* was carried out by the 'Centre technique forestier tropical' (CTFT/CIRAD) and national research institutes with funds from FAO in the late 1980s and stored in genebanks in CTFT France (Corbasson et al., 1987). Field trials of some selected *F. albida* populations were established in Cameroon, Niger, Burkina Faso and Zimbabwe (Peltier and Eyog-Matig, 1988; PPDAF, 1988; Sniezko and Stewart, 1989). While it is good to maintain genetic resources in genebanks, it is very important to note that diversity can be managed only by maintaining landraces in their natural environments (Jarvis et al., 2011). The aim of this research is to investigate the genetic resources of *F. albida* in the Sudano-Sahelian regions of Cameroon. Specifically, to identify populations in the distribution range within their climatic and environmental conditions (geographical location, altitude, etc), describe the conservation status of these populations and identify the threats faced and management activities carried out in these populations.

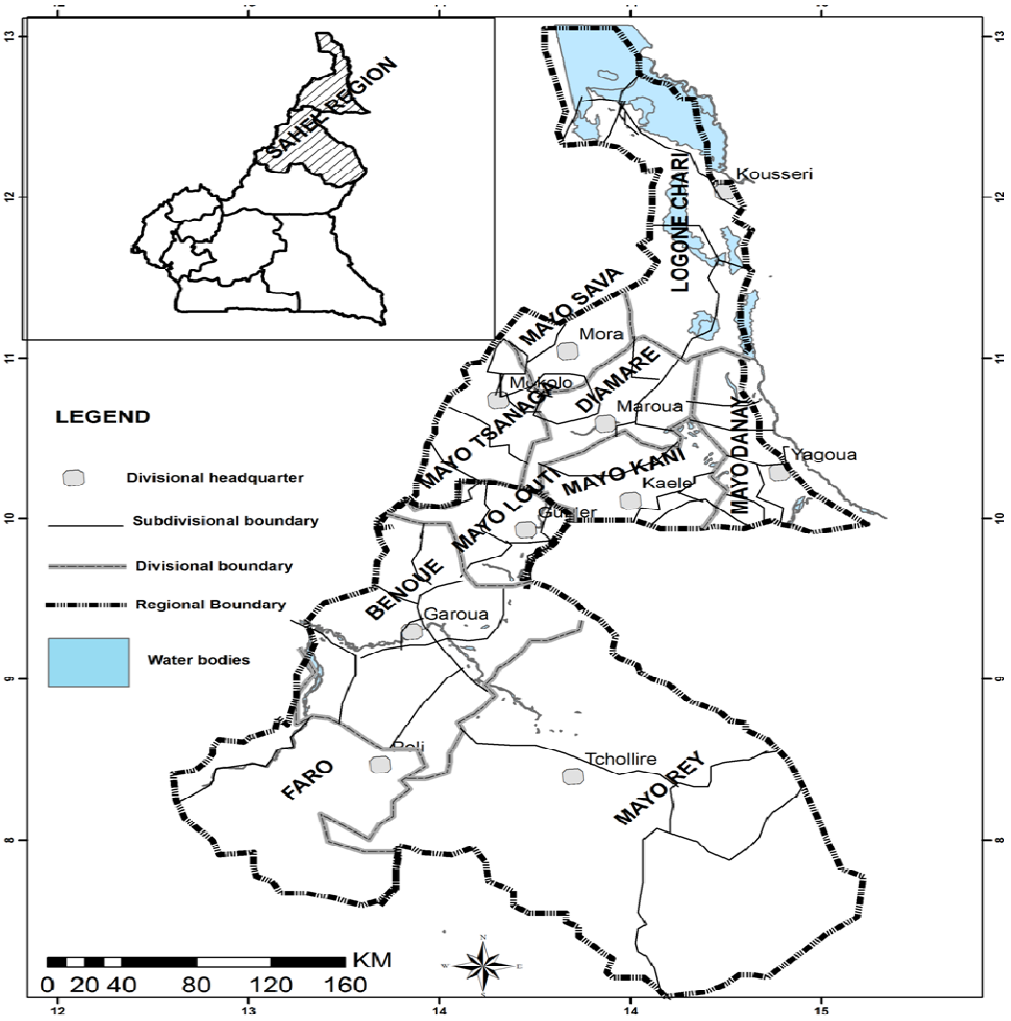

Figure. 1*:* Administrative map of the Sudano-Sahelian zone of Cameroon

MATERIALS AND METHODS

Study area

The Sudano-Sahelian zone of Cameroon covers an area of 102,068 km² and includes the major ecological regions of the Mandara Mountains, Plains of the Far North and Plains of Benoué. The Sudano-Sahelian zone of Cameroon includes the Far-North and the North regions characterized by eight to nine months of dry season and three to four months of rainy season. : The administrative map of the Sudano-Sahelian zone of Cameroon showing the regions, divisions, subdivisions and districts is shown in Figure 1. This zone is situated between longitude 9-13°N and latitude 13-15°E with altitude ranging from 350-450 m. The temperature is between 16°C and 45°C and annual rainfall ranges from 150-1000 mm.

Data collection

Literature was reviewed from online resources, published articles, reports of projects and books. Information on the possible distribution range of the species was obtained and the populations to be visited were identified. Reports of the DPGT projects carried out in the 1980s provided valuable information on the creation of the *F. albida* parklands. Formal and informal discussions were carried out with local people, governmental and non governmental organizations and scientists working in the forestry sector in the Sudano-Sahelian region. During field visit each site was located using a GPS and observed for any signs and effects of degradation before conducting survey in communities living around the forest. Semi structured questionnaires were administered to male and female respondents randomly selected from the 25 to age range who must have settled in the village for at least two decades. Females

Table I. Age, gender and education levels of respondents

Age range (%)	Gender: Male/Female (%)	% (level of education)
25-35 years (22,4)	88/12	6 (none)
		16 (Primary)
		12 (secondary)
		0 (tertiary)
		0 (others e.g. Arabic)
36-45 years (26,3)	75/25	12 (none)
		12 (Primary)
		13 (secondary)
		2 (tertiary)
		1 (others e.g. Arabic)
> 45 years (51,3)	90/10	47 (none)
		25 (Primary)
		0 (secondary)
		1 (tertiary)
		6 (others e.g. Arabic)

constituted between 10 – 25 % of respondents in each age group with different education levels (Table 1). A total of 30 questions were included in the questionnaire and were intended to get information on the origin of the *Faidherbia albida* population, creation of the parklands, biodiversity in parklands, conservation activities, management activities, and threats to the populations. A community member, to whom the objective of the research was thoroughly explained was recruited in each village to accompany the research team as the interview were conducted in the local language of the people and French.

RESULTS AND DISCUSSIONS

Distribution of *F. albida* populations in Cameroon

From our literature search and field observation *F. albida* populations are found throughout the Northern (Sudanian and Sahelian) regions of Cameroon. Annual rainfall in this zone ranges from 700 – 1000 mm with varied soil conditions. The species is distributed from latitude 09º.02´ to 11º N and longitutde 13º 30´ to 14º 72´E in mixed stands with other species (Table 2) but constitute the dominant species to be considered as *Faidherbia* agroforestry parklands (Seignobos, 1982a; Seignobos, 1978; Raison, 1988). With this criterion, 91 % of respondents indicated that the *F. albida* populations assessed were parklands that had originated from natural regeneration and protected by communities, projects and individual initiatives. Although some scattered individuals of the species were reported to be found above latitude 11º N (Zeh-Nlo and Joly, 1992) we did not visit the sites because of the prevailing insecurity in the area (Figure 1). From the descriptive analysis, Sahelian zone recorded more parklands than the Sudanian zone but few trees of *F. albida* were found in other parklands dominated by other species such as the *Acacia* parkland in Poli.

Conservation status

Our findings show that *F. albida* populations are conserved both *ex-situ* and *in-situ*. They are found in gene banks, domesticated (living gene banks and on–farm) and natural stands within the distribution range of the species in Cameroon.

Gene banks populations

Ex-situ conservation refers to all conservation methods in which the species are taken out of their natural habitat and kept in man-made environments**.** According to Corbasson et al. (1987) large collections of *F. albida* populations have been stored in gene banks around the world: - populations

Table II. *Faidherbia albida* parklands and their geographical conditions in the distribution range in Cameroon

Populations	Climatic conditions	Division	Longitude (E)	Latitude (N)
Makary	Sahelian	Logone and Chari	14° 28' E	12° 34' N
Mora	Sahelian	Mayo sava	14° 13' E	11° 00' N
Tokombere	Sahelian	Mayo sava	14° 09' E	10° 52' N
Guetale	Sahelian	Mayo sava	13° 55' E	10° 57' N
Zamay	Sahelian	Mayo Tsanaga	13° 54' E	10° 36' N
Mokyo	Sahelian	Mayo Sanaga	14° 16' E	10 °51' N
Mokolo	Sahelian	Mayo Tsanaga	13° 48' E	10° 44' N
Kodek	Sahelian	Diamare	14°41' E	10°65' N
Mambang	Sahelian	Diamare	14°28' E	10°65' N
Kongola	Sahelian	Diamare	14° 24' E	10° 38' N
Bogo	Sahelian	Diamare	14° 32' E	10° 43' N
Maroua	Sahelian	Diamare	14° 15' E	10° 40' N
Dinao	Sahelian	Mayo Kani	14°72' E	10°14' N
Moulvoudaye	Sahelian	Mayo Kani	14°50' E	10 23' N
Doukoula	Sahelian	Mayo Danay	14° 32' E	10° 57' N
Mayo Oulo	Sudanian	Mayo Louti	13° 43' E	09° 57' N
Parkine	Sudanian	Mayo Louti	13°54' E	09° 56' N
Ngong	Sudanian	Mayo Louti	13° 30' E	09° 02' N
Adoumri	Sudanian	Benoue	13° 50' E	09° 16' N
Bibemi	Sudanian	Benoue	13° 50' E	09° 16' N

in CTFT France are Bibemi, Guetale, Makary, Mora, Moulvouday and Zamay. Populations collected by the Oxford Forestry Institute (OFI) are Adoumri, Bogo, Maroua, Doukoula and Mayo Sava. Gene banks maintain the plant material as seeds, *in vivo* when the storage of seeds is difficult or *in vitro* mostly through cryopreservation. Living gene banks included three provenance trials established in Mouda, Cameroon in 1990 for silvicultural purposes holding populations from Bogo, Mokolo, Mokyo and Ngong. Results of the evaluation after five years of growth indicated within population variation and poor performance due to management ((Harmand and Njiti, 1992). The populations at the trial site of Mouda were established in 1986 but surprisingly, the respondents indicated it has never produced seed. The provenance trial in Burkina Faso and Niger contain some populations from Cameroon (Bogo, Doukoula and Guetale) and genetic diversity studies indicated Cameroon population was more diverse than other populations from the West African Sahel countries (Torrekens et al., 1992). Genetic diversity studies were carried out on the species including collection of germplasm for west and central African countries (Joly et al., 1992).

In situ and on farm conservation

As opposed to *ex situ* conservation in genebanks where only a section of the whole diversity is covered, the *in situ* approach is able to save large parts of the diversity. In addition to populations found in gene banks more populations (Kodek, Mambang, Dinao Parkine) currently under the surveyance of IRAD Maroua and others (Tokombere, Mayo oulo, Kongoloa) were visited during the survey. Many (99%) of the respondents indicated that the population originated from natural regeneration and coppicing making it an uneven aged stands. A few (5%) respondents point out that direct sowing of seedlings propagated from seeds were planted around home gardens to provide shade for the family. There is no risk of losing genetic resources if forest populations regenerate spontaneously, however genetic diversity may be reduced due to natural processes or anthropogenic influence (Isajev et al., 2009).

Table III. Distribution of respondents according to conservation activities, threats and management in the *F. albida* populations

Activities	Activity types	Respondents (%)
Uses that threaten the *F. albida* populations	Wood for firewood	98
	Wood for construction	41
	Prunning for forage/grazing	92
	Pharmaceutical products	90
	Revenue generation	20
	Natural factors	100
Management	Crop rotation	90
	Natural regeneration	91
	Planting	5
	Wild	4

All respondents interviewed indicated that the *in-situ* conservation sites are mainly used for agroforestry activities whereby the parkland is cultivated in rotation with sorghum, cotton, cowpea maize or groundnut. Ninety percent of respondents revealed that they planted sorghum followed by maize, cotton, groundnut and cowpea. Many (88% of respondents) reported that not only are parklands used for agroforestry activities, but the trees also provide fuelwood, wood for making mortars and furnitures (30 % of respondents) in general, whereas leaves and seeds are forage for animals (92% of respondents). *F. albida* also provide pharmaceutical products (90 % of respondents) and environmental protection (100 % of respondents). This result is similar to that of Garine et al. (2005) in the parkland of Duupa, Poli in Cameroon. 20 % of respondents indicated products from *F. albida* is a source of revenue. Although, there are no markets for the sale of these products, limited sales take place in front of homes (Table 3).

Studies on biodiversity have been carried out in the parklands (Seignobos, 1982b, Dounias, 1998, Garine et al., 2005, IRAD, unpublished reports). Respondents indicated the existence of other biodiversity within the parklands and said it helps communities to diversity their food source and improve their livelihood throughout the year. Several species common in the parkland included *Khaya senegalensis*, *Acacia spp* etc and none specific to a particular parkland. Agroforestry systems are sources of livelihood for farmers and ecosystem services confirmed from other findings (Cerda et al., 2014; Rice and Greenberg, 2000). The i*n-situ* stands must be protected and managed by all stakeholders (Government, NGOs, village communities and individuals) in a network of natural conservation populations covering the distribution range of the species and possibly complemented with artificial populations such as seed orchards.

Natural populations

Natural populations are scattered at very low density around some villages and above latitude 11º N which include the towns from Waza, Kouserri and the border with the Republic of Chad which were not assessed because of the prevailing insecurity in the area. These populations are in their natural state with no human activity except climate change that is affecting their distribution.

Threats to the germplasm

Respondents indicated that decline in the various populations is due to natural factors such as climate change (intense and prolonged drought). Concerning human impact in the parklands, 90 % of the respondents indicated agriculture was their main source of livelihood in the village and many respondents explained that excessive collection of fuel wood for cooking and forage for animals were the primary activities. Hamed (1990) reported that 100 % of rural people depend on wood for cooking in the Sadano-Sahelian zones of Africa. Cattle rearers (*Mbororo*) pruned branches of trees for forage and this was identified in all the populations. However, this phenomenon was very intensive in the Tokombere population where all the trees were pruned and no fruit could be produced during fruiting period. Prunning was also identified by Montagne (1984) as the one factor affecting the growth and development of the parkland. The effect of pruning on fruiting and seed production has already been observed but no report or scientific

publications were found on the subject. Such study will be necessary to provide information to the government of Cameroon for immediate measures to be taken. Nobody gave the trend on the rate of deforestation but respondents reported an increase in human population and frequent movement towards the forest for settlement in the last five years. However, (5 %) of respondents revealed that there was reduction in human population because people have moved to urban centers in search of jobs and some parklands were abandoned.

Management activities

For the management of these genetic resources, five percent of respondents indicated they had been collecting seeds from their best trees for planting around home gardens. No large scale planting was observed in the region and farmers explained they donot have the potential or knowledge to establish and manage such plantations also reported by Harmand et al. (1997). Sometimes seeds are infested by pests even before they are harvested. Consequently, farmers would not go for *Faidherbia* seeds because they help in spreading pest to crops. Some parklands (65%) are managed by the government, communities (22%), individuals (9%) and by the members from the chiefdom (4%) . The IRAD carries out research in the parklands of Dinao, Parkine, Mambang and Kodek to test different silvicultural treatments on the species. On the contrary, cropping in the rest of the parklands is done by individuals. Cases of seeds germination of seeds and storage of seeds are few. Fertilizer application is rarely done during the planting season when crops are integrated in the parklands as *Faidherbia* is believed to provide sufficient fertilizer for the crops.

CONCLUSION

Plant genetic resources are the most valuable raw materials for the present and future forestry production. From the study it can be concluded that the *Faidherbia alnida* populations in the Sahel region of Cameroon has a wide range of distribution. They are being used as agroforestry parklands for some decades now and the species is of great benefit to the rural population especially for its fertilizing effect and use as forage. However, the methods of harvesting for forage is unsustainable because it leads to the total failure of seed set in the population. **F**rom the analysis of the information during field assessment, some parklands e.g Tolombere were overexploited. Although the trend in deforestation rate was not determined it could be noticed that the human population has moved towards the forest for settlement. In addition natural factors were observed to affect the growth and development of these populations. Conservation in genebanks are necessary but not sufficient because the evolution of a species will depend on the *in-situ* stands. Knowledge on the available genetic resources of *Faidherbia albida* is necessary for proper conservation and management to be effective. In addition most breeders, scientists and lecturers find it difficult to access genetic resources of valuable species in their countries for use in research. The government of Cameroon should assist village communities to seek for an alternative source for forage, so as to reduce excessive pressure on this valuable agroforestry species. Establishment of plantations of the species in well designed agroforestry systems and mixed plantations should be encouraged. Further research will be to evaluate the phenotypic and genetic diversity of *Faidherbia albida* populations for breeding programs.

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