Ecology, Morphology, Distribution, and Use of Sesbania tchadica (Sesbania Sesban) from the Republic of Chad: A Review

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Ecology, Morphology, Distribution, and Use of *Sesbania tchadica* (*Sesbania Sesban*) from the Republic of Chad: A Review.

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Key message: **A review of literature of potential uses and a survey study about the tree *Sesbania tchadica* (*Sesbania Sesban*) leguminous native from the Republic of Chad are described in this paper.**

Abstract: This study on the leguminous plant *Sesbania tchadica* has made it possible to highlight its description, specification and identification in N'Djamena region *S. tchadica* (*Sesbania Sesban Merr.* (L)) is an annual tree that measures more than 4 meters in height. This species is abundant especially in Ndjamena. In most of the district of Ndjamena, *S. tchadica* was the most common type. *S. tchadica* shows a rapid early growth and grows well in various soils especially sandy siltstone and silty shale. The local inhabitants use the species in many ways: as a medicine, a livestock feed, for improving soil fertility, for fuelwood and to repel desert encroachment. In this study, various academic publishing websites like Science Direct, Springer Nature, some online international plant databases, and other national data herbaria from the republic of Chad were used to identify, describe and summarize the research literature on *Sesbania Sesban*. This paper also describes the morphological characteristics observed in *Sesbania Sesban* from the republic of Chad and its taxonomy to assist in future program evaluations.

Keywords: *Sesbania tchadica* (*Sesbania sesban*); leguminosae; morphology; distribution; flora of Chad.

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Introduction

The taxonomic diversity of legumes is enormous. In addition, they provide important benefits to humans including food, medicines, and environmental services. For example, leguminous food grains include beans (*Phaseolus vulgaris* L.), peas (*Pisum sativum* L.), soya beans (*Glycine max* L.), and forage legumes such as clover (*Trifolium repens* L.), sainfoin (*Onobrychis* Mill.) and *Sesbania sesban*. Other legumes are ornamental, (*Cercis siliquastrum*, *Acacia mollissima*) melliferous (*Robinia pseudoacacia*, *Melilotus albus*), or medicinal (*Ceratonia siliqua*, *Trigonella foenum-graecum*, *Sesbania sesban*). These plants (leguminosae) also fix atmospheric nitrogen via their symbiotic association with soil bacteria, belonging to the genera *Rhizobium*, *Azorhizobium, Bradyrhizobium, Synorhizobium* (Lahdachi et *al.,* 2015). They can be used for soil improvement. They are among the world's most important crops (Toomsan et *al.,* 2012) (Rochester et *al.,* 2001). They provide nutritious bodybuilding food for man and animals the world over (Li et *al.,* 2017). In addition to being rich in protein, leguminous crops are also high in bone-building fibers,

complex carbohydrates, minerals, and vitamins essential to good health (Polak et *al.,* 2015) (Maria et *al.,* 2021). They can obtain most of the nitrogen they need from the vast supply of gaseous nitrogen in the air (Cocking, 2000). Air is about 78 percent nitrogen; there are around 6 400 kilograms of nitrogen above every hectare of land and water (NifTAL, 1985). These plants gather and use this nitrogen by working symbiotically with special bacteria (rhizobia) in nodules on their roots (Ndoye & Dreyfus, 1988) (Sharma et *al.,* 2005). Rhizobia infect the root hairs of the leguminous host; nodules develop and become small nitrogen factories on the legume roots. The host plant provides a home for the bacteria and energy to fix or gather air nitrogen. In return, the plant receives fixed nitrogen from the nodule and produces food and forage protein (NifTAL, 1985) (Mmoudiongh. & Rinaudoe, 1985) (Abdel Magid et *al.,* 1988) (Semba et *al.,* 2021). They also leave fixed nitrogen in the soil for succeeding crops (Dakora F. D. and Keya S. 0., 1997) (Toomsan et *al.,* 2012). Since nitrogen is commonly the most limiting element in food production, and one of the most expensive in fertilizer, this special ability of leguminous crops to work symbiotically with rhizobia to produce protein is becoming increasingly important in world agriculture (Sileshi et *al.,* 2014). Some forage legumes such as *Sesbania* sp. are used in agroforestry in tropical regions for other purposes such as stakes, fuelwood and reducing soil erosion. Land management practices featuring legumes include cereal-legume intercropping, relay cropping, biomass transfer and fodder banks (Ndungu and Boland, 1994) (Kwesiga et *al.,* 1999) (Orwa et *al.,* 2009) (Sileshi et *al.,* 2014).

In general, leguminous species from arid habitats play a great role in reforestation development programs and in the fight against desertification (Curasson, 1956) (Bashan et *al.,* 2012). They are suitable alone or mixed with other species for use in arid zone agriculture (Bradbury, 1990). Moreover, the integration of legume trees increases yield stability in cropping systems and prevents land degradation (Sileshi et *al.,* 2008) (Sileshi *al.,* 2012). These characteristics give these « fertilizer trees » a very important economic and environmental value (Kiptot et *al.,* 2014).

The genus *Sesbania* sp. includes many species indigenous to Africa such as *S. goetzei, S. keniensis S. rostrata and S. sesban,* which possess several desirable characteristics that make them suitable for use as multipurpose trees in farming systems, particularly *S. sesban* (Heering, 1995). Endemic *Sesbania* sp found in Chad are *Sesbania tchadica* (*Sesbania sesban*), *Sesbania dalzielii*, *S. rostrata* and others (Jean and Cyrille, 2019).

One of the most serious constraints to the sustainability of agriculture in sub-Saharan Africa is soil nutrient depletion (Bindraban et *al.,* 2012). Many factors cause the decline of soil fertility and carbon stocks of African drylands including deforestation, overgrazing, unsustainable agriculture, and climate change (DeRouw, 1998) (Bakhoum et *al.,* 2018). One of the solutions is the use of mineral fertilizer; however, they are expensive and unsustainable. To address these challenges, scientists have experimented on low cost agroforestry options for soil fertility replenishment (Bindraban et *al.,* 2012). Planting nitrogen fixing trees such as *S. sesban* (*S. tchadica*) is an effective solution for increasing soil productivity (Bakhoum et *al.,* 2018). The International Center for Agroforestry Research (ICRAF) is interested in the role of *Sesbania sesban* in improved fallows especially in savannah woodland region (Anon, 1992) (Ndungu and Boland, 1994) (Kwesiga et *al.,* 1999). Improved fallows involve planting mainly legume tree/shrub species in rotation with cultivated crops. In Zambia, ICRAF researchers found that growing *Sesbania* in depleted agricultural fields or on fallow lands for 2 or 3 years and then introducing a hybrid maize crop after the fallow period produced exciting and encouraging results. Without N fertilizers, maize yields were 2.3 t ha-1 after 1 year of *Sesbania* fallow; 5.6 t ha-1, after 2 years; and 6.0 t ha- 1, after 3 years. Continuous maize crops gave only 1.5 t ha-1 (Anonymous, 1985). Shrubs (mostly legumes) and annual crops may be grown together and the shrubs retained as fallows for 2–3 years to improve the soil (Dagar and Tewari, 2017). Afterwards, crops are grown (Kwesiga et *al.,* 1999). Intercropping sweetpotato with other leguminous plants such as *Sesbania sesban* improves yield of the crop (Muimba-Kankolongo, 2018). *Sesbania tchadica* (*Sesbania Sesban*) has many other uses in domestic, environmental, fiber, food, beverages, forage, medicine and wood products and services (Richard and ILDIS, 2018). The objective of this paper is to give a general morphological identification and description of *Sesbania tchadica* A. Chev.

from the republic of Chad. This paper provides also an overview and updated information concerning this very useful but less-exploited plant with the purpose to help develop and conserve it.

1- Material and methods:

Study area: N'Djamena is the administrative capital and the largest city of Chad Republic. It is located in the center-west of the country (Figure 1), at the confluence of the Chari and Logone rivers. Its population is estimated in 2020 at 1,422,547 habitants with a total growth rate of the country about 3.69% (UN, 2021). N'Djamena has a tropical, arid climate, including a long dry season (7 to 8 months, November to May) and a short wet season (3 to 5 months, May to October). Rainfall varies between 400 to 700 mm/year with many heavy showers. In recent years, rain falls mainly over a three-month period (July-September). Temperatures observed are between 20°C and 45°C in the dry season and 18°C and 30°C in the rainy season (FAO , 2012).

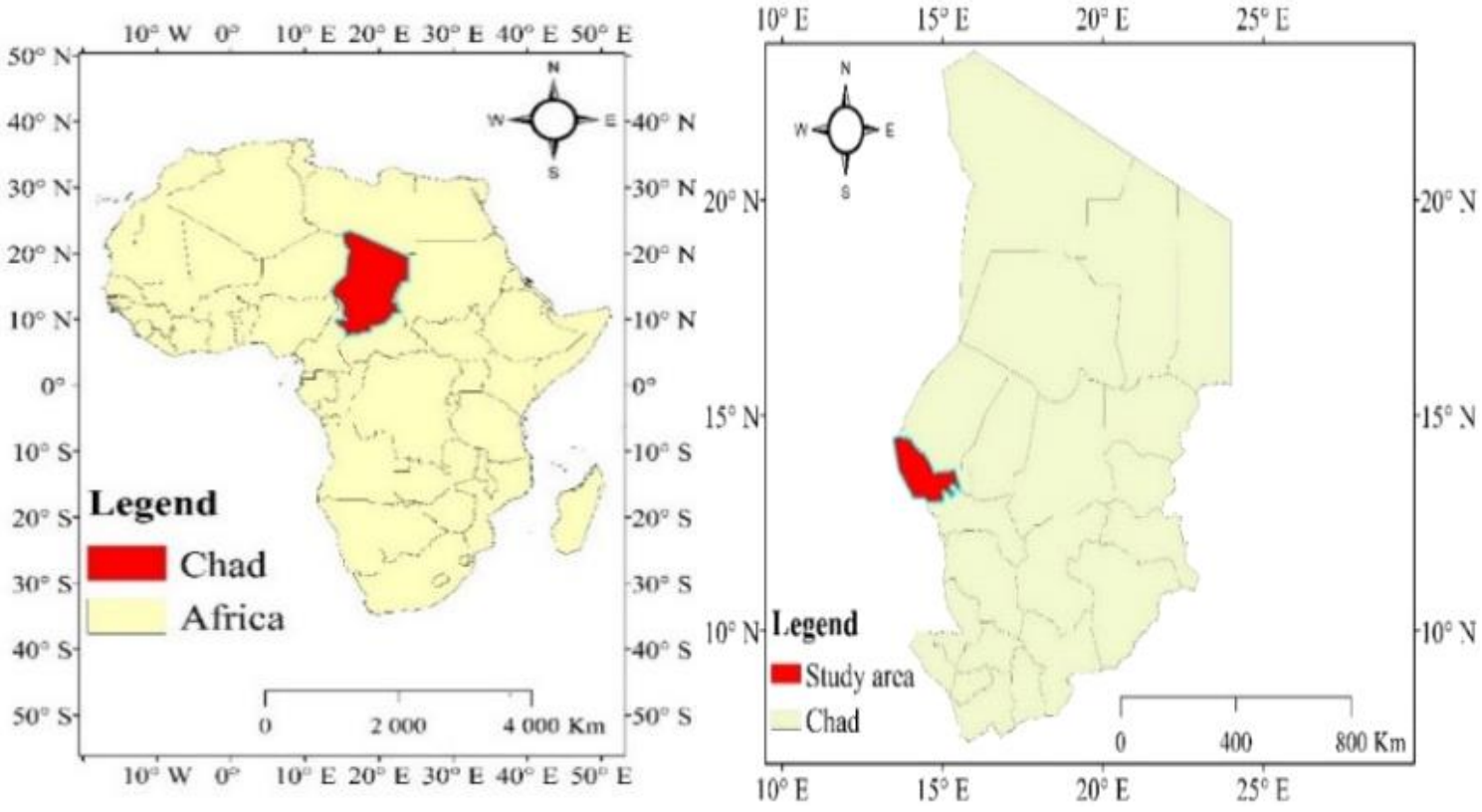


Figure 1: Study area: Map of the Republic Chad and N'Djamena area.

Sampling of the species: The data for this study on *Sesbania tchadica (Sesbania sesban*) was collected as part of a larger study on medicinal plants of Chad. The morphological determination of *Sesbania tchadica* is based on the empirical keys determination of plant species (leaves and pods forms, leaves and pods forms, flower form, leaflets form, inflorescence disposition, standard form and position, and plant and branch size). In order to present distinct morphological groups between *Sesbania tchadica* and other *Sesbania* sp., leaves and branches were harvested and organized according to their morphology (Figures 6 and 7). The identification and confirmation of the species is based on a comparison of the samples with those of the herbarium of Toumaï Institute, the herbarium of the Livestock Research Institute for Development Institut de Recherche en Elévage pour le Developpement (IRED) (N'Djamena) and assessments by foresters from the National Federation of Associations of Healers and Practitioners of Medicine Fédération Nationale des Associations des Praticiens de la Médicine au Tchad (FENAPMT) (which is under the supervision of the Ministry of Public Health of Chad). The species (Accession number: N° 48 TI (Toumaï Institute)) is

registered in the herbariums of the Toumaï Institute, the IRED and then in the Applied Biology and Pathology Laboratory Herbarium (Morocco). The authors also conducted a review of the literature on *Sesbania tchadica (Sesbania sesban)*, its applications in biochemistry and its interactions with other organisms and its environment.

2- Results

***Sesbania tchadica* A. Chev. (Augustin Chevalier):** *''* Sesbania'' is a Persian term and in the Arabic language is ''Saysaban''. The original taxon was created by Antonio Jose Cavanilles (1745-1804) and modified by George Bentham in 1859 in his book Flora brasilensis (Gillett, 1963). However, the names "Sesbania" (Auguste, 1913), "Seseban" and "Sesban" already existed (Gillett, 1963). Related names or synonyms are *Sesbania Sesban* var. nubica*, Sesbania sesban* Merr. (L) (Ndungu and Boland, 1994) (Baker, 1926) *or Sesbania aegyptiaca* auct. non Pers. (Jean and Cyrille, 2019). The local name in Chad is Seysaban, Surridj alkoubar or Surridj addougag (Patrice, 1997). The following table shows the taxonomic classification of *Sesbania tchadica* (table 1).

Table 1: *Sesbania tchadica* taxonomic classification (Gillett, 1963) ; (Taugourdeau Simon et *al.,* 2019) ; (IPNI, 2020).

Sesbania tchadica A. Chev.	
Kingdom	Plantae
Division	*Magnoliophyta* or Angiosperms dicotyledonous (Flowering plants)
Tribe	Robinieae
Classe	Magnoliopsida
Order	Fabales
Family	Fabaceae
Subfamily	Papilionoideae
Gender	*Sesbania*
Species	*Sesbania Sesban* (L.) Merr. *(Sesbania tchadica* A. Chev.)

Range: The genus *Sesbania* (Fabaceae or Papilionoideae) is composed of annual shrubs and perennial woody plants that are widespread in the tropics and subtropics (Jamnadas et *al.,* 2005). *Sesbania tchadica* is an indigenous species of Chad with a height between four and five meters. The only other African countries where *Sesbania* sp is found in native habitat only are Egypt, Kenya and Uganda (Orwa et *al.,* 2009) (Figure 2).

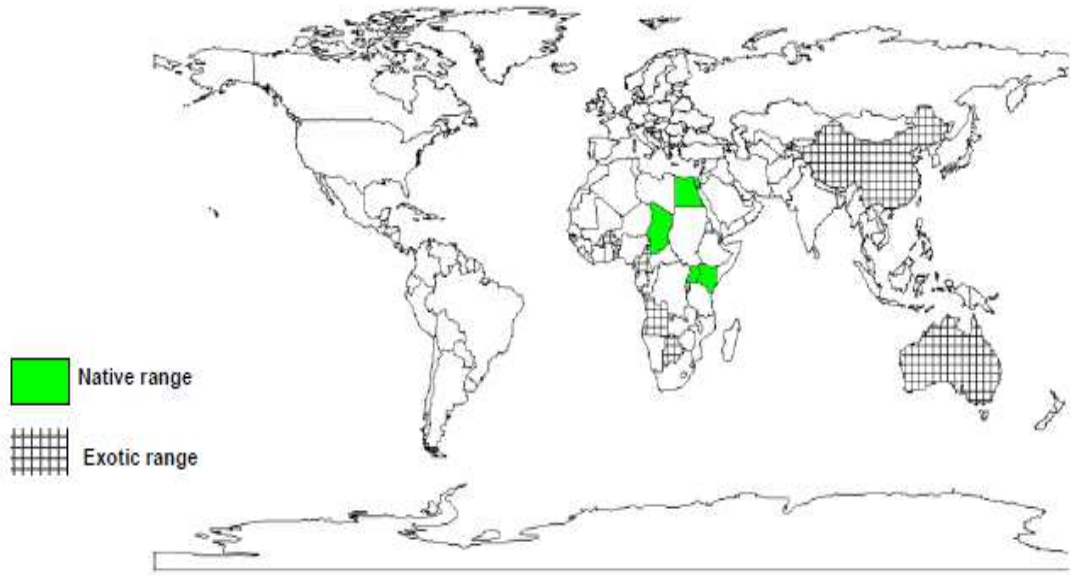


Figure 2: *Sesbania sesban* Merr. (L) in Chad and others African countries(Orwa et *al.,* 2009).

Habitat and Ecology: *Sesbania sesban* grows well in the subtropics and in cooler, higher elevation regions of the tropics. It withstands waterlogging and is ideally suited to seasonally-flooded environments (Orwa et *al.,* 2009). It occurs naturally in wet habitats such as lake shores, on muddy river banks and seasonally flooded valley bottoms (Ndungu and Boland, 1994); (Jamnadass et *al.,* 2005). but also grows in open savannah (George & Gottwald, 2009) and dry, semi-arid zones (Mohammed Abbas et *al.,* 2001). It grows in a wide variety of soils from loose sandy soils to heavy clays (Heuzé et *al.,* 2016). In Chad, especially in N'Djamena, *Sesbania tchadica* (*Sesbania Sesban*) often occurred in different types of soil: silt siltstone, limestone, silty shale, sandy soils, and clays (Figure 3B).

Biophysical limits: The mean annual growing temperature of *Sesbania sesban* is between 18 °C and 23 °C (maximum 45 °C) and the mean annual rainfall is from 500 to 2000 mm. The mean altitude is between 100 and 2300m. *Sesbania tchadica* grows at altitude around 300m (Orwa et *al.,* 2009).

Pests and diseases: *Sesbania* sp is attacked by nematodes, insects, fungi and viruses (Orwa et *al.,* 2009). The leaf-eating beetle *Mesoplatys ochroptera* can completely defoliate *Sesbania* leading to mortality. Caterpillars, Hymenoptera, and stem borers attack *S. sesban.* Some potentially destructive root-knot nematodes have been recorded in India on *S. sesban* (Orwa et *al.,* 2009). *Sesbania* is infected by mild and severe mosaic disease virus, which is transmitted from sap and root, showing vein clearing and reduction of leaflets. The prevalence of infection of mosaic disease virus ranges from 5-20%. *Sesbania* plants grown ''in vitro'' with mild mosaic virus inoculation had fewer pods and were very small in size. The virus inoculated ''in vitro'' has a great tolerance of dilution (between 1,000-10,000), a resistance to heat (40-60°C) and has long longevity in vitro varying between 10-14 days and (10-25°C) (Mall and Kisan, 2003).

Distribution of *Sesbania sesban* in Africa and in the area of study: *Sesbania sp.* consists of about 50 species of fast-growing trees, perennial shrubs and herbaceous annuals. Some thirty-three are found in Africa, distributed between central and eastern

Africa. *Sesbania* species develop wild in most geographical zones of Africa and in many different soil types (Mohammed Abbas et *al.,* 2001). *Sesbania sesban* is the most widely distributed and most important species, with a large number of accessions collected (Heering, 1995). In Chad, the genus *Sesbania* sp is represented by many species: *Sesbania tchadica* A. Chev. *(Sesbania sesban* (L.)) (Figure 4), *Sesbania microphylla* Harms ex Phill & Hutch, *Sesbania leptocarpa* D.C., *Sesbania pachycarpa* D.C., *Sesbania pubescens* D.C., *Sesbania rostrata Brem. & Oberm*., *Sesbania sesban* (*L.*) *var. nubica*, *Sesbania sesban subsp. punctata* D.C. & Gillett, *Sesbania dalzielii* E. Phillips & Hutch.(Gaston and Fotuis, 1971) (Jean and Cyrille, 2019). Chad is a center of diversity for some of these species. However, *Sesbania* species have not been fully exploited as multi-purpose plants in many central African countries (Gaston and Fotuis, 1971). Our study shows that the species *S. tchadica* is abundant in the area that the study was conducted. In the most districts of N'Djamena, we found *S. tchadica* to be the most common type (Figure 3A). It shows a rapid early growth and grows well in different soil types in Chad (Figure 3B). As reported by Jean and Cyrille (2019) and IPNI (2020), *Sesbania tchadica* (*Sesbania sesban*) is localized also in Chad in different zones like: riverbanks, stream beds; riparian; water sources of Borkou and Ennedi (Figure 4).

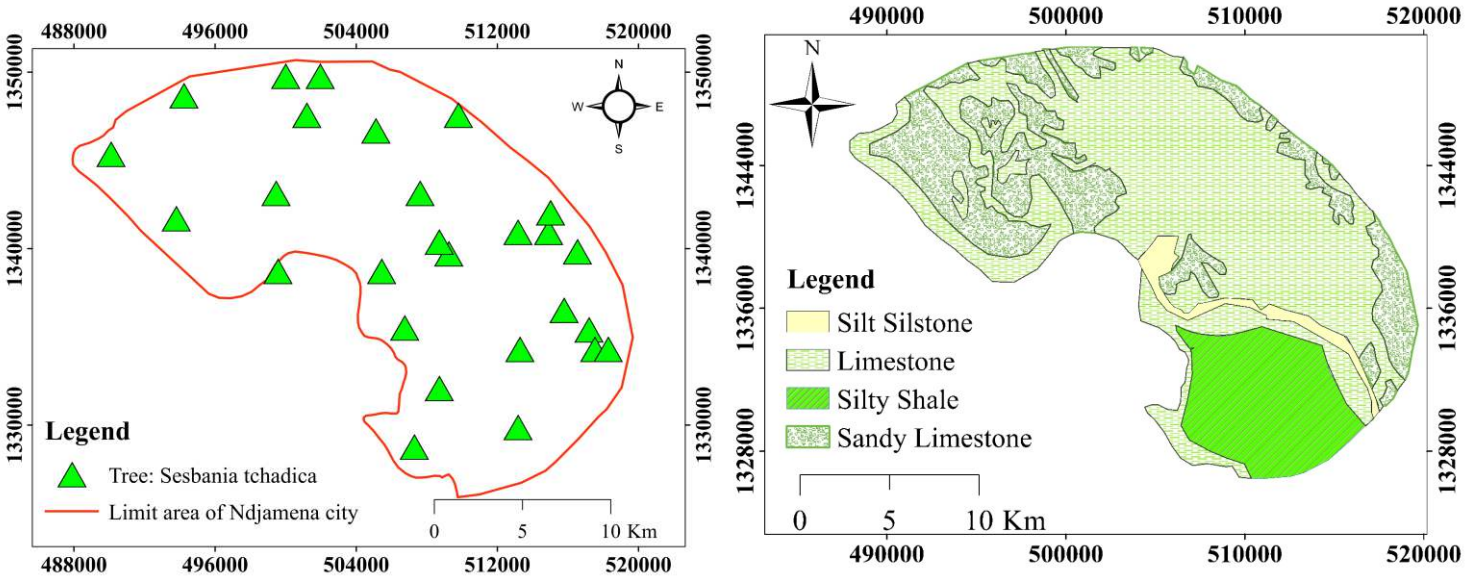
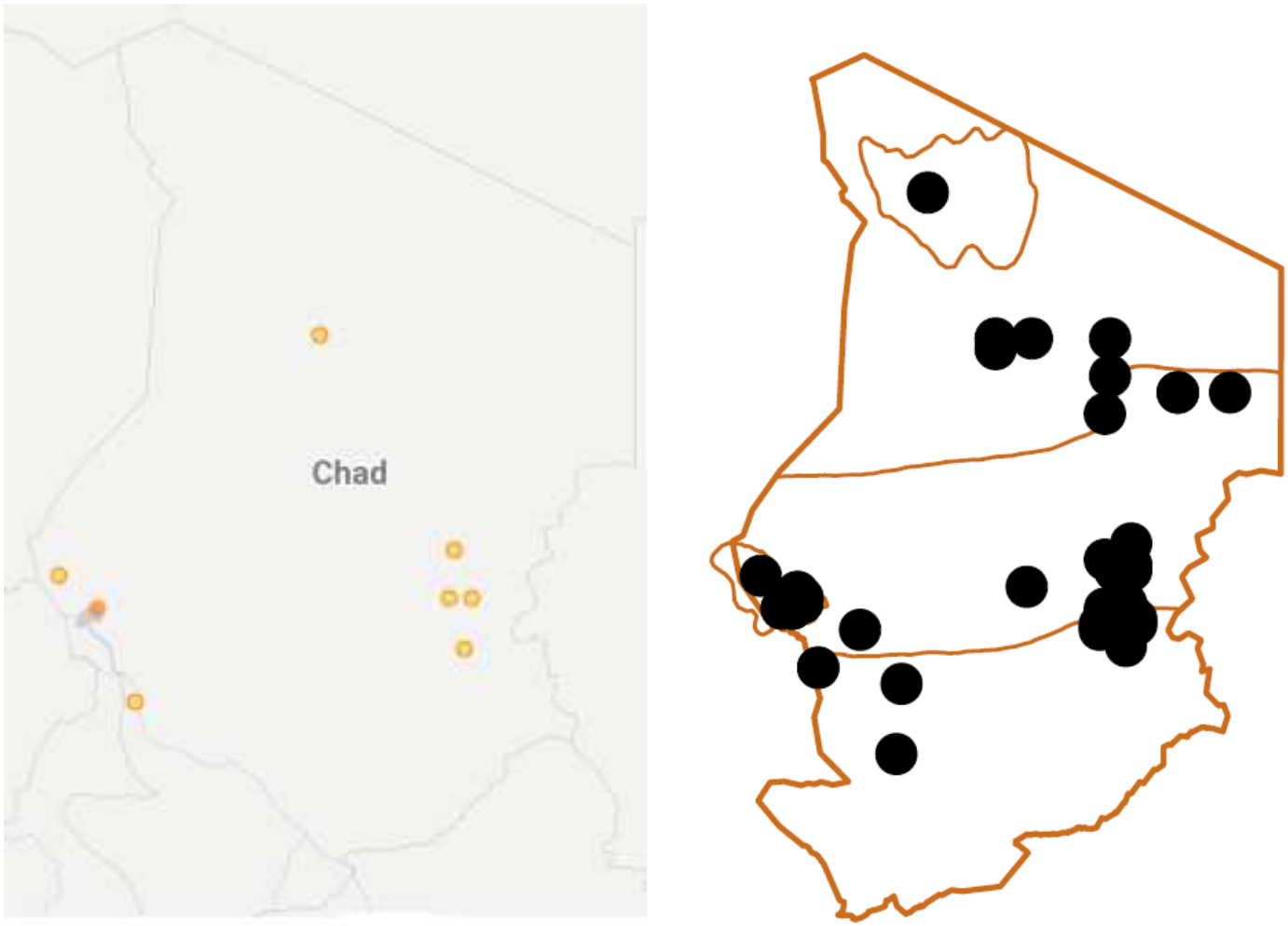


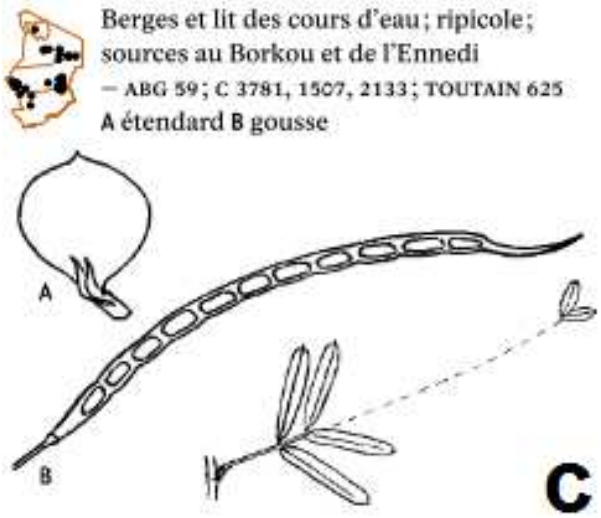
Figure 3: **A:** Location of *Sesbania tchadica* (*Sesbania sesban*) in the study area. **B:** Soil types in the study area.



Figures 4: In orange color: Zones of Chad where *Sesbania tchadica* A. Chev (*Sesbania sesban* Merr.) is found (IPNI, 2020) (GBIF, 2020) . In black point: Zones of Chad where *Sesbania tchadica* (*Sesbania sesban*) is found (Jean and Cyrille, 2019).

Morphological description: *Sesbania tchadica* (*Sesbania Sesban*) has several basal stems that spread with spiked branches (Figure 5A). Its branches are organized with opposite pairs of leaves as a straight line, with points that look like hair. There are at least 20 pairs of leaves that cross one by one each 180° from the previous, forming a cone that gradually closes(Jean and Cyrille, 2019). These leaves are odd-pinnate with one pair of leaflets at the base with large irregularly-lobed terminal leaflets (Figure 5A). Pods are light green in color just after formation and yellow in color when maturing (Figure 5B). Five to seven pods are grouped together, in grapes form (Figure 5A). Pods and leaves drawing are presented in figure 6C (Jean and Cyrille, 2019). The flowers are yellow and are arranged in clusters forming from two to 20 flowers and almost 20 cm long (figure 6A). The Filament-sheath is 9-13 mm, the inflorescence is never branched and is yellow speckled with purple or, in rare cases, is pure yellow. The plant glabrescent or glabrous (Figure 5 and figure 6A) (Gillett, 1963) (Ndungu and Boland, 1994) (Jean and Cyrille, 2019). Soaking the seeds in water for a few days is sometimes required to make them germinate (Gillett, 1963). Mani et *al.,* (2011) describe that *Sesbania tchadica* (*Sesbania Sesban*) is a short-lived shrub or small tree up to 8 m tall. Its leaves are pinnately compound, 2-18 cm long with 6-27 pairs of linear oblong leaflets (26 × 5 mm). The raceme has 2-20 flowers which are yellow with purple or brown streaks on the corolla. Pods are sub cylindrical, straight or slightly curved up to 30 cm long and 5 mm wide containing 10-50 seeds. Five varieties of *S. sesban* are recognized botanically but their differences do not correlate strongly with their agricultural value

(Mani et *al.,* 2011). For this purpose, we employ survey data collected from Ndjamena to describe the species *Sesbania tchadica* (*Sesbania Sesban*) (Figure 5 and Figure 6).



Figures 5: A: *Sesbania tchadica* (*Sesbania Sesban*): Tree and branches. (Latitude 12° 02' 0'' North Longitude 15° 12' East). **B:** Dry pods. **C:** Drawing pods and leaves.

We note that the botanical missions carried out on *Sesbania tchadica (Sesbania Sesban)* date from 1968 by the botanist Léonard, and by the botanists Jean and Cyrille (2019) (Jean and Cyrille, 2019). Léonard collected this species in the region of Lake Chad (Léonard, 1968) (Figures 6).

Figures 6: (A) *S. tchadica* (*S. sesban*): leaves, flowers, stems, and fresh pods. **(B) :**The figure shows the botanical mission carried out on the *Sesbania sesban* species in Lake Chad area (Léonard, 1968).

Medicinal and other benefits, uses and applications of *Sesbania tchadica*: *Sesbania tchadica* (*Sesbania sesban*) is used as a medicine and as a feed for livestock. Healers in Chad use its leaves and bark alone to treat breast cancer, oedemas and wounds (Ousman et *al.,* 2017) (unpublished). In addition, livestock-keepers cut, carry and feed the leaves to ruminants. The pods are also cut and fed to dairy sheep, goats and oxen. These leaves and pods are considered as a high-protein fodder to increase the milk productivity of these animals (Ousman et *al.,* 2017) (unpublished). Several authors have reported on the medicinal value and ethnobotanical uses of *S. tchadica* (Moyo et *al.,* 2015). Others reported on the species ecological services such as nodulation, its use in intercropping and in improving fallows (in agriculture), its use as fuelwood (Adelanwa. & Tijani, 2016), for biomass production

(Zulfiqar et *al.,* 2015), and for its ethno-veterinary performance (Frank et *al.,* 2009) (Mohammed et *al.,* 2010). Sontosh et *al.,* (2017) found that the biomass yield of *S. sesban* accessions produced at the earlier growing period is used as green manure crop in shorter fallow period (up to 20 days after sowing DAS) in rotation culture of Rice-Rice-Mustard or other similar cropping patterns. *Sesbania sesban* produced higher biomass yield at the early growth stages (up to 20 DAS) and its decomposability, organic matter accumulation, and N2-fixing ability may be processed to release as recommended cultivar. *S. sesban* can be grown in a very short of this rotation culture to maximize organic matter addition to the soil (Sontosh et *al.,* 2017). Details of different uses and applications of *Sesbania tchadica* (*Sesbania Sesban*) are shown in Table 2.

Table 2: Results of a review of literature on the uses of *Sesbania tchadica* (*Sesbania sesban*)

Different uses of *Sesbania tchadica* (*Sesbania Sesban*)			
Use	**Types of use and diseases treated**	**Part used and optimal solvents**	**References**
Medicinal uses	Antioxidant activity (saponins and flavonoids, anthocyanins)	Leaves, seeds (ethanolic extracts, methanol)	(Mani et *al.,* 2011) (Kathiresh et *al.,* 2012)
	Anti-microbial activity (anthocyanins) Antimicrobial and cytotoxicactivity (carbohydrates, flavonoids, steroids, alkaloids, tannins, saponins)	Flower petals (methanol and acidified methanol). Bark (ethanol, diethyl ether, chloroform)	(Kathiresh et *al.,* 2012) (Arif et *al.,* 2013)
	Anti-inflammatory activity (crude saponins)	Leaves (methanol)	(Tatiya et *al.,* 2013) (Shaikh et *al.,* 2012)
	Anthelmintic activity (saponin glycosides)	Leaves, seed (aqueous extracts)	(Ibrahim, 1992)
	Antidiabetic activity (Triterpenoids, tannins, saponins, glycosides, steroids)	Leaves (aqueous extracts)	(Pandhare et *al.,* 2011)
	Antinociceptive activity (Sterols, triterpenes flavonoids)	Wood (petroleum ether, Chloroform ethyl acetate)	(Nirmal et *al.,* 2012)
	Traditional medicine (in Chad) (Breast cancer, oedema, swollen glands)	Preparations method Breast cancer: -- Maceration of leaves for 48 hours -- Infusion of root, bark Oedema and swollen glands:	(Ousman et *al.,* 2017) (unpublished)

		-- Powder of leaves with oil applied in the body	
	Central nervous system stimulant (carbohydrate, alkaloids, phytosterols, a phenolic compound	Bark (petroleum ether, chloroform, alcohol, aqueous extracts)	(Naik et *al.,* 2011)
	Control the fertility of female albino rats	Seeds (distilled water)	(Shiv Pal Singh, 1990)
	Potent spermicidal activity (oleanolic acid 3-β-D-glucuronide (OAG) decline the fertility of rats to zero)	Roots (ethylacetate, n-butanol saturated, ethanol, water).	(Nilanjana et *al.,* 2011)
	Ethnoveterinary uses (Cattle)	Leaves, stems	(Harun-or-Rashid et *al.,* 2010) (Mohammed et *al.,* 2010)
	Antimalarial activity	Leaves *Preparation method*: The vapor from boiling leaves is inhaled	(Chinsembu, 2015)
	Mosquito repellant	Leaves Preparation method: -- Washing bodies of animals with water leaves extracts -- Leaf decoction was used for cattle drench to repel tsetse fly	(Samajdar & Ghosh, 2017) (Vidavel et *al.,* 2012)
	Type of use in agriculture and other applications	**Part used**	**References**
	Fixes atmospheric nitrogen in the soil Green manure for lowland rice Reduction of nematodes and trapping of *Hirschmannieffa oryzae* et *H. spinicaudata* *Sesbania Sesban* produces nodules that can fix 12 tons of biomass (fresh weight)/hectare for a growth period of 45	Tree, roots Whole tree	(Mmoudiongh & Rinaudoe, 1985) (Ndoye et *al.,* 1996) (Dreyfus & Dommergue, 1981) (Ndoye & Dreyfus, 1988)

	days in in waterlogged or drained soils. *Sesbania rostrata* compared to *Sesbania Sesban,* fixes approximately 110 kg of nitrogen per hectare in 60 days, which places it among the most powerful fixatives *Sesbania* species with a higher dry matter.		
	Sesbania sesban is used as a green manure which increases the nitrogen on the soil (in crops of rice and wheat)	Tree, roots	(Patra et *al.,* 2006)
Agricultural uses	*Rhizobuim* strains induce root nodules and fix nitrogen from the air on the soil in symbiosis with *Sesbania* sp. Inducing of root nodules *Rhizobuim* strains and nitrogen fixing on the soil in symbiosis with *Sesbania sesban*	Whole tree Germinated seedlings	(Sobere, 1991) (Bala et *al.,* 2002) (Sharma et *al.,* 2005)
	Improved fallow systems to enhance agricultural productivity by increasing the yields of maize and sorghum by 1.2 - 1.8 mg /hectare and 0.1 - 0.7 mg / hectare, respectively. Apply about 7.3 Mg ha−1 dry matter and 165 kg N ha−1 to irrigated wheat and rice.	Whole tree	(Sileshi et *al.,* 2008) (Sileshi et *al.,* 2014)
	Cultivated in rotation with cotton to enhance nitrogen fertility and improve soil condition	Whole tree	(Curasson, 1956) (Rochester et *al.,* 2001)
	The production of nutrients nitrogen, phosphorus, calcium, magnesium potassium by foliar biomass	Whole tree Bark, Stems	(Balaisubramanian & Sekayange, 1992) (Mohammed Abbas et *al.,* 2001)
	Biomass yield of *S. sesban* accessions produced is used as green manure crop in shorter fallow. *S. sesban* maximizes organic matter addition to the soil.	Seeds accessions, Whole tree	(Sontosh et *al.,* 2017)
	Intercropping sweetpotato with *Sesbania sesban* improves yield of the crop	Whole tree	(Muimba-Kankolongo, 2018)
	Intercropping with rice and annual grasses in semi-arid conditions for managing weeds and optimizing the yield of dry-seeded rice. *Sesbania*, being an aquatic plant, can also be grown together with rice to suppress weeds	Whole tree Bark	(Mohammed Abbas et *al.,* 2001) (Singh et *al.,* 2007)
	Improved fallows and as herbaceous cover crops	Whole tree	(Dagar and Tewari, 2017) (Nair, 1993)
	If used as a supplement, it may improve the cow's health and shorten the calving interval.	Leave meal	(Roothaert & Paterson, 1997) (Frank et *al.,* 2009)
	Improving the traditional sheep husbandry: Increased milk and meat production	Leave and young twigs. Whole tree	(Mekoya et *al.,* 2009) (Franzel et *al.,* 2014)
	Improve smallholder's livestock productivity, source of	Whole tree	(Franzel et *al.,* 2014)

Other applications	revenue, and livelihoods. Fodder, feed livestock tree for dairy goats, sheep, and cows (small ruminants).		
	Vegetation covers in desert areas. Fodder for livestock (goats, sheep). Increasing the fertility and productivity of sandy soil in the desert area	Whole tree	(Ousman et *al.,* 2017) (unpublished) (Curasson, 1956) (Mohammed Abbas et *al.,* 2001)
	Restore eroded soil by fixing N2	Whole tree	(Degefu et *al.,* 2011) (Nigussie & Getachew, 2013)
	Sesbania sesban is used as hedge	Whole tree	(Curasson, 1956)
	Sesbania sesban is developed for its wind shade. *Sesbania sesban* is used as windbreaks, as cover crops, ornamental plants, and as fish poisons for light sticks, used in building huts, making charcoal, preparing gunpowder.	Whole tree	(Samajdar & Ghosh, 2017) (Gillett, 1963)
	The biomass of *Sesbania sesban* can produce wood within just 3-6 months when it grows with *Cajanus cajan* (leguminous) and used so as cooking fuel	Whole tree	(Adelanwa & Tijani, 2016)
	Sesbania sesban is used in many African countries as a good source of fuel, grows fast, burns well, can be coppiced. It is used as fiber for ropes and fishing nets, and the seeds produce a gum.	Stem and thick branches Bark	(World Agroforestry Centre, 2002)
	Sesbania grows in the salt-affected soils and limits the effect of salinity. Inoculating of *Sesbania sesban* with salinity-tolerant rhizobia under saline conditions increases biological nitrogen fixation	Whole tree	(Bakhoum et *al.,* 2018) (Bala et *al.,* 1990)
	Soil treatment laden with heavy metals Potential for use in treatment systems of waste or polluted water	Whole tree	(Gupta et *al.,* 2011) (Dan and Hans, 2009) (Dan et *al.,* 2011)
	Green manure plants as *Sesbania* sp. combined with sewage sludge are an initial fertility driver for rapid increasing yield of maize, decreased salinity and pH, and increased organic carbon, nitrogen and phosphor concentrations in mudflat soil.	Whole tree	(Bai et *al.,* 2017)

Phytochemical compounds of *Sesbania tchadica* (*Sesbania sesban*): *Sesbania tchadica* (*Sesbania sesban*) has different chemical compounds that are, once extracted, very useful for treating diseases, manufacturing of drugs, organic or chemical supplements and antibacterial or antioxidant agents, manufacturing of biological manure, among others (Patra et *al.,* 2006) ; (Kathiresh et *al.,* 2012) (table 1). Details of phytochemicals compound combined with different extraction solvents are shown in Table 3.

Table 3: *Sesbania tchadica* (*Sesbania sesban*): Different Phytochemical compounds with the parts used and their extracts solvent.

Phytochemicals compounds and parts used of *Sesbania tchadica*	**Solvents Extracts**	References

(*Sesbania sesban*)		
Sterols, saponins, flavonoids Sterols, alkaloids. Fats and oil. Proteins, sterols, saponins, flavonoids, glycoside, vitamins sesbanins, sesbanimid phosphorus (Leaves).	Methanol, Chloroform , Petroleum ether 60-80°	(Shaikh et *al.,* 2012)
Campesterol, beta-sitosterol. (Pods, leaves). Cyanidin, delphinidin glucosides (Flowers).	Aqueous extracts	(Khare, 2007)
Triterpenoids, carbohydrates, vitamins, amino acids, proteins, tannins, saponin glycosides steroids (Leaves, seed)	Aqueous extracts	(Pandhare et *al.,* 2011) (Ibrahim, 1992)
Phenolics, anthocyanins, flavonoids (Flowers)	Methanol	(Kathiresh M. et al., 2012)
Steroids, Alkaloids. Reducing Sugars (carbohydrates), Tannins, Flavonoids, Saponin (Bark)	Ethanol Ether (diethyl ether) Chloroform (95% each one)	(Arif et *al.,* 2013)
Cholesterol, campesterol and beta-sitosterol (Pods)	-	(Goswami et *al.,* 2016) (Khare, 2007)
Alpha-ketoglutaric, oxaloacetic and pyruvic acids (Pollen and pollen tubes)	-	(Khare, 2007)
Crude protein and crude fiber (Dry matter of leaf)	-	(Siaw et *al.,* 1993)(Kaitho, 1997)
Sterols, triterpenes. Flavonoids (Wood)	Petroleum ether and Chloroform. Ethyl acetate	(Nirmal et *al.,* 2012)

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3- Discussion 207

Sesbania tchadica is a leguminous tree native to Chad that is used to increase crop yields and vegetation in some desert areas. The local 208
population and particularly pastoralists plant it in arid zones to increase the plant cover, to obtain shade for humans and their animals and 209
to use its wood for construction. The local population also uses *Sesbania tchadica* to enrich soil fertility for increasing yields of crops 210
such as rice, maize and sorghum and to repel desert encroachment in zones with little vegetation (Ousman et *al.,* 2017) (unpublished). 211
The author (Bashan et *al., 2*012) have demonstrated that native leguminous trees such as *Sesbania tchadica* are essential to ensure the 212
revegetation of eroded desert lands and to restore eroded soil. These authors have also inoculated these leguminous trees with Plant 213
Growth-Promoting Bacteria (PGPB) in agricultural and agroforestry systems. They planted a high density of these leguminous trees in 214
certain areas with severely eroded soil and the result was a remarkable degree of revegetation and more stabilized soils. *Sesbania tchadica* 215
can play an important role, along with other leguminous species, in land restoration and the protection and conservation of indigenous 216
species in Chad (FAO, 2012). 217

In the present study, the authors found that most populations of *Sesbania tchadica* in N'Djamena are planted by the local population 218
whereas in areas surrounding the city, most are wild (Jean and Cyrille, 2019). This suggests that the local population is aware of the 219
importance of the species and wishes to benefit from its fast growth and its use for fuelwood, for improving soil fertility and for feeding 220
and shading livestock. it measures approximately 4-5 meters in height.in six months with a diameter of up to 12 cm (Shun-ching, 1960), 221
(Anonymous, 1985), (Ousman et *al.,* 2017) (unpublished). The average diameter growth measured in basal circumference is ranging from 222
16-28cm (Shun-ching, 1960). In South of Morocco, to support the agriculture systems limited by the lack of water resources and 223
disturbing salinization of surface or underground freshwater sources, the National Institute of Agronomic Research Institut National de la 224

Recherche Agronomique INRA has become interested in the adaptation of certain crops to saline environments and their contribution to improving food and fodder production in desert or arid areas. Successful results of resilient cultures and cover vegetation are obtained by the introduction of *Sesbania sesban* in a saline environment in the region of Laâyoune (INRA, 2019). Bala et *al.,* (1990) found also that biological nitrogen fixation can be significantly increased by inoculating tree legumes such *Sesbania sesban* with salinity-tolerant rhizobia under saline conditions.

However, some important problems exist which threaten *Sesbania tchadica* and other leguminous trees in Chad. Robert & Mahamat Ali, (2005) pointed out that around cities such as Ndjamena; the high demand for fuelwood threatens the sustainability of supply. Nwilo et *al.,* (2020) noted that vegetation in the northwest and the northeast of Nigeria including the region of Lake Chad declined by 2.18% from 1984 to 2000 and by 2.02% from 2000–2016. The causes included agricultural activities such as extensive grazing, and annual cropping, other uses of the trees such as for fuelwood, charcoal, panelling and woodwork and variations in climate (Nwilo et *al.,* 2020). Such exploitation poses risks to the conservation of the whole flora in these and other tropical and sub-tropical regions (Rukangira Ernest, 2001), (Ribeiro et *al.,* 2017). Rukangira (2001) noted that policy makers, other stakeholders and citizens need to support conservation and help increase awareness of the problem.. Moreover, effective strategies for biodiversity conservation should focus on regions with rare and endangered species, on locally abundant species that are functionally vital in maintaining the plant community and on regions with considerable heterogeneity of vegetation (Ribeiro et *al.,* 2017). The collection of the plant material and the documentation, botanical identification and preparation of the herbarium vouchers are tasks that cannot be automated and thus require specialists who are becoming increasingly rare (Bucar et *al.,* 2013); (Bruno et *al.,* 2015).

In the current study, the species *Sesbania tchadica* was collected using standard procedures by Chadian expert foresters and botanists from the Toumaï Institute and LRID Herbaria. Next, to identify the plant material, the authors used the empirical keys determination (leaves and pods forms, plant size, etc.). This determination is based on previous work of the botanist Léonard (Léonard, 1968) who did a collection of this species in the region of Lake Chad as part of a Belgian botanical expedition. This study also uses the plant illustrations of *Sesbania sesban* and *Sesbania tchadica* done by botanists Jean César and Cyrille Chatelain in their study of the Chadian flora (Jean and Cyrille, 2019). Jean and Cyrille (2019) explain that botanists who conduct research in Africa rarely have the opportunity to study the DNA of the plants they work on. For this reason, in the current study (as the Léonard and Jean & Cyrille studies), we have used the classical determination keys of *Sesbania tchadica*, (as cited above). This allows a more logical hierarchy of groups based on morphological characters, which are really the only ones accessible to the field botanist.

4- Conclusion

The ethnobotanical study carried out specifically from Ndjamena region and its surroundings allowed the authors to assess at the local level an important tree and shrub species, *Sesbania tchadica* (*Sesbania Sesban*). *Sesbania tchadica* leaves were harvested and organized according to a morphological model in order to facilitate its identification. However, this morphological and descriptive study conducted on *Sesbania tchadica* proved to be very complex because the exploitation of data at local level still less-exploited. As a result, this paper contributes to the production and maintenance of a new database on this species. It is also a gain for the scientific world and the research organizations in Chad and internationally. This study will hopefully contribute to the protection, use and value of *Sesbania tchadica*.

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Declarations

Ethics approval and consent to participate: The manuscript is not submitted to other journal for simultaneous consideration. The work is original and has not been published elsewhere in any form or language. Authors adhere to discipline- specific rules for acquiring, selecting and processing data

Compliance with ethical standards

Competing interests: The authors have no relevant financial or non-financial interests to disclose.

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Availability of data and materials: The data that support the findings of this study are available from the corresponding author upon reasonable request. All data relating to this species generated during the study survey are included in this paper. A voucher specimen is deposited of the Toumaï Institute and IRED herbaria (Chad) and then in the Applied Biology and Pathology Laboratory Herbarium (Morocco).

Authors' contribution statements: O. B. M.: Conceptualization, Methodology, Data, Writing, and Investigation. S. Y., B. B. O. and S. F.: Supervision, Writing, Reviewing, Investigation. A. O. M. Software, Data. A. F. and the other authors: Visualization, Investigation. All authors read and approved the final manuscript.

References:

Abdel Magid H. M., Singleton, P. W., & Tavares, J. W. (1988). *Sesbania- Rhizobium* Specificity and Nitrogen Fixation. *Desert Plants*, *9*(2), 45–48. http://hdl.handle.net/10150/609114

Adelanwa E. B., & Tijani M. O. (2016). Performance of *Cajanus cajan* [l.] millsp. and *Sesbania sesban* as cooking fuel. *Journal of Bioscience and Biotechnology Discovery*, *1*, 1–5. https://doi.org/10.31248/JBBD2016.005

Anon 1992. Annual Report 1991, & International Centre for Research in Agroforestry ICRAF. Nairobi. (1992). *In: Ndungu J. N. and Boland D. J. (1994). Sesbania seed collections in Southern Africa. Developing a model for collaboration between a CGIAR Centre and NARS.*

Anonymous. (1985). *Sesbania sesban* (L.) Merr. *Sesbania grandiflora* (L.) Pers. http://projects.nri.org/biomass/conference_papers/sesbania_sesban.pdf

Arif Ahmed, Labu, Z., Dey, S., Hira, A., Howlader, M. I., Hossain, M., & Roy, J. (2013). Phytochemical screening, antimicrobial and cytotoxic activity of different fractions of *Sesbania sesban* bark. *International Journal of Basic Medical Sciences and Pharmacy*, *5*(4), 206. https://doi.org/10.4103/1947-489x.210546

Auguste Chevalier. (1913). Etudes sur la flore de l'Afrique centrale française (Bassins de l'Oubangui et du Chari) Tome I. Enumération des plantes récoltées. Université de Cornell and Paris, A. Challamel, Mission Chari-Lac Tchad. http://www.ipni.org/ipni/idAuthorSearch.do;jsessionid=CABB88F11DFEAC53116E0A7296EFB841?id=1584-1&back_page%0AChevalier

Bai Yanchao, Zang, C., Gu, M., Gu, C., Shao, H., Guan, Y., Wang, X., Zhou, X., Shan, Y., & Feng, K. (2017). Sewage sludge as an initial fertility driver for rapid improvement of mudflat salt-soils. *Science of the Total Environment*, *578*, 47–55. https://doi.org/10.1016/j.scitotenv.2016.06.083

Baker J. G. (1926). The Leguminosae of Tropical Africa (1926).): *Base de données des plantes d'Afrique: Sesbania tchadica* A. Chev. Conservatoire et Jardin Botaniques & South African National Biodiversity Institute. http://www.ville-ge.ch/musinfo/bd/cjb/africa/details.php?langue=fr&id=127976

Bakhoum N., Fall, D., Fall, F., Diouf, F., Hirsch, A. M., Balachandar, D., & Diouf, D. (2018). *Senegalia senegal* (synonym : *Acacia senegal*), its importance to sub-Saharan Africa , and its relationship with a wide range of symbiotic soil microorganisms. *South African Journal of Botany*, *119*, 362–368. https://doi.org/10.1016/j.sajb.2018.10.007

Bala Abdullahi, Murphy Phillip, & Giller Ken E. (2002). Occurrence and genetic diversity of rhizobia nodulating *Sesbania sesban* in African soils. *Soil Biology and Biochemistry*, *34*(11), 1759–1768. https://doi.org/10.1016/S0038-0717(02)00163-3

Bala Neeru, Sharma P. K., & Lakshminarayana K. (1990). Nodulation and nitrogen fixation by salinity-tolerant rhizobia in symbiosis with tree legumes. *Agriculture, Ecosystems and Environment*, *33*(1), 33–46. https://doi.org/10.1016/0167-8809(90)90142-Z

Balaisubramanian V., & Sekayange L. (1992). Effets de la culture en couloirs sur les propriétés du sol et les performances des arbustes et des cultures vivrières dans un environnement semi-aride au Rwanda. *International Rice Research Institute*, 180–190. https://www.researchgate.net/publication/32976933

Bashan Y., Salazar, B. G., Moreno, M., Lopez, B. R., & Linderman, R. G. (2012). Restoration of eroded soil in the Sonoran Desert with native leguminous trees using plant growth-promoting microorganisms and limited amounts of compost and water. *Journal of Environmental Management*, *102*, 26–36. https://doi.org/10.1016/j.jenvman.2011.12.032

Bindraban S Prem, van der Velde, M., Ye, L., van den Berg, M., Materechera, S., Kiba, D. I., Tamene, L., Ragnarsdóttir, K. V., Jongschaap, R., Hoogmoed, M., Hoogmoed, W., van Beek, C., & van Lynden, G. (2012). Assessing the impact of soil degradation on food production. *Current Opinion in Environmental Sustainability*, *4*(5), 478–488. https://doi.org/10.1016/j.cosust.2012.09.015

Bradbury M. (1990). The effect of water stress on growth and dry matter distribution in juvenile *Sesbania sesban* and *Acacia nilotica.* *Journal of Arid Environments*, *18*(3), 325–333. https://doi.org/10.1016/s0140-1963(18)30842-5

Bruno David, Jean Luc Wolfender, & Daniel A. Dias. (2015). The pharmaceutical industry and natural products: historical status and new trends. *Phytochemistry Reviews*, *14*(2), 299–315. https://doi.org/10.1007/s11101-014-9367-z

Bucar F., Wube, A., & Schmid, M. (2013). Natural product isolation-how to get from biological material to pure compounds. *Natural Product Reports*, *30*(4), 525–545. https://doi.org/10.1039/c3np20106f

Chinsembu Kazhila C. (2015). Plants as antimalarial agents in Sub-Saharan Africa. *Acta Tropica*, *152*, 32–48. https://doi.org/10.1016/j.actatropica.2015.08.009

Cocking, E. C. (2000). Helping plants get more nitrogen from the air. *European Review*, *8*(2), 193–200. https://doi.org/10.1017/S1062798700000193

Curasson G. (1956). Etudes sur les pâturages tropicaux et sub-tropicaux: Legumineuses fourragères. (1956). *Revue d'élevage et de*

médecine vétérinaire des pays tropicaux, p. 49-84, 1956. https://www.researchgate.net/publication/318309602_Etudes_sur_les_paturages_tropicaux_et_subtropicaux_plantes_appartenant_a_des_familles_autres_que_les_graminees_et_les. https://doi.org/10.19182/remvt.6916

Dagar J. C. and Tewari V. P. (2017). Agroforestry: Anecdotal to Modern Science. In *Agroforestry*. Springer Nature Singapore Pte Ltd. p. 869. https://doi.org/10.1007/978-981-10-7650-3

Dakora F. D. and Keya S. 0. (1997). Contribution of legume nitrogen fixation to sustainable agriculture in sub-saharan Africa. *Soil Biology and Biochemistry*, *29*(5–6), 809–817. https://doi.org/10.1016/S0038-0717(96)00225-8

Dan Truong Hoang and Hans Brix. (2009). Growth responses of the perennial legume *Sesbania sesban* to NH 4 and NO 3 nutrition and effects on root nodulation. *Aquatic Botany*, *91*(3), 238–244. https://doi.org/10.1016/j.aquabot.2009.07.004

Dan Truong Hoang, Le Nhat Quang, Nguyen Huu, & Hans Brix. (2011). Treatment of high-strength wastewater in tropical constructed wetlands planted with *Sesbania sesban* : Horizontal subsurface flow versus vertical downflow. *Ecological Engineering*, *37*(5), 711–720. https://doi.org/10.1016/j.ecoleng.2010.07.030

Degefu Tulu, Wolde-meskel, E., & Frostegård, Å. (2011). Multilocus sequence analyses reveal several unnamed *Mesorhizobium* genospecies nodulating *Acacia* species and *Sesbania sesban* trees in Southern regions of Ethiopia. *Systematic and Applied Microbiology*, *34*(3), 216–226. https://doi.org/10.1016/j.syapm.2010.09.006

DeRouw A. (1998). Gestion de la fertilité du sol sur un terroir sahélien. Fumure animale, matière organique et encroûtement superficiel du sol dans les systèmes de culture de mil, étude au Niger. Soil fertility management in the Sahel. Manure, organic matter and crust form. *Agriculture et Développement CIRAD*, *18*, 63–70. https://agritrop.cirad.fr/400925/1/document_400925.pdf

Dreyfus B. L., & Dommergues Y.R. (1981). Nitrogen-fixing nodules induced by *rhizobium* on the stem of the tropical legume *Sesbania rostrata*. *FEMS Microbiology Letters*, *10*(4), 313–317. https://www.sciencedirect.com/science/article/abs/pii/0378109781901166

FAO Food and Agriculture Organisation. (2012). Synthèse des études thématiques sur la foresterie urbaine et périurbaine de N'Djaména, Republique du Tchad. *Document de travail sur la foresterie urbaine et périurbaine n°7.* http://www.fao.org/3/i2850fwp7/i2850fwp7.pdf

Frank Place, Roothaert, R., Lucy, M., Judith, S., Franzel, S., & Wanjiku, J. (2009). The impact of fodder trees on milk production and income among smallholder dairy farmers in East Africa and the role of research (P. Fredenburg (ed.)). p. 47. Nairobi, Kenya. https://www.academia.edu/download/53084101/The_impact_of_fodder_trees_on_milk_produ20170511-3627-m2wjsk.pdf

Franzel S., Carsan, S., Lukuyu, B., Sinja, J., & Wambugu, C. (2014). Fodder trees for improving livestock productivity and smallholder livelihoods in Africa. *Current Opinion in Environmental Sustainability*, *6*(1), 98–103. https://doi.org/10.1016/j.cosust.2013.11.008

Gaston André and Fotuis Georges. (1971). Lexique de noms vernaculaires de plantes du Tchad. p. 355. Laboratoire de Farcha, Fort-Lamy NDjamena,Tchad. http://horizon.documentation.ird.fr/exl-doc/pleins_textes/divers11-05/05320.pdf

George Ouma, & Gottwald Franz-theo. (2009). Agrarian Science for Sustainable Resource Management in Sub-Saharan Africa. In *Support Africa International*. Peter Lang. p. 129. Google book.

https://books.google.co.ma/books?id=NgK16l6nboUC&dq=sesbania+sesban+grows+in+savannah&hl=fr&so

Gillett J. B. (1963). *Sesbania* in Africa (Excluding Madagascar) and Southern Arabia. *Plants People Possibilities Springer on Behalf of Royal Botanic Gardens, Kew*, *17*(1), 91–159. http://www.jstor.org/stable/4118710

Global Biodiversity Information Facility GBIF. (2020). *Sesbania sesban* (L) Merr . Chad. FLOTROP, a Massive Contribution to Plant Diversity Data for Open Ecosystems in Tropical Africa. Published by *CIRAD SELMET*. https://www.gbif.org/occurrence/map?country=TD&has_coordinate=true&has_geospatial_issue=false&taxon_key=2970648

Goswami, S., Mishra, K., Singh, R. P., & Singh, P. (2016). *Sesbania sesban*, A Plant with Diverse Therapeutic Benefits : An Overview. *Journal of Pharmaceutical Research & Education*, *1*(1), 111–112. https://www.researchgate.net/publication/307601150%0ASesbania

Gupta Amit K., Su, S. W., & Chen, Z. S. (2011). Heavy-Metal bioavailability and Chelate mobilization efficiency in an assisted phytoextraction process by *Sesbania sesban* (L.) Merr. *Communications in Soil Science and Plant Analysis*, *42*(2), 231–245. https://doi.org/10.1080/00103624.2011.535073

Harun-or-Rashid Mohammed, Tanzin, R., Ghosh, K. C., Jahan, R., Khatun, M. A., & Rahmatullah, M. (2010). An ethnoveterinary survey of medicinal plants used to treat cattle diseases in Birishiri area, Netrakona district, Bangladesh. *Advances in Natural and Applied Sciences*, *4*(1), 10–13. https://www.researchgate.net/publication/289176508_An_ethnoveterinary_survey_of_medicinal_plants_used_to_treat_cattle_diseases_in_Birishiri_area_Netrakona_district_Bangladesh

Heering J. H. (1995). Botanical and agronomic evaluation of a collection of *Sesbania sesban* and related perennial species [Thesis, p. 124. Wageningen Agricultural University, Wageningen, The Netherlands.]. https://library.wur.nl/WebQuery/wurpubs/29941

Heuzé V., Tran G., & Bastianelli D. (2016). *Sesban (Sesbania Sesban).* Feedipedia, a Programme by INRA, CIRAD, AFZ and FAO. https://www.feedipedia.org/node/253

Ibrahim A. M. (1992). Anthelmintic Activity of some Sudanese Medicinal Plants. *Phytotherapy Research*, *6*, 155–157. https://doi.org/10.1002/ptr.2650060312

INRA Institut National de la Recherche Agronomique National Institute of Agronomic Research. (2019). Maroc : Premier Forum international sur l 'agriculture biosaline à Laâyoune. Des exemples réussis de cultures résilientes en milieu salin. Institut National de La Recherche Agronomique INRA, Maroc. https://www.inra.org.ma/fr/content/05052019-des-exemples-réussis-de-cultures- résilientes-en-milieu-salin-à-foum-el-oued. http://agripeche.com/4239-maroc- premier-forum-international-sur-lagriculture-biosaline-a-laayoune.html

IPNI International Plant Names Index. (2020). *Sesbania tchadica* A.Chev. International Plant Names Index Collaborators (2019). Checklist Dataset. https://www.ipni.org/n/urn:lsid:ipni.org:names:518546-1

Jamnadass Ramni, Hanson, J., Poole, J., Hanotte, O., Simons, T. J., & Dawson, I. K. (2005). High differentiation among populations of the woody legume *Sesbania sesban* in sub-Saharan Africa : Implications for conservation and cultivation during germplasm introduction into agroforestry systems. *Forest Ecology and Management*, *210*, 225–238. https://doi.org/10.1016/j.foreco.2005.02.033

Jean César and Cyrille Chatelain. (2019). Flore illustrée du Tchad. *Conservatoire et Jardin botaniques de la Ville de Genève en co-*

édition avec l'Université de N'Djaména et la Coopération Suisse au Tchad, p. 387. https://www.researchgate.net/publication/334113080_Flore_illustree_du_Tchad. https://www.researchgate.net/publication/334113080_Flore_illustree_du_Tchad

Kaitho, R. J. (1997). Nutritive value of browses as protein supplement to poor quality roughages [Thesis, p. 196. Landbouw Universiteit Wageningen. - With réf. - With summary in Dutch. ISBN90-5485-735-8]. https://core.ac.uk/download/pdf/29327941.pdf

Kathiresh M., Devi, P. S., & M.Saravanakumar. (2012). Bioactive compounds in *Sesbania sesban* flower and its antioxidant and antimicrobial activity. *Journal of Pharmacy Research*, *5*(1), 390–293. https://jprsolutions.info/article_detail.php?article_id=1430

Khare C. P. (2007). Indian Medicinal Plants:An Illustrated Dictionary. p. 900. Springer-Verlag New York. https://doi.org/10.1007/978-0-387-70638-2_7

Kiptot Evelyne, Franzel, S., & Degrande, A. (2014). Gender, agroforestry and food security in Africa. *Current Opinion in Environmental Sustainability*, *6*(1), 104–109. https://doi.org/10.1016/j.cosust.2013.10.019

Kwesiga F. R., Franzel, S., Place, F., Phiri, D., & Simwanza, C. P. (1999). *Sesbania sesban* improved fallows in eastern Zambia: Their inception, development and farmer enthusiasm. *Agroforestry Systems*, *47*(1–3), 49–66. https://doi.org/10.1023/a:1006256323647

Lahdachi F. Z., N., L., Jamal I., And, & Faouzia M. (2015). Aperçu sur les *Acacias* spontanés et introduits au Maroc. *European Scientific Journal*, *11*(23), 88–102. https://www.researchgate.net/publication/282217944_APERCU_SUR_LES_ACACIAS_SPONTANES_ET_INTRODUITS_AU_MAROC

Léonard Joseph Jean. (1968). Expédition au Lac Tchad : Expédition nationale belge Horti-Botanique au Tchad (entre Djimtilo et le Lac Tchad), branche nord-est du delta.

Li, L., Yang, T., Liu, R., Redden, B., Maalouf, F., & Zong, X. (2017). Food legume production in China. *Crop Journal*, *5*(2), 115–126. https://doi.org/10.1016/j.cj.2016.06.001

Mall T. P. and Kisan P. G. (2003). Virus diseases of dhaincha *Sesbania aculeata* Pers. *Journal Liv- World India*, *10*(2), 16–19. https://www.researchgate.net/publication/327466758%0AVirus

Mani R.P., Awanish, P., Shambaditya, G., Poonam, T., Kumudhavalli, V., & Ajay Pratap, S. (2011). Phytochemical Screening and In-vitro Evaluation of Antioxidant Activity and Antimicrobial Activity of the Leaves of *Sesbania sesban* (L) Merr. *Free Radicals and Antioxidants*, *1*(3), 66–69. https://doi.org/10.5530/ax.2011.3.9

Maria Vittoria Conti, Guzzetti, L., Panzeri, D., De Giuseppe, R., Coccetti, P., Labra, M., & Cena, H. (2021). Bioactive compounds in legumes: Implications for sustainable nutrition and health in the elderly population. *Trends in Food Science and Technology*. https://doi.org/10.1016/j.tifs.2021.02.072

Mekoya A., Oosting, S. J., Fernandez-Rivera, S., Tamminga, S., & Van der Zijpp, A. J. (2009). Effect of supplementation of *Sesbania sesban* to lactating ewes on milk yield and growth rate of lambs. *Livestock Science*, *121*(1), 126–131. https://doi.org/10.1016/j.livsci.2008.06.002

Mmoudiongh A., & Rinaudoe, G. (1985). Fixation d'azote par *Sesbania rostrata* : son utilisation comme engrais vert. *Bulletin de Recherche Agronomique. Gembloux*, *20*(3/4), 833–849. http://horizon.documentation.ird.fr/exl-doc/pleins_textes/pleins_textes_7/b_fdi_59-60/010026661.pdf

Mohammed Abbas, Monib, M., Rammah, A., Fayez, M., & Hegazi, N. (2001). Intercropping of *sesbania (Sesbania sesban)* and *leucaena* (*Leucaena leucocephala*) with five annual grasses under semi-arid conditions as affected by inoculation with specific rhizobia and associative diazotrophs. *Agronomie*, *21*(6–7), 517–525. https://doi.org/10.1051/agro:2001141

Mohammed Rahmatullah, Mollik, M. A. H., Alam, M. J., Ahmmed, B., Jahan, F. I., Mariz, S., Himel Nahreen Khaleque, Majeedul H. Chowdhury, F. A. N., Rahman, S., Jahan, R., & Sera, S. (2010). An Ethnoveterinary Survey of Medicinal Plants Used by Folk Medicinal Practitioners to Treat Cattle Diseases in Randomly Selected Areas of Bagerhat District, Bangladesh. *American-Eurasian Journal of Sustainable Agriculture*, *C*(C), CC–CC. https://www.academia.edu/5776667/An_Ethnoveterinary_Survey_of_Medicinal_Plan_ts_Used_by_Folk_Medicinal_Practitioners_to_Treat_Cattle_Diseases_in_Randomly_Select_ed_Areas_of_Bagerhat_District_Bangladesh

Moyo MacK, Aremu, A. O., & Van Staden, J. (2015). Medicinal plants: An invaluable, dwindling resource in sub-Saharan Africa. *Journal of Ethnopharmacology*, *174*, 595–606. https://doi.org/10.1016/j.jep.2015.04.034

Muimba-Kankolongo, A. (2018). Root and Tuber Crops. In *Food Crop Production by Smallholder Farmers in Southern Africa* (pp. 123–172). Academic Press. https://doi.org/10.1016/b978-0-12-814383-4.00009-8

Naik N. N., Tare H. L., Sherikar A .K., Deore S.R., & Dama G.Y. (2011). Central Nervous System Stimulant Effect of Extracts Obtained From the Barks of *Sesbania Sesban*. *International Journal of Institutional Pharmacy and Life Sciences*, *1*(1), 77–92. http://www.ijipls.com/uploaded/journal_files/110715110700.pdf

Nair Ramachandran P.K. (1993). An Introduction to Agroforestry. p. 489. Kluwer Academic Publishers, Dordrecht, The Netherlands. https://doi.org/10.1177/003072709402300413

Ndoye I., & Dreyfus B. (1988). N2 fixation by *Sesbania rostrata* and *Sesbania sesban* estimated using 15N and total N difference methods. *Soil Biology and Biochemistry*, *20*(2), 209–213. https://doi.org/10.1016/0038-0717(88)90038-7

Ndoye I., Dreyfus B., & M., B. (1996). *Sesbania rostrata* as green manure for lowland rice in Casamance (Senegal). *Tropical Agriculture (Trinidad)*, *73*(3), 234–237. https://www.researchgate.net/publication/32971749

Ndungu J. N. and Boland D. (1994). *Sesbania* seed collections in Southern Africa Developing a model for collaboration between a CGIAR Centre and NARS. *Agroforestry Systems*, *27*, 129–143. https://doi.org/10.1007/BF00705470

NifTAL Nitrogen Fixation for Tropical Agricultural Legumes (NifTAL) Project. USA. (1985). *Legume inoculants and their use. A Pocket Manual* (Food and Agriculture Organization of the United Nations (ed.)). Food & Agriculture Org. https://www.worldcat.org/title/legume-inoculants-and-their-use-a-pocket-manual/oclc/1131330060

Nigussie Zerihun, & Getachew Alemayehu. (2013). *Sesbania sesban* (L.) Merrill: Potential uses of an underutilized multipurpose tree in Ethiopia. *African Journal of Plant Science*, *7*(10), 468–475. https://doi.org/10.5897/AJPS2012.0716

Nilanjana Das, Chandran, P., & Chakraborty, S. (2011). Potent spermicidal effect of oleanolic acid 3-beta-d-glucuronide, an active principle isolated from the plant *Sesbania sesban* Merrill. *Contraception*, *83*(2), 167–175. https://doi.org/10.1016/j.contraception.2010.05.009

Nirmal S. A., Bairagi, J. H., Patil, A. N., Pal, S. C., Upasani, C. D., & Mandal, S. C. (2012). Antinociceptive activity of *Sesbania sesban* (Linn) wood extracts, a preliminary study. *Indian Journal of Experimental Biology*, *50*(1), 61–64.

Nwilo P. C., Olayinka, D. N., Okolie, C. J., Emmanuel, E. I., Orji, M. J., & Daramola, O. E. (2020). Impacts of land cover changes on desertification in northern Nigeria and implications on the Lake Chad Basin. *Journal of Arid Environments*, *181*(March), 104190. https://doi.org/10.1016/j.jaridenv.2020.104190

Orwa C., Mutua, A., R, K., Jamnadass R, & S Anthony. (2009). Agroforestree Database:a tree reference and selection guide version 4.0: *Sesbania sesban* (L.) Merr. Fabaceae - Papilionoideae. In *Agroforestry Database*. http://www.worldagroforestry.org/sites/treedbs/treedatabases.asp

Pandhare Ramdas B., Sangameswaran B., B., M. P., & G., K. S. (2011). Antidiabetic activity of aqueous leaves extract of *Sesbania sesban* (L) Merr. in streptozotocin induced diabetic rats. *Avicenna Journal of Medical Biotechnology*, *3*(1), 37–43. https://doi.org/10.1093/neuonc/nos096

Patra A. K., Chhonkar P. K., & Khan M. A. (2006). Effect of green manure *Sesbania sesban* and nitrification inhibitor encapsulated calcium carbide (ECC) on soil mineral-N , enzyme activity and nitrifying organisms in a rice – wheat cropping system. *European Journal of Soil Biology*, *42*, 173–180. https://doi.org/10.1016/j.ejsobi.2005.12.007

Patrice Jullien de Pommerol. (1997). L'arabe tchadien : émergence d'une langue véhiculaire. Karthala Éditions, coll. « Dictionnaires et langues », France. p. 174. https://www.amazon.fr/Livres-Patrice-Jullien-de-Pommerol/s?rh=n%3A301061%2Cp_27%3APatrice+Jullien+de+Pommerol%0AAffiner

Polak, R., Phillips, E. M., & Campbell, A. (2015). Legumes: Health Benefits and Culinary Approaches to Increase Intake. *Clin Diabetes*, *33*(4), 198–205. https://doi.org/10.2337/diaclin.33.4.198

Ribeiro J. H.C., Fonseca, C. R., & Carvalho, F. A. (2017). The woody vegetation of quartzite soils in a mountain landscape in the atlantic forest domain (south-eastern Brazil): Structure, diversity and implications for conservation. *Edinburgh Journal of Botany*, *74*(1), 15–32. https://doi.org/10.1017/S096042861600024X

Richard White, & and International Legume Database and Information Service. (2018). *Sesbania sesban* (L.) Merr. International Legume Database and Information Service (ILDIS). https://ildis.org/cgi-bin/Araneus.pl?version~10.01&LegumeWeb&tno~1556&genus~Sesbania&species~sesban

Robert J Van der Plas, & Mahamat Ali Abdel-Hamid. (2005). Can the woodfuel supply in sub-Saharan Africa be sustainable? The case of N'Djaména, Chad. *Energy Policy*, *33*(3), 297–306. https://doi.org/10.1016/j.enpol.2003.08.001

Rochester I. J., Peoples, M. B., Hulugalle, N. R., Gault, R. R., & Constable, G. A. (2001). Using legumes to enhance nitrogen fertility and improve soil condition in cotton cropping systems. *Field Crops Research*, *70*(1), 27–41. https://doi.org/10.1016/S0378-4290(00)00151-9

Roothaert R. L., & Paterson R. T. (1997). Recent work on the production and utilization of tree fodder in East Africa. *Animal Feed Science and Technology*, *69*(1–3), 39–51. https://doi.org/10.1016/S0377-8401(97)81621-5

Rukangira Ernest. (2001). Medicinal Plants and Traditional Medicine in Africa: Constraints and Challenges. *Conserve Africa International, Sustainable Development International*, 179–184. https://www.semanticscholar.org/paper/Medicinal-Plants-and-Traditional-Medicine-in-Africa/7b6f7ffe3a8fb509450ab0c52500f6dc36f72667

Samajdar Saptarshi, & Ghosh Amiya Kr. (2017). Pharmacological effects of *Sesbania sesban* Linn : An overview. *PharmaTutor*, *5*(7), 16–21. https://www.pharmatutor.org/articles/magazines/articles/july-2017/pharmacological-effects-of-sesbaniasesbanlinn-an-overview

Semba, R. D., Ramsing, R., Rahman, N., Kraemer, K., & Bloem, M. W. (2021). Legumes as a sustainable source of protein in human diets. *Global Food Security*, *28*, 100520. https://doi.org/10.1016/j.gfs.2021.100520

Shaikh Sajid R., Vijay Pawar T., & Md. Rageeb Md. Usman. (2012). Anti-Inflammatory activity of *Sesbania sesban* (L) Merr. *International Research Journal of Pharmacy*, *3*(1), 176–180. https://pdfs.semanticscholar.org/1822/c44801e7e849685ddf3ce9310e702cc91d5d.pdf

Sharma Radhey Shyam, Asif Mohmmed, Mishra, V., & Cherukuri Raghavendra Babu. (2005). Diversity in a promiscuous group of rhizobia from three *Sesbania* spp. colonizing ecologically distinct habitats of the semi-arid Delhi region. *Research in Microbiology*, *156*(1), 57–67. https://doi.org/10.1016/j.resmic.2004.08.009

Shiv Pal Singh. (1990). Fertility Control of Female through *Sesbani Sesbian* Seeds. *Journal of Research and Education in Indian Medicine*, *9*(4), 27–32. https://pdfs.semanticscholar.org/.../1ce2e6e2570d7d0d42eace6065...%0A

Shun-ching Lee. (1960). The Study on the effect of light to the development and growth of *Sesbania Sesban* (Merr.). *Taiwania Journal. National Taiwan University & Biodiversity Association of Taiwan*, *7*(1), 9–15. https://doi.org/10.6165/tai.1960.7.9

Siaw, D. E. K. A., Osuji, P. O., & Nsahlai, L. V. (1993). Evaluation of multipurpose tree germplasm the use of gas production and rumen degradation characteristics. *The Journal of Agricultural Science*, *120*(3), 319–330. https://doi.org/10.1017/S0021859600076486

Sileshi G. W., Akinnifesi, F. K., Ajayi, O. C., & Place, F. (2008). Meta-analysis of maize yield response to woody and herbaceous legumes in sub-Saharan Africa. *Plant and Soil*, *307*(1–2), 1–19. https://doi.org/10.1007/s11104-008-9547-y

Sileshi G. W., Mafongoya, P. L., Akinnifesi, F. K., Phiri, E., Chirwa, P., Beedy, T., Makumba, W., Nyamadzawo, G., Njoloma, J., Wuta, M., Nyamugafata, P., & Jiri, O. (2014). Agroforestry: Fertilizer Trees. *Encyclopedia of Agriculture and Food Systems*, *1*, 222–234. https://doi.org/10.1016/B978-0-444-52512-3.00022-X

Sileshi W. Gudeta, Debusho L. K., & Akinnifesi Festus K. (2012). Can integration of legume trees increase yield stability in rain-fed maize cropping systems in Southern Africa ? *Agronomy Journal*, *104*(5), 1–21. https://doi.org/10.2134/agronj2012.0063

Singh S., Ladha, J. K., Gupta, R. K., Bhushan, L., Rao, A. N., Sivaprasad, B., & Singh, P. P. (2007). Evaluation of mulching, intercropping with *Sesbania* and herbicide use for weed management in dry-seeded rice (*Oryza sativa* L.). *Crop Protection*, *26*(4), 518–524. https://doi.org/10.1016/j.cropro.2006.04.024

Sobere Augustin Traore. (1991). Contribution à l'étude de la nodulation de tige par rhizobium chez une légumineuse aquatique, *Sesbania pubescens.* [p. 98. Maitrise en Sciences Agronomique. Faculté des Sciences et Techniques, département de Biologie Végétale, Bibliothèque Numérique, Université Cheikh Anta Diop Dakar, Sénégal.]. http://horizon.documentation.ird.fr/exl-doc/pleins_textes/doc34-01/38223.pdf

Sontosh Chanda C., A. K. M. Azad-ud-doula Prodhan, & A. K. M. Golam Sarwar. (2017). Screening of *Sesbania* accessions based on early biomass yield. *Journal of Bangladesh Agricultural University*, *15*(2), 188–192. https://doi.org/10.3329/jbau.v15i2.xxxxx

Tatiya Anil U., Dande, P. R., Mutha, R. E., & Surana, S. J. (2013). Effect of saponins from of *Sesbania sesban* L. (Merr) on acute chronic inflammation in experimental induced animals. *Journal of Bio-Sciences*, *13*(3), 123–130. https://doi.org/10.3923/jbs.2013.123.130

Taugourdeau Simon, Daget, P., Chatelain, C., Mathieu, D., Juanes, X., Huguenin, J., & Ickowicz, A. (2019). FLOTROP, a massive contribution to plant diversity data for open ecosystems in northern tropical Africa. *Scientific Data*, *6*(1), 4–11. https://doi.org/10.1038/s41597-019-0120-8

Toomsan, B., Limpinuntana, V., Jogloy, S., Patanothai, A., Pathak, P., Wani, S. P., & Sahrawat, K. L. (2012). Role of Legumes in Improving Soil Fertility and Increasing Crop Productivity in Northeast Thailand. *In:* Community Watershed Management for Sustainable Intensification in Northeast Thailand. *70-12*. http://oar.icrisat.org/6538/

United Nations. (2021). World City Populations. World City Populations 2021. https://worldpopulationreview.com/world-cities/n-djamena-population

Vidavel et al. (2012). *In :* Samajdar Saptarshi, and Ghosh Amiya Kr. 2017. "Pharmacological Effects of Sesbania Sesban Linn : An Overview.*" PharmaTutor 5 (7): 16–21.* https://www.pharmatutor.org/articles/magazines/articles/july-2017/pharmacological-effects-

World Agroforestry Centre. (2002). *Sesbania sesban*. In *World Agroforestry Centre*. http://www.worldagroforestry.org/treedb/AFTPDFS/Sesbania_sesban.PDF

Zulfiqar Ali, Ashraf, M., Al-Qurainy, F., Salim Khan, M., & Akram, N. A. (2015). Appraising drought tolerance in local accessions of *sesbania* [*Sesbania sesban* (L) Merril.] using biomass production, relative membrane permeability and photosynthetic capacity as selection criteria. *Pakistan Journal of Botany*, *47*(3), 845–850. https://doi.org/10.1109/LCOMM.2018.2798670