Ethnobotanical and biochemical features of Sesbania sesban L. Merr., a nitrogen-fixing plant native to the Republic of Chad

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Ethnobotanical and biochemical features of *Sesbania sesban* L. Merr., a nitrogen-fixing plant native to the Republic of Chad

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Abstract

This study reports on a literature review of the leguminous tree *Sesbania sesban* (L.) Merr, which is found in the N'Djamena region, the Republic of Chad. The study focused on *S. sesban*'s phytochemical features and its use as a medicine and fodder to assist in future evaluations. A literature review using international academic websites, such as Science Direct, Springer, Nature, plant databases, and data from national herbaria was done. *S. sesban* is a perennial shrub or tree that measures 3–4 meters in height. This species is becoming rare in Ndjamena but can be found in some gardens of some institutions in Ndjamena such as the Higher Institute of Educational Sciences (ISSED). The local inhabitants in Chad use the species as medicine, livestock feed, fuel-wood, and for improving soil fertility and repelling desert encroachment. Traditional healers use its leaves to treat breast cancer and edema. *S. sesban* is an essential species native to the Republic of Chad that needs conservation and valorization. Viewing its rarity in N'Djamena today, a strategy of replanting the species in gardens, homes, and fields around Ndjamena and other regions of Chad is recommended.

Key words: Fixing-nitrogen tree, flora of the Republic of Chad, leguminous plants, medicinal plant, N'Djamena, *Sesbania sesban*.

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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 *S. sesban* L. Merr. 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 (Bindraban et *al.* 2012). Nitrogen is commonly the most limiting element in food production and one of the most expensive in fertilizers. This special ability of leguminous crops to work symbiotically with rhizobia to produce nitrogen is becoming increasingly important in world agriculture (Sileshi et *al.* 2014).

Some forage legumes such as *S. sesban* are used in agroforestry systems in tropical regions including Sub-Saharan Africa. They are also used 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 (Kwesiga et *al.,* 1999, Ndungu & Boland 1994, Orwa et *al.* 2009, Sileshi et *al.* 2014).

Leguminous species (including *S. sesban*), also play a great role in reforestation development programs in arid areas, and the fight against desertification (Curasson 1956, Bashan et *al.* 2012, Bindraban et *al.* 2012) They are suitable alone or mixed with other species (Bradbury 1990).

In Africa, many indigenous species such *S. goetzei* Harms*, S. keniensis* J. B. Gillet, *S. rostrata* Bremek & Oberm, and *S. sesban* represent the genus *Sesbania.* These species and particularly *S. sesban,* possess several desirable characteristics that make them suitable for use as multipurpose trees in farming systems (Heering 1995). *S. sesban* is considered suitable to alternate and/or intercrop with other agricultural species. It grows fast and efficiently recycles available nutrients within the system, thus shortening the time required to restore fertility (Dagar & Tewari 2017, Nair 1993).

In Chad, the genera *Sesbania* are represented by many species such as: *S. sesban*, *S. microphylla* Harms ex Phill & Hutch, *S. leptocarpa,* D.C., *S. pachycarpa,* D.C., *S. pubescens* D.C., *S. rostrata* Brem. & Oberm., *S. sesban* (L.) var. *nubica* Chiov., *S. sesban* subsp. *punctata* D.C. & Gillett and *S. dalzielii* E. Phillips & Hutch. (Gaston & Fotuis 1971, Jean & Cyrille 2019). *Sesbania* species found in Chad include *S. sesban*, *S. dalzielii*, *S. rostrata, S. leptocarpa*, *S. sericea* (Willd.) (*S. pubescens* DC), *S. hepperi* J.B.

Gillett, *S. cannabina* (Retz.) Pers., *S. tetraptera* Hochst. ex Baker, *S. pachycarpa* DC, and *S. microphylla* Harms (Jean & Cyrille 2019).

The objective of this paper is to report the use and features of *S. sesban* based on a literature review. Potential uses of the species in Chad and other countries are reported in this paper. For medicinal uses, the paper also provides biochemical evidence supporting the use of this species. This paper contributes updated information concerning this useful but less exploited plant with the purpose to help develop and conserve it in Chad.

Materials and methods

Study area: N'Djamena is the administrative capital and the largest city of Chad. It is located in the center west of the country (Fig. 1), at the confluence of the Chari and Logone rivers. Its population is estimated in 2020 at 1,422,547 inhabitants with an annual growth rate of 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 and 700 mm/year with many heavy showers. In recent years, rain has fallen mainly over a three-month period (July-September). Temperatures observed are between 20°C and 45°C in the dry season and between 18°C and 30°C in the rainy season (FAO 2012).

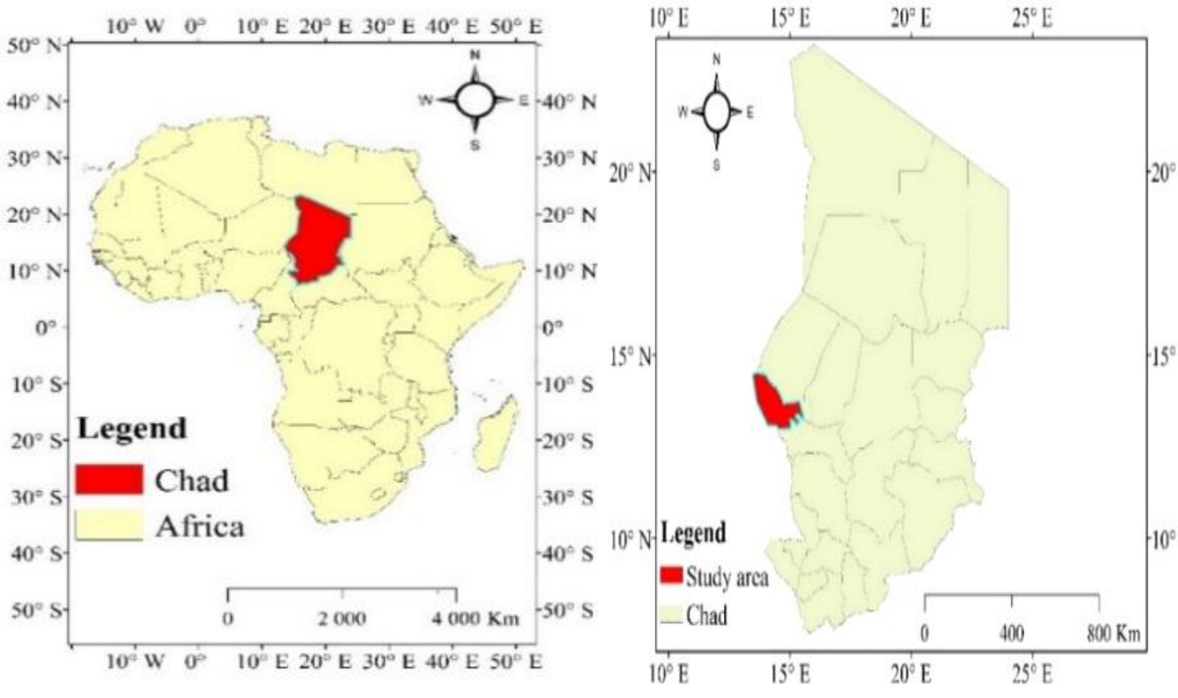

Figure 1. Study area: Map of Chad and N'Djamena area.

The authors conducted a review of the literature on *S. sesban*, its applications, biochemistry, and interactions with other organisms and its environment. Sources for the review included various academic websites such as Science Direct and Springer Nature, some online international plant databases, and data from national herbaria in Chad.

Results

***S. sesban*:** Sesbania is a Persian term and in the Arabic language is Seysaban. 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 *S. Sesban* var. *nubica* Chiov. (Baker, 1926, Ndungu & Boland 1994) or *S. aegyptiaca* auct. (Degefu et *al.,* 2011, Jean & Cyrille 2019). The local names in Chad are Surridj, Surridj, alkoubar, Surridj, addougag (Patrice 1997), and Seysaban (B. Ousman et al., 2017) (unpublished). Table 1 shows the taxonomic classification of *Sesbania sesban*.

Table 1. *S. sesban* taxonomic classification (Gillett 1963, Taugourdeau et *al.,* 2019, IPNI 2020).

S. sesban Merr. (L.)	
Kingdom	Plantae
Division	Magnoliophyta or Angiosperms dicotyledonous (Flowering plants)
Tribe	Robinieae
Classe	Magnoliopsida
Order	Fabales
Family	Fabaceae
Subfamily	Papilionaceae
Gender	*Sesbania*
Species	*S. sesban* Merr. (L.)

Distribution of *S. sesban* in Africa and in Chad: The genus *Sesbania* (Fabaceae or Papilionaceae) consists of about 50 species of fast-growing trees and composed of annual shrubs and perennial woody plants that are widespread in the tropics and subtropics (Jamnadass et *al.* 2005), with a large number of accessions collected (Heering 1995, Abbas et *al.* 2001). Some 33 species are found in Africa, distributed between central and eastern Africa. *S. sesban* is widely distributed in semi-arid to subhumid regions throughout the continent (Degefu et *al.* 2011). It develops in the wild in most geographical zones of Africa and in many different soil types (Abbas et *al.* 2001).

S. sesban is an indigenous species of Chad with a height between four and five meters. As reported by Orwa et *al.* (2009), the other African countries where *Sesbania* sp is found in habitat are Egypt, Kenya, and Uganda (Fig. 2).

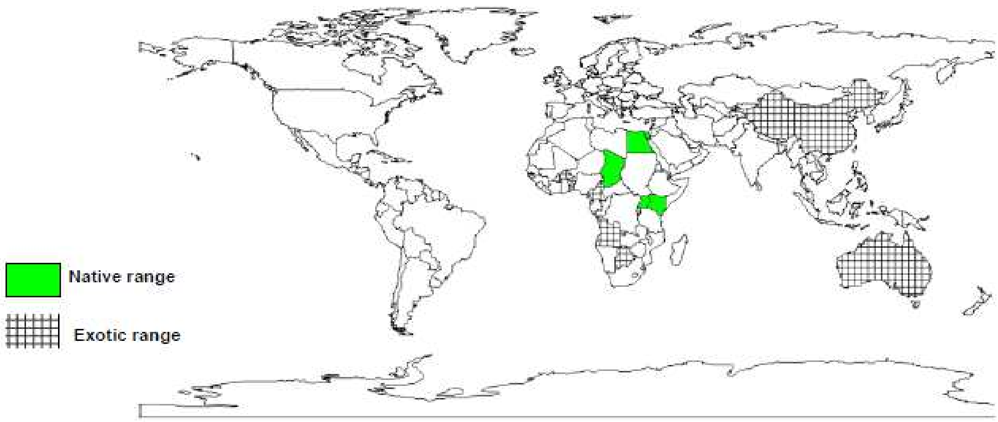

Figure 2. *S. sesban* Merr. (L.) in Chad and other countries (Orwa et *al.* 2009).

In Chad, *Sesbania* species includes *S. sesban* (Fig. 3), *S. microphylla* Harms ex. Phill & Hutch, *S. leptocarpa* D.C., *S. pachycarpa* D.C., *S. pubescens* D.C., *S. rostrata* Brem. & Oberm., *S. sesban* (L.) var. *nubica* Chiov., *S. sesban subsp. punctata* D.C. & Gillett and *S. dalzielii* E. Phillips & Hutch (Gaston & Fotuis 1971*,* Jean & Cyrille 2019). Chad is a centre of diversity for some of these species. However, *Sesbania* species have not been fully exploited as multipurpose plants in many central African countries (Gaston & Fotuis 1971). As reported by Jean & Cyrille (2019), IPNI (2020), *S. sesban* is found in different niches in Chad such as: on riverbanks, in stream beds, wetlands and around the water sources of Borkou and Ennedi (Fig. 3).

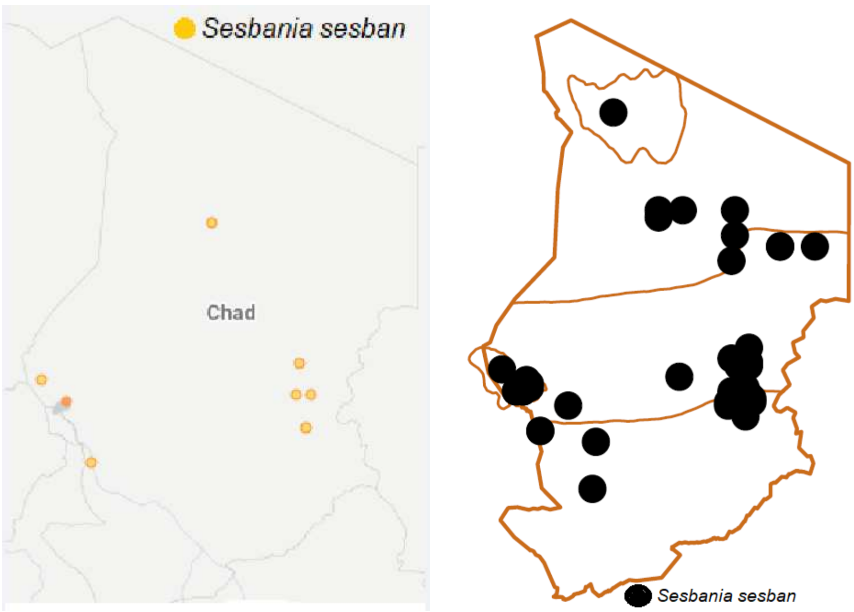

Figure 3. In orange color: zones of Chad where *S.sesban* is found (IPNI 2020, GBIF 2020). In black color: zones of Chad where *S.sesban* is found (Jean & Cyrille 2019).

Habitat and Ecology: Widely adapted, *S. sesban* tolerates drought, waterlogging, soil acidity, alkalinity, and salinity (Daniel 2001). *S. sesban* grows well in the subtropics and in cooler, higher elevation regions of the tropics (Orwa et *al.,* 2009, Partey et *al.* 2017). It 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 in seasonally flooded valley bottoms (Ndungu & Boland, 1994, Jamnadass et *al.* 2005). It also grows in open savannah (George & Gottwald 2009) and dry, semi-arid zones (Abbas et *al.* 2001). It grows in a wide variety of soils from loose, sandy soils to heavy clays (Shaikh et *al.* 2012, Heuzé et *al.* 2016). *S. sesban* has moderate tolerance of frost (Franzel et *al.* 2014). *S. sesban* grows well on acidic and infertile soils in a semi-arid region of Rwanda (Balaisubramanian & Sekayange 1992).

Biophysical limits: The mean annual growing temperature of *S. sesban* is between 18 °C and 23 °C (maximum 45 °C) and the mean annual rainfall is from 500 to 2000 mm (Orwa et *al.* 2009, Franzel et *al.* 2014). Its altitude ranges between 100 and 2500m (Orwa et *al.* 2009, Franzel et *al.* 2014).

Pests and diseases: *Sesbania* spp. is attacked by nematodes, insects, fungi, and viruses (Orwa et *al.* 2009). The leaf-eating beetle *Mesoplatys ochroptera* can completely defoliate *S. sesban* leading to mortality. Various caterpillars, *Hymenoptera*, and stem borers attack *S. sesban.* Some potentially destructive rootknot 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 by sap and roots, 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. The virus inoculated in vitro has a great tolerance of dilution (between 1000-10,000), resistance to heat (40-60°C) and has longevity in vitro varying between 10 and 14 days (Mall & Kisan 2003). Sileshi et *al.* (2000) conducted a survey in Southern Malawi and found that insects *Anoplocnemis curvipes*, *Aphis fabae, Hilda patruelis, Megaleurothrips sjostedti, Mylabris dicincta, Nezara viridula* and *Ootheca* spp. have the potential to become pests of *S. sesban*.

Morphological description: *S. sesban* is a soft, slightly woody, and short-lived shrub or small tree reaching 3-4m tall (Fig. 4a) (Mani et *al.,* 2011; Kathiresh et *al.* 2012 ; Mythili & Ravindhran 2012 ; Tatiya et *al.* 2013;. B. Ousman et *al.,* 2017 (unpublished)). Partey et *al.* (2017) described *S. sesban* as a narrow-crowned, deep-rooting, single or multistemmed shrub or small tree, 1–5 m tall. Shun-ching (1960) reports that in Taiwan, *S. sesban* measures approximately 4-5 meters in height, after six months with a diameter of up to 12 cm. Jean & Cyrille (2019) also mentioned that *S. sesban* is a tall shrub plant measuring 3–4 meters. The average diameter growth measured in basal circumference is ranging from 16-28cm. Branches have opposite pairs in a straight line, with points that look like hairs. There are at least 20 pairs of leaves that cross one by one each 180° from the previous one, and forming a cone that gradually closes (Fig. 4a, 4c) (Jean & Cyrille 2019). These leaves are odd-pinnate with one pair of leaflets at the base having large, irregularly lobed terminal leaflets (Fig. 4a, 4c). The flowers are yellow and are arranged in clusters forming from 2 to 20 flowers and almost 20cm long. The filament sheath is 9-13 mm and yellow-purple speckled, and in rare cases, is pure yellow (Fig. 5). The plant is glabrescent or glabrous (Fig. 4a and Fig. 5) (Gillett 1963, Ndungu & Boland 1994, Jean & Cyrille 2019). Five to seven pods are grouped together in the form of grapes (Fig. 4b). Pods are subcylindrical, light green just after formation, and yellow in color when maturing, straight or slightly curved, up to 30cm long and 5mm wide, containing 10-50 seeds (Fig. 4b) (Jean & Cyrille 2019). A drawing pod and leaves are presented in figure 4c. Soaking the seeds in water for a few days is sometimes required to make them germinate (Gillett1963).

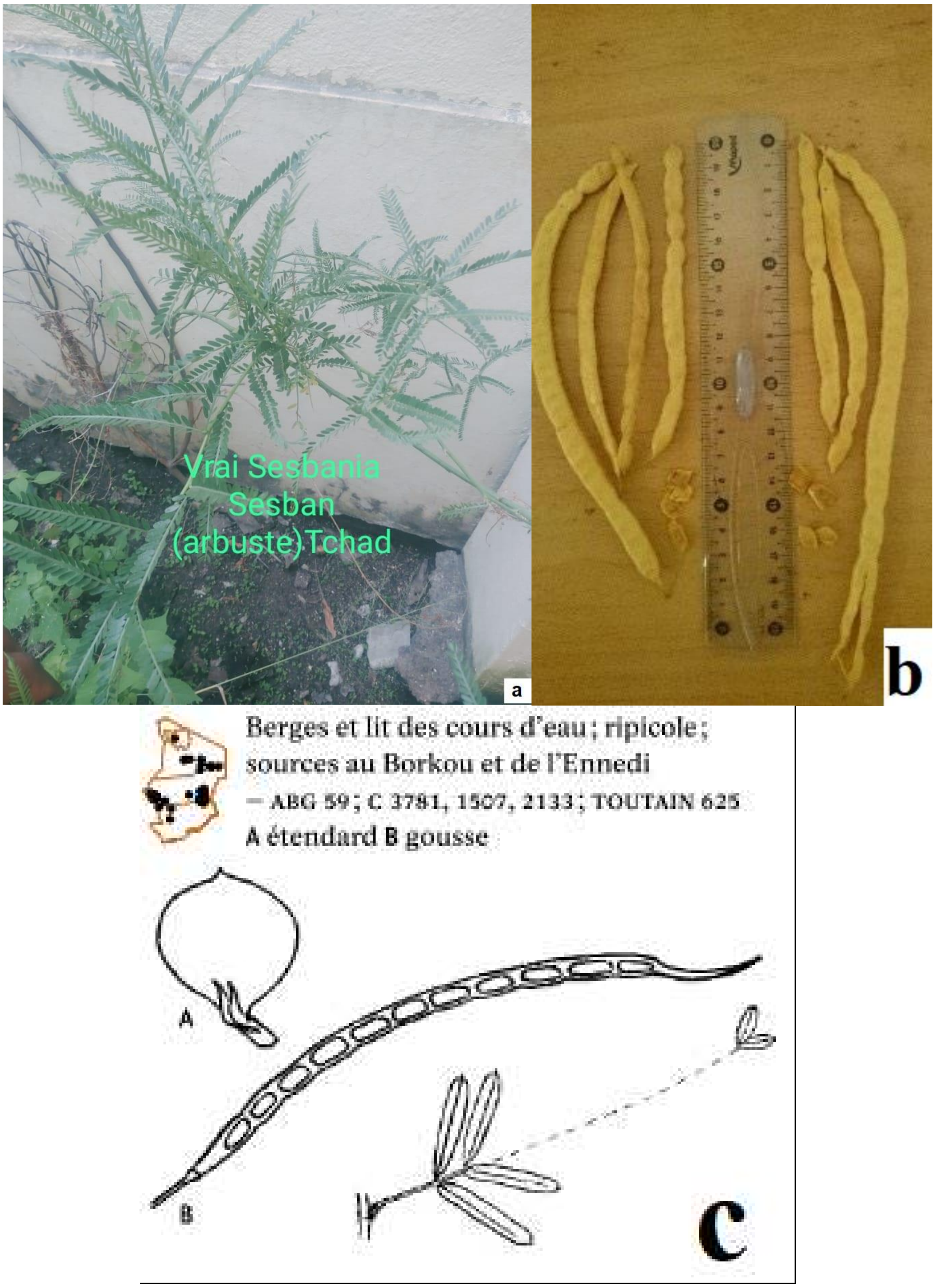

Figure 4. a: *S. sesban*: Shrubs and branches. (Latitude 12° 02' 0'' North Longitude 15° 12' East). **b:** Dry pods. **c:** Drawing of pods and leaves (Jean & Cyrille 2019).

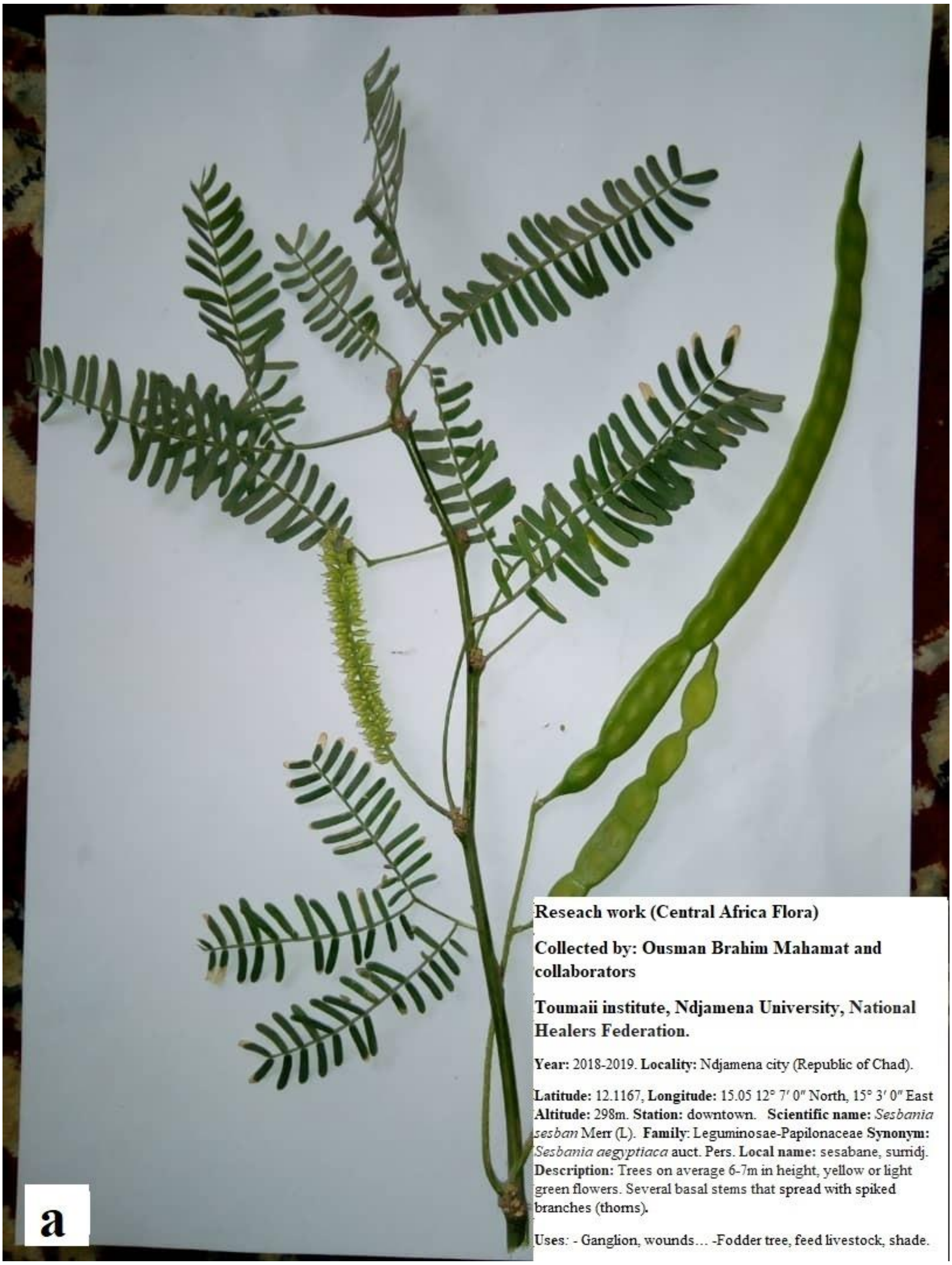

Figure 5. *S. sesban*: leaves, flowers, stem, and fresh pods.

We note that the botanical missions carried out on *S. sesban* date from 1968 by the botanist Léonard (Bijmoer et *al.,* 2022) and from 2019 by the botanists Jean and Cyrille (Jean & Cyrille 2019). Léonard collected this species in the region of Lake Chad (Bijmoer et *al.,* 2022) (Fig. 6).

Figure 6. The figure shows the botanical mission carried out by *S. sesban* in Lake Chad area by Léonard in 1968 (Bijmoer et *al.,* 2022).

Uses of *S. sesban*: In sub-Saharan Africa, the use of plant resources for therapeutic/medicinal, agricultural, and other purposes is common, hence the need for intervention in protecting and enhancing these resources (Moyo et *al.* 2015). The local population in Chad was aware of the importance of the species *S. sesban* and wished to benefit from its use for medicine, for improving land cover and soil fertility for feeding and shading livestock and for wood.

Medicinal uses, ethnobotanical and biochemical features: Table 2 summarizes *S. sesban's* medicinal uses, plant parts used, and ethnobotanical and biochemical features. More detail is provided in the text below. Healers in Chad use the leaves and bark of *S. sesban* alone to treat breast cancer, oedemas and wounds. Breast cancer is treated in traditional medicine by macerating the leaves for 48 hours or an infusion of root and bark. After macerating the leaves, the juice obtained is drunk in the morning and evening. To treat edema and swollen glands, the leaf powder is mixed with oil and then applied to the body. In Chad, traditional healers often sell *S. sesban* formulations from leaves and bark to patients in the form of syrup or powder to treat breast cancer, oedemas and wounds. Healers sold such medicine about 360 times per year, earning an average of $1.74 per sale. Annual revenue thus amounted to about $US 625$/year (B. Ousman et *al.* 2017) (unpublished).

Numerous studies across the world have shown that *S. sesban* has considerable potential for combatting disease and improving health. Kamel et *al.* (2011) reported that the administration of *S. sesban* leaves" methanol extract to infected mice exhibited a moderate antischistosomal effect (against the parasite *Schistosoma mansoni* which infected mice). The results suggest that the administration of *S. sesban* has antischistosomal properties, hence ameliorating liver function.

Manjusha et *al.* (2012) found that *S. sesban* may have a hypoglycaemic potential for treating type 2- diabetes. Their results show that the doses (250, 500, and 1000mg/kg) of *S. sesban* administered orally to normal and streptozotocin (STZ) induced type- 2 diabetic mice caused a marked decrease of fasting blood glucose in STZ induced type -2 diabetic mice. *S. sesban* decreased the cholesterol, triglyceride, urea, and creatinine levels and increased insulin, high density lipoproteins, cholesterol, and total protein levels.

Mani et *al.* (2011) evaluated *the in vitro* antioxidant and antimicrobial activities of *S. sesban* leaves" ethanolic extracts. The phytochemical screening reports the presence of saponins, tannins, phenolic compounds, and flavonoids. The antioxidant activity of ethanolic extracts was demonstrated by the DPPH (Diphenyl -2-Picryl hydrazyl) radical scavenging test, which shows a remarkable scavenging activity depending on the dose. The reducing capacity increased with the increasing concentration of the sample. When the 100µg/ml ethanol extract was found, the active free radical scavenging activity increased from 16.71% (20mg/ml) to 76.25% (100 mg/ml). This reducing power serves as a significant indicator of antioxidant activity.

Kathiresh et *al.* (2012) found further evidence of *S. sesban*'s antimicrobial activity. They extracted anthocyanin compounds, total phenol, and flavonoids from *Sesbania sesban* flower petals using methanol and acidified methanol extracts. The anthocyanins content confirmed by ferric chloride and aluminium chloride tests were used to analyze the antioxidant and antimicrobial properties. The total anthocyanin content obtained from the methanol and acidified methanol extracts were

0.38mg/100g and 0.28mg/100g respectively. The antioxidant activity of acidified methanol extracts using the hydrogen peroxide test showed high scavenging activity of 84% at lower concentration (1mg) along with the standard butylated hydroxytoluene (37.65%). The antimicrobial property of *S. sesban* flower extract was explained by the zone of inhibition occurring around the wells containing different concentrating of the extracts. This antimicrobial activity of the samples showed that the zone of inhibition was found in Gram-positive bacteria (*Staphylococcus aureus* (1mg) and *Staphylococcus saprophyticus* (12.5mg)) whereas there were no inhibition in Gram-negative bacteria.

Ahmed et *al.* (2013) found further evidence of *S. sesban'*s antimicrobial features, justifying the use of its bark to treat a number of ailments in Bangladesh. They investigated the phytochemical screening of ethanol, ether and chloroform extract of the plants" bark and found the presence of carbohydrates, flavonoids, steroids, alkaloids, tannins and saponins. The antimicrobial assay showed that the chloroform extract (both 250µg/ml and 500µg/ml) and the ethanol extract (500µg/ml) of *S. sesban* bark inhibited all bacteria. In a disk diffusion assay, 250µg/ml of the ethanol extract of bark inhibited all microorganisms except *Proteus vulgaris* and *Enterococcus faecalis* and the ether extracts (both 250µg/ml and 500µg/ml) of *S. sesban* bark inhibited all microorganisms except *Proteus vulgaris*. The highest zone of inhibition was 14.2 mm against *Fusarium oxysporum*. Minimum inhibitory concentration (MIC) of these extracts was determinated by broth macro dilution assay. The MIC of the extracts (ethanol, ether, and chloroform) was obtained at a higher concentration (8000µg/ml) than the extract content in the disc (250µg/ml and 500µg/ml). The cytotoxicity activity was investigated by the brine shrimp lethality bioassay to determine the percent mortality nauplii caused by the test extracts. The LC_{50} (lethal concentration in half) values of ethanol, ether, and chloroform extracts of bark were found to be 1280, 640, and 320µg/ml, respectively.

In India, many people use *S. sesban* leaves to relieve rheumatic pain and the biochemical evidence supporting this is clear (Tatiya et *al.* 2013). Crude saponins (containing triterpenoids and steroids) extracted from *S. sesban* leaves showed an anti-inflammatory effect on experimental-induced rats and mice (Tatiya et *al.* 2013). Rats pretreated with saponins significantly decreased ($p<0.01$) the carrageenan-induced paw edema by 59% at a higher dose of 500 mg/kg, 3h after the injection of noxious agent. Rats pretreated with saponins significantly inhibited ($p<0.01$) the histamine induced rat paw edema by 38.41 and 43.02% at the dose of 250 and 500mg/kg, respectively. The test of cotton pellet granuloma in rats showed that saponins (500 mg/kg) inhibited the formation of fibroblast by 38.17% which was comparable with that of standard diclofenac sodium (44.32%). In the oxazolone induced delayed hypersensitivity test, saponins (500mg/kg) showed maximum inhibition (69.68% after 22days) of ear edema comparable to the standard drug which gave 73% inhibition after 22 days. Saponins therefore showed significant activity in the acute phase of inflammation in the *in vivo* and *in vitro* model at the oral dose of 500mg/kg body rat‟s weight when compared to the control and standard drug.

Similarly, Shaikh et *al.* (2012) evaluated the anti-inflammatory activity of *S. sesban* leaf extracts. They obtained the extracts after a preliminary phytochemical investigation which showed the presence of the following active principles:

--- Methanol: Sterols, saponins, flavonoids,

--- Petroleum ether (60-80°): Fats and oil.

--- Chloroform: Sterols, alkaloids, and flavonoids.

The methanolic extract showed a significant reduction in paw edema (the dose of 250mg/kg administrated reduced 45.34% of the reduction within three hours) compared to the control group, whereas petroleum ether (60-80°) extract and chloroform extract showed comparatively less reduction in paw edema volume.

Ibrahim (1992) examined the anthelmintic activity in vitro of *S. sesban* leaves (aqueous extract (0.25-50mg/ml) using the free-living rhabditid nematode, *Cuenorhabditis elegans*. A considerable amount of anthelmintic activity was demonstrated by extracts of *S. sesban* leaves (2.5 mg/ml) when the percentage mortality of *Cuenorhabditis elegans* nematodes was 30% and 96% after 2h and 6h treatments, respectively. Seed extracts introduced a percentage mortality of 5.6-25.5% at concentration levels of 0.25-50mg/ml. Ibrahim (1992) concluded that *S. sesban* showed the highest anthelmintic effect upon *Cuenorhabditis elegans* survival at concentration levels 2.5 mg/mL, and the median lethal concentration LC_{50} values of *S. sesban* leaves were the most effective compared to other plant species studied. The LC_{50} attained 8.0 mg/mL at a minimum effective concentration 2.5 mg/ml.

Pandhare et *al.* (2011) evaluated the aqueous leaf extract of *S. sesban* for its antidiabetic potential on normal and streptozotocin (STZ)-induced diabetic rats. The doses of 250 and 500mg/kg body weight per day for 30 days were administered to normal and streptozotocin-induced diabetic rats. The aqueous leaf extract administrated (250 and 500mg/kg/day) to streptozotocin induced diabetic rats (compared to the antidiabetic drug glibenclamide (0.25mg/kg body weight) indicated significant increase in the body weight, liver glycogen, serum insulin and high-density lipoproteins cholesterol levels and decrease in blood glucose, glycosylated haemoglobin, total cholesterol and serum triglycerides. Finally, the study concluded that the aqueous leaf extract of *S. sesban* has beneficial effects in reducing elevated blood glucose levels and the lipid profile of streptozotocin-induced diabetic rats, but has no effect on normal rats.

Indians use the powder of *S. sesban* wood extracts for the treatment of pain. Nirmal et *al.* (2012) investigated wood's antinociceptive agents that are compounds capable of diminishing pain without negative effects on consciousness or without producing anesthesia (Sheikholeslami et *al.* 2016). The anti-nociceptive activity was determinate by hot plate and acetic acid induced tests. Doses were selected on the basis of a toxicity study and mice were divided into 18groups of 6animals each. The experiment was terminated 20seconds after their placement on the hot plate to avoid damage to the paws. Petroleum ether, chloroform, and ethyl acetate extracts (50 and 100mg/kg) showed significant results while their action was blocked by the opioid antagonist, naloxone (1 mg/kg). The involvement of opioid receptors (transmembrane neurotransmitters) was revealed by giving the extracts after an opioid antagonist (naloxone) (1mg/kg). The mechanism of the analgesic effect of the extracts of *S. sesban* wood could probably be due to blockage of the effect or release of endogenous substances that excite pain nerve endings (Nirmal et *al.* 2012). They concluded that petroleum ether, chloroform, and ethyl acetate extracts of wood showed potent antinociceptive activity while naloxone blocked the antinociceptive activity of the extracts by inducing opioid receptors.

The aqueous extract of *S. sesban* bark has a potential central nervous system (CNS) stimulant effect (Naik et *al.* 2011). The investigation of CNS stimulant activity was carried out on albino mice and caffeine was used as a reference drug. The animals receiving the treatment were divided into three groups: Group I (served as control and treated orally with vehicle (normal saline), Group II served as standard, and caffeine 30mg/kg was given, and Group III received aqueous extract of *S. sesban* bark 400mg/kg. In the elevated plus maze experiment, the animals received the treatment 45min before the start of session. At the beginning of the session, a mouse was placed at the centre of the maze, its head facing the closed arm. It was allowed to explore the maze for 5 minutes. The time spent in the open arms, percent entries in the open and closed arms, and total entries were recorded. An entry was defined as the presence of all four paws in the arm. Naik et *al.* (2011) concluded that the crude aqueous extract showed significant central nervous system CNS stimulant activity in comparison to the control group and the results were comparable to the activity shown by the reference drug.

Other studies suggest that *S. sesban* may have potential as an ingredient of contraceptives. Shiv (1990) studied the effect of *S. sesban* seed powder in female albino rats to evaluate its effects on genital organs and fertility. In the results, rats of the control group did not show any change in body weight and genital organ weight. The dose 100mg/kg for 30 days of administration caused no deleterious effect on ovarian tissues, whereas the 250mg/kg dose severally affected the ovarian structure, mature follicles underwent atresia, some developing follicles showed lysis of ova, the stroma was compact with poor vascularity. However, the genital organ weight was reduced significantly ($P<0.05$) after the treatment at 250 and 400 mg/kg doses for 30days. The dose 250mg/kg reduced endometrial height and size of the uterine glands. The administration of 400mg/kg for 30days caused a great reduction in endometrial height, uterine glands. The control group of rats showed normal fertility; all became pregnant and showed a good number of implants, whereas the dose 100mg/kg dose showed pregnancy and reduction of implants. The doses 250 and 400mg/kg showed 100% antifertility activity and no implants were recorded in the uterus of these rats on the 10th day of pregnancy. The experiment showed that *S. sesban* seed powder inhibits ovarian function, changes the uterine structure, and prevents implantation and, thus, controls the fertility of female albino rats (Shiv 1990).

In another study, Nilanjana et *al.* (2011) isolated from *S. sesban* roots an active principle oleanolic acid 3-beta-D-glucuronide (OAG) which is suggested to have a potent spermicidal activity. In the experiment, the minimum effective concentration of OAG was 50mcg/mL. More than 97% of the OAG-treated sperm lost their hypo-osmotic swelling responsiveness in a dose-dependent manner. The transmission electron microscopy and sperm membrane lipid peroxidation revealed that OAG affected the sperm membrane integrity. All observations in the experiment clearly demonstrated that OAG has very strong antifertility activity and other properties that qualify the agent to serve as an active ingredient of vaginal contraceptives (Nilanjana et *al.* 2011).

Mythili and Ravindhran (2012) observed the presence of alkaloids, flavonoids, phenols, and phytosterols, fixed oil and gum in the phytochemical analysis of methanol and ethanol extracts from *S. sesban* in India. The authors tested the biological screening effects of *S. sesban* methanol stem extract against ten bacterial species and five fungal species. The results showed highly significant activity against the bacteria *Erwinia amylovora* followed by *Escherichia coli*. The fungi *Curvularia lunata* and *Fusarium oxysporum* were inhibited completely by *S. sesban* methanol stem extract. They concluded that the stem extracts of *S. sesban* possess a broad spectrum of activity against common bacterial and fungal diseases in the region of Coimbatore in India.

Other uses of *S. sesban* were reported from Zambia and Sudan. Elegami et *al.* (2001) mentioned that the leaves and fruit of *S. sesban* have antibacterial activity in Sudanese folk medicine. The plant is used there to treat sore throat, gonorrhoea, and syphilis. Chinsembu (2015) reported that the vapour of *S. sesban* leaves obtained from boiling were inhaled and used to cure malaria in Zambia.

S. sesban is also used in treating livestock diseases. Harun-or-Rashid et *al.* (2010) reported that the leaves of *S. sesban* are used in Bangladesh for the treatment of cattle diseases. The leaves are administrated orally to treat the retention of urine of cows, goats, and buffaloes. Similarly, Rahmatullah et *al.* (2010) conducted an ethnoveterinary survey among selected villages of Bagerhat district in Bangladesh and documented that *S. sesban* leaves and stem are used topically to treat pain arising out of pox of cattle. The leaves are dried in sunlight and then spread over the bodies of cows, goats, or buffaloes. At the same time, the bodies of cows, goats, or buffaloes are brushed with stems and leaves (Rahmatullah et *al.* 2010). Samajdar and Ghosh (2017) reported that *S. sesban* leaves are used as mosquito repellent in India for livestock. The preparation method is to wash the bodies of animals with water leaf extracts. The leaf decoction is used for cattle drench to repel tsetse flies in India (Vidavel et *al.* 2012, Samajdar & Ghosh 2017). Table 2 shows the medicinal uses and ethno-botanical and biochemical features of *S. sesban*.

Table 2. Medicinal uses, plant parts used, ethno-botanical, and biochemical features of *S. sesban*.

Type of use, Medicine and biochemical use	**Biochemical activity and Phytochemicals compounds obtained**	**Plant part used and optimal solvents**	**References**
	Antioxidant activity (saponins and flavonoids, anthocyanins)	Leaves, seeds (ethanolic extracts, methanol)	(Mani et *al.* 2011) (Kathiresh et *al.* 2012)
	Anti-microbial activity (anthocyanins)	Flower petals (methanol and acidified methanol)	(Kathiresh et *al.* 2012)
	Antimicrobial and cytotoxic activities (Carbohydrates, flavonoids, steroids,	Bark (ethanol, diethyl ether, chloroform)	(Ahmed et *al.* 2013)

	alkaloids, tannins, saponins)		
	Anti-inflammatory activity (saponins)	Leaves (methanol)	(Tatiya et *al.* 2013) (Shaikh et *al.* 2012)
	Anthelmintic activity (saponins, glycosides)	Leaves, seed (aqueous extracts)	(Ibrahim 1992)
	Antidiabetic activity (triterpenoids, tannins, saponins, glycosides, steroids)	Leaves (aqueous extracts)	(Pandhare et *al.* 2011)
	S. sesban roots extract exhibited significant antihyperglycemic activities in streptozotocin STZ-induced diabetic mice (Phytosterols, fixed oils, fats, saponins, proteins, gums, mucilage and amino acids)	Roots (Petroleum ether extract)	(Manjusha et *al.* 2012)
	Antinociceptive activity (Sterols, triterpenes flavonoids)	Wood (petroleum ether, chloroform, ethyl acetate)	(Nirmal et *al.* 2012)
	Central nervous system stimulant (carbohydrate, alkaloids, phytosterols)	Bark (aqueous extracts)	(Naik et *al.* 2011)
	Control the fertility of female albino rats	Seeds (distilled water)	(Shiv 1990)
	Potent spermicidal activity	Roots (ethylacetate, n-butanol saturated, ethanol,water)	(Nilanjana et *al.*2011)
	Ethno-veterinary use (for cattle)	Leaves, stems	(Harun-or-Rashid et *al.* 2010) (Rahmatullah et *al.* 2010)
	Antimalarial activity	Leaves: Preparation method: The vapour from	(Chinsembu 2015)

		boiling leaves is inhaled	
	Antischistosomal effect against the parasite *Schistosoma mansoni* infected the mice	Leaf powder	(Kamel et *al.* 2011)
	Mosquito repellant	Leaves	(Samajdar & Ghosh 2017) (Vidavel et *al.* 2012)
	Traditional medicine (in Chad)	Breast cancer: Maceration of leaves for 48 hours or infusion of root and bark. Oedema and swollen glands: Leaf powder and oil were applied to the body.	(B. Ousman et *al.* 2017 (unpublished)
	Antischistosomal effect against the parasite *Schistosoma mansoni* infected the mice	Leaf powder	(Kamel et *al.* 2011)
	S. sesban has highly significant antibacterial and antifungal activity	Stem (methanol)	(Mythili & Ravindhran 2012)

Use as feed for livestock and as food for humen: Access to adequate livestock feed is the main constraint limiting livestock productivity in Africa (Baltenweck et *al.* 2020). *S. sesban* is widely used as a feed across the continent, as evidenced in the following examples. In Chad, livestock keepers cut, carries, and feed the leaves to ruminants. The pods are also cut and fed to dairy sheep, goats, and oxen. The leaves and pods are considered as a high-protein fodder to increase milk productivity.

Many studies have been conducted in East Africa to assess animal production characteristics such as growth rates, milk production levels, and fertility when cattle, sheep, and goats were fed tree fodder such as *S. sesban* (Place et *al.* 2009). Place et *al.* (2009) reported that *S. sesban* is considered as a fodder tree and has been widely tested and disseminated in East Africa, although its uptake has not been as significant as that of *Calliandra calothyrsus*. However, in Uganda, *S. sesban* is widely grown. In Ethiopia, among fodder trees, *S. sesban* is the most important planted and is generally grown in home gardens (Franzel et *al.* 2014). Smallholders feed it to goats, sheep, and cows.

Numerous studies confirm *S. sesban's* high feed value. Some studies conducted at the University of Queensland in Australia reported that *S. sesban* was shown to have high nutritive value (28% crude protein) and high dry matter digestibility (86%) (Daniel 2001). Roothaert and Paterson (1997) found in Kenya that *S. sesban* had the highest dry matter digestibility compared to some common fodder tree species such as *Leucaen, leucocephala* and *Calliandra calothyrsus. S. sesban* also had low acid detergent fiber levels and average crude protein content, which gave it a high nutritive value overall. Roothaert and Paterson (1997) also reported on a study in which separate groups of local goats with an average initial age and live weight of 8 months and 8.4kg were allowed to graze daily on the natural ranges for two wet and two dry seasons. They were supplemented at night with sun-dried leaves and small twigs of *S. sesban.* The mean intake was 76g day$_{-1}$ per head and the mean daily live weight gain was 24g day$_{-1}$ per head.

Mekoya et *al.* (2009) conducted a study in the central highlands of Ethiopia on the effect of the supplementation of *S. sesban* on the milk yield of sheep. They concluded that supplementation of *S. sesban* at 30% of the ration (0.98% of their body weight) during lactation improved the milk yield of ewes and the growth rate of lambs compared to supplementation with concentrates. *S. sesban* thus has the potential of increasing milk and meat production of sheep and so it can serve as a substitute ration to commercial concentrates for resource poor farmers (Mekoya et *al.* 2009). Studies conducted by Peters (1988) have shown that the leaves of *S. sesban* from Ethiopia are highly nutritious as the crude protein content of the leaves is high (25% to 30% of dry matter) and they contain little tannin and other polyphenols The authors report that *S. sesban* is a useful source of protein for ruminant diets, and may prove useful to farmers with livestock and the need for improved fodder (Peters 1988). *S. sesban* is not widely consumed by humans, but Bunma and Balslev (2019) reported that there are many uses of *S. sesban* for human food. *S. sesban's* seeds contained 39% of protein. One hundred g of dry seeds contained 29–32g of crude protein, 5–6g of crude lipid, 16g of crude fiber, 18–19g of total starch with 7.2–7.4g of digestible starch, 4.85– 5.95g of total phenols, 1.97–2.02g of tannins, 5.05–5.14g of condensed tannins, 2.35–2.37g of phytate, and 1.26–1.46g of saponins. *S. sesban* can produce up to 20 tons of dry matter per hectare per year. It has a protein content ranging between 35-30%. (Fabian and Zootechnician, 2020).

Use in soil improvement and agriculture: Land degradation and declining soil fertility are critical problems impacting livelihoods in many parts of Africa (Sileshi et *al.* 2014).

In Chad, the local population, particularly pastoralists plant *S. sesban* in arid zones to increase the plant cover, to provide shade for humans and their animals, and to use its wood for construction. The local population also uses the tree to enrich soil fertility for increasing yields of crops such as *Oryza* sativa L., *Zea mays* L., *Sorghum bicolor* L., and to repel desert encroachment in zones with little vegetation (B. Ousman et *al.* 2017) (unpublished). *S. sesban* can play an important role, along with other leguminous species, in land restoration and protection and conservation of indigenous species in Chad (FAO 2012).

In México, Bashan et *al.* (2012) have demonstrated that native leguminous trees such as *S. sesban* are essential to ensure the revegetation of eroded desert lands and restore eroded soil by fixing nitrogen at the southern limit of the Sonoran Desert. These authors have also inoculated *S. sesban* with growth promoting bacteria in agricultural and agroforestry systems. They planted a high density of these leguminous trees in certain areas with severely eroded soil and the result was a remarkable degree of revegetation and more stabilized soil. Samajdar and Ghosh (2017) mentioned that *S. sesban* is appreciated for its nitrogen fixing and as a wind on farms in India. Abbas et *al.* (2001) found in Egypt that *S. sesban* intercropped with some annual grasses (barley, pearl millet, and Rhodes-rye and Sudan-grasses) and inoculated with rhizobia improved the quality and quantity of field forage crops.

Some authors reported on the species'ecological services such as nodulation and its use in intercropping. Nohwar et *al.* (2019) found that *Rhizobia* species isolated from *S. sesban* root nodules growing in different areas of Mumbai, India, have a capacity to adapt in high salinity (up to 20%) zones and have pH tolerance. They claim that these *Rhizobia* species from *S. sesban* are suitable therefore to be used as biofertilizers in unfavourable environmental conditions for legume cropping and could also help to reduce the use of chemical fertilizers. They propose that they could be tested in agricultural fields to exploit their natural benefits. Sobere (1991), Bala et *al.* (2002), Sharma et *al.* (2005) reported in the same way that *Rhizobuim* strains induce root nodules and fix nitrogen from the air in symbiosis with *S. sesban.*

The International Center for Agroforestry Research (ICRAF) is interested in the role of *S. sesban* in improving fallow especially in the savannah woodland region (ICRAF 1992, Ndungu & Boland 1994, Kwesiga et *al.* 1999).

Improved fallows involve planting mainly legume tree/shrub species in rotation with cultivated crops. In Eastern Zambia, Phiri et *al.* (2003) quantified the yield, root zone, soil water balance, and water use efficiency of maize in rotation with 2year *S. sesban* fallow and of continuous maize with and without fertilizer. The authors found that growing *S sesban* in depleted agricultural fields or on fallow land for 2 or 3years and then introducing a hybrid maize crop after the fallow period produced encouraging results. S. *sesban* fallow increased grain yield and dry matter production of subsequent maize per unit amount of water used. Average maize grain yields following *S. sesban* fallow and in continuous maize with and without fertilizer were 3, 6, and 1mg/ha with corresponding water use efficiencies of 4.3, 8.8 and 1.7kg/mm/ha, respectively. *S. sesban* fallow increased the soil water storage in the soil profile and drainage below the maximum crop root zone compared with conventionally tilled non-fertilized maize (Phiri et *al.* 2003). Many farmers in Eastern Province, Zambia, started using *S. sesban* improved fallows in the late 1990s and early 2000s, but the practice declined for a number of reasons including a reduction in extension support and the introduction of fertilizer subsidies (Jacobson & Ham 2020).

Curasson (1956), Rochester et *al.* (2001) reported that *S. sesban* is cultivated in rotation with cotton in Sudan and Australia and it may enhance soil fertility and improve soil conditions. It is sometimes also cultivated in rotation with sugar cane, or alone as a feed for sheep and goats, which consume the leaves and young stems. It is also grown as a hedge (Curasson 1956). *S. sesban* yields are reported to range from 28 to 35 tons/hectare after three years of growth (Curasson 1956). Balaisubramanian and Sekayange (1992) reported on an experiment in a semi-arid site in Rwanda with *S. sesban* grown as a hedge spaced 5 meters apart in cultivation with beans (*Phaseolus vulgaris* L.), sorghum (*Sorghum bicolor* L.), maize (*Zea mays* L.) and sweet potato (*Ipomoea batatas* L.), The produced foliar biomass was 1.78 and 0.59t/hectare respectively for 1983/84 and 1985/86. The wood produced was 0.27 and 0.28 t/hectare for 1983/84 and 1985/86, respectively. In addition, it allowed the production of nutrients for the soil of 25.6 kg of nitrogen/ha, 1.4 kg of phosphate/ha, 14 kg of potassium/ha, 16.2 kg of calcium/ha and 4.4 kg of magnesium/ha, significantly improving soil fertility.

Other studies have found that *S. sesban* improves soil fertility. Bakhoum et *al.* (2018) reported that planting nitrogen-fixing trees such as *S. sesban* were an effective solution for increasing soil productivity. Nigussie and Getachew (2013) reported that *S. sesban* has the ability to restore eroded soil by fixing nitrogen in the soil. Mengistu et *al.* (2002) reported on the use of *S. sesban* as green manure in Ethiopia. *S. sesban* biomass decomposes rapidly due to the soft plant structure and high N content, and it provides nutrients to the soil and other plants. It is used for improvement of fallows, mixed cropping, relay cropping, and biomass transfer (Muimba-Kankolongo 2018a). *S. sesban* helps restore and enhance soil fertility by drawing up nutrients from lower soil layers and then adds nutrients to the soil in a litter fall (Muimba-Kankolongo, 2018a).

Sontosh et *al.* (2017) harvested the biomass of *S. sesban* accessions 20 days after sowing and used it as a green manure crop in a rotation of Rice-Rice-Mustard. They demonstrated that *S. sesban* can be grown and harvested over a very short period and still be useful for adding organic matter to the soil. They also pointed out that the decomposability, organic matter accumulation, and N2-fixing ability of *S. sesban* biomass make it a suitable cultivar for poor nutrient deficit soils.

In intercropping and alley cropping, agricultural crops are grown simultaneously with a long-term tree crop to provide annual income while the tree crop matures. Muimba-Kankolongo (2018b) reported that intercropping sweet potato with *S. sesban* improves yield of the crop. In the same way, intercropping *S. sesban* with rice and annual grasses in semi-arid conditions helps manage weeds and optimize the yield of dry-seeded rice (Abbas et *al.* 2001) (Singh et *al.* (2007). Singh et *al.* (2007) concluded that application of wheat residue mulch at 4t/ha and *S. sesban* intercropped for 30 days were equally effective in controlling weeds associated with dry-seeded rice. Economic analysis showed that *S. sesban* was as effective as mulch in realising higher economic returns for dry-seeded rice yields during 2003 and 2004. Table 3 summarizes the uses of *S. sesban* for soil improvement and in cropping systems.

S. sesban also has considerable potential in saline environments where many plants cannot grow. In southern Morocco, agriculture systems are limited by the lack of water resources and salinization of surface and underground freshwater sources. The National Institute of Agronomic Research (INRA) has become interested in the adaptation of *S. sesban* to saline environments and its contribution to improving food and fodder production in desert or arid areas. INRA scientists have successfully introduced *S. sesban* in a saline environment for these purposes 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 *S. sesban* with salinity-tolerant rhizobia under saline conditions.

Other uses: Fuelwood availability is a key problem throughout Africa and particularly in Chad (Robert & Abdel-Hamid 2005). Robert and Abdel-Hamid (2005) reported that some important forest trees (including *S. sesban*) will continue to be used as fuel wood for quite some time to come in most sub-Saharan cities and the sustainability of supply is questionable. Research conducted by the World Agroforestry Centre (2002) found that *S. sesban* is used in many African countries as a source of fuel and is appreciated because it grows fast, burns well and can be coppiced.

In western Kenya, Swinkels et al. (2002) reported that three-quarters of farmers had *S. sesban* in their cropped fields (mainly maize), and that 20 percent planted it. Its main use was as fuelwood but farmers also appreciated its contribution to soil fertility. Its other uses are as a fiber for ropes and fishing nets, and the seeds produce gum (World Agroforestry Centre (2002). Adelanwa and Tijani (2016) found in Nigeria that the biomass of *S. sesban* can produce wood within just 3-6 months when grown on *Cajanus cajan* (leguminous). *S. sesban* is used as a cooking fuel.

Gupta et *al.* (2011) found that *S. sesban* may enhance the phytoextraction of heavy metals like cadmium (Cd), lead (Pb), and zinc (Zn) from artificially contaminated soil by application of ethylene di-amine tetra-acetic acid (EDTA). They reported that *S. sesban* may enhance chemically by chelate induction, the phytoextraction of the cited heavy metals from the spiked soil through the application of 5mmol EDTA/kg.

Dan and Brix (2009) evaluated the growth responses of *S. sesban* to NH4 (about 70mg/l) and NO3 in a hydroponic culture. They found that *S. sesban* can grow without an external inorganic N supply by fixing atmospheric N2 gas via root nodules. They also found that the addition of external concentrations NH4+ and NO3 alone or mixed at a range of 0, 0.1, 0.2, 0.5, 2, and 5 mM) stimulated the growth of seedlings of *S. sesban*. Resulting relative growth rates range from 0.19/day and 0.21/day. The authors concluded that these characteristics of *S. sesban* concerning N nutrition make it a very useful plant as N2-fixing fallow crop in N-deficient areas and a recommended species for use in constructed wetland systems for the treatment of NH4+ rich waters.

Dan et *al.* (2011) evaluated the potential of using *S. sesban* in constructed wetland systems. *S. Sesban* plants grew well in the vertical flow and horizontal flow systems. The parameters measured such as root elongation rate, shoot elongation rate, leaf production rate, and biomass production were generally high in the two systems. The biomass productions for the experimental periods were 20.2 and 17.2 kg/m2/year for the vertical flow and horizontal flow systems, respectively. Nitrogen content in *S. sesban* biomass was relatively high in general. They concluded that *S. sesban* can be used to treat high-strength wastewater in tropical areas while the species grows well and produces a large amount of nitrogen containing biomass which is used as fodder and for soil amendment (Dan et *al.* 2011).

S. sesban is used also as windbreak, as cover crop, ornamental plants, as fish poisons, and for sticks for construction. It is also used for building huts, making charcoal, and preparing gunpowder (Samajdar & Ghosh 2017, Gillett 1963). Details of the other uses of *S. sesban* discussed in this section are summarized in Table 3.

Table 3. Details uses of *S. sesban* as feed for livestock, food, soil improvement in cropping systems, and others uses.

Type of use	Detail of use	Part used	References
Feed for livestock, food, soil improvem ent and in cropping	Potential of improving traditional sheep husbandry by increasing milk and meat production.	Leaves and young twigs. Whole tree	(Mekoya et *al.* 2009)
	S. sesban has high feed quality		(Franzel et *al.* 2014)
	S. sesban is used as feed for livestock (goats, sheep) and thus contributes to improve food security, income and livelihoods.	Whole tree Leaves and pods	(Daniel 2001) (Place et *al.* 2009) (Franzel et *al.* 2014)
	In Chad, *S. sesban* is planted to increase plant cover, to provide shade for humans and their		(B. Ousman et *al*

systems	animals, to enrich soil fertility for increasing yields of crops		.2017) (unpublished)
	S. sesban is used for human food and their nutrition	Seeds	(Bunma & Balslev 2019)
	S. sesban induces in symbiosis the root nodules *Rhizobuim* strains and fixes nitrogen on the soil	Whole tree Germinated seedlings	(Sobere 1991) (Daniel 2001) (Bala et *al.* 2002) (Sharma et *al.* 2005)
	Rhizobuim bacteria isolated from *S. sesban* root nodules can tolerate high salinity soil (up to 20%) and high pH, which make them suitable to be used as biofertilizers in unfavourable environmental conditions for legumes cropping	Root nodules	(Nohwar et *al.* 2019)
Feed for livestock, food, soil improvement and in cropping systems	*S. sesban* improves fallow systems and enhances agricultural productivity by increasing the yields of maize and sorghum	Whole tree	(Sileshi et al. 2014) (Phiri et *al.* 2003)
	Cultivated in rotation with cotton to enhance nitrogen fertility and improve soil condition	Whole tree	(Curasson 1956) (Rochester et *al.* 2001)
	The foliar biomass production of *S. sesban* allows the production of nutrients nitrogen, phosphorus, calcium, magnesium and potassium when the species is intercropped with *Phaseolus vulgaris* L., *Sorghum bicolor* L., *Zea mays* L., and *Ipomoea batatas* L.	Whole tree Bark, Stems	(Balaisubramanian & Sekayange 1992) (Abbas et *al.* 2001)
	S. sesban accessions are used as green manure crops in short fallow and used as sources of organic matter and nitrogen for improvement of poor, nutrient deficit soils	Seeds accessions Whole tree	(Sontosh et *al.* 2017) (Mengistu et *al.* 2002) (Myers et *al.* 1994)
	Intercropping sweet potato with *S. sesban* improves yield of the crop	Whole tree	(Muimba-Kankolongo 2018b)
	Intercropping of *S. sesban* with rice and annual grasses in semi-arid conditions for managing weeds and optimizing the yield of dry-seeded rice	Whole tree Bark	(Abbas et *al.* 2001) (Singh et *al.* 2007)
	Improved fallows and as herbaceous cover crops	Whole tree	(ICRAF 1992) (Ndungu & Boland 1994) (Kwesiga et *al.* 1999) (Muimba-Kankolongo

			2018a)
	Vegetation covers in desert areas. Increases the fertility and productivity of sandy soil in the desert area	Whole tree	(Ousman et *al.* 2017) (unpublished) (Curasson 1956) (Abbas et *al.* 2001)
	Restore eroded soil by fixing N2	Whole tree	(Bashan et *al.* 2012) (Nigussie & Getachew 2013)
Feed for livestock, food, soil improvement and in cropping systems	*S. sesban* grows in the salt-affected soils and limits the effect of salinity	Whole tree	(Bakhoum et *al.* 2018) (Bala et *al.* 1990)
	S. sesban can tolerate relatively high concentrations of ammoniac ion NH4+ in a hydroponic culture at a range of (0, 0.1, 0.2, 0.5, 2 and 5 mM)		(Dan & Brix 2009)
	S. sesban is used as hedge	Whole tree	(Curasson 1956)
	S. sesban is used as shade. windbreaks, cover crops, ornamental plants, such as fish poisons and sticks for construction	Whole tree	(Samajdar & Ghosh 2017) (Gillett 1963)
	S. sesban biomass is used as firewood for cooking and heating.	Whole tree	(Adelanwa & Tijani 2016) (Muimba-Kankolongo 2018a)
Other uses	*S. sesban* is used as a good source of fuel, as fiber for ropes and fishing nets, and the seeds produce a gum	Stem and thick branches, Bark	(Robert & Abdel-Hamid 2005) (World Agroforestry Centre 2002)
	S. sesban may enhance chemically the phytoextraction of heavy metals (cadmium, lead, and zinc) from the soil, when 5mmol EDTA/kg is applied.	Whole tree	(Gupta et *al.* 2011) (Dan & Brix 2009)
	S. sesban, as an N2-fixing shrub, is used for treatment of polluted water	Whole tree	(Dan et *al.* 2011)

<u>Phytochemical compounds of *S. sesban*:</u> *S. sesban* has different chemical compounds that are, once extracted, very useful for treating diseases and manufacturing drugs, organic or chemical supplements, and antibacterial or antioxidant agents. They are also useful for manufacturing biological manure (Patra et *al.* 2006, Kathiresh et *al.* 2012). Details of phytochemicals compounds combined with different extraction solvents are shown in Table 5.

Table 5: *S. sesban*: different phytochemical compounds, parts used, and their solvent extracts.

Phytochemicals, compounds and parts used of *S. sesban*	**Solvents Extracts**	References
Sterols, saponins, flavonoids. Alkaloids, fats and oil, proteins, sterols, glycoside, vitamins, sesbanins, sesbanimid phosphorus (leaves).	Methanol, Chloroform, Petroleum ether 60-80°	(Shaikh et *al.* 2012)
Triterpenoids, carbohydrates, vitamins, amino acids, proteins, tannins, saponin glycosides steroids (Leaves, seed)	Aqueous extracts	(Pandhare et *al.* 2011) (Ibrahim 1992)
Crude protein and crude fiber (dry matter of leaf)	-	(Siaw 1993) (Kaitho 1997)
Phenolics, anthocyanins, flavonoids (Flowers)	Methanol	(Kathiresh et *al.* 2012)
Cyanidin, delphinidin glucosides (Flowers).	Aqueous extracts	(Khare 2007) (Samajdar & Ghosh 2017)
Steroids, alkaloids. Reducing sugars (carbohydrates), tannins, flavonoids, saponins (bark). Glucose, fructose, erithryrol, arabinitol, myo-inositol (bark).	Ethanol Ether (diethyl ether) Chloroform (95% each one)	(Arif et *al.* 2013) (Samajdar & Ghosh 2017)
Cholesterol, campesterol and beta-sitosterol (pods)	-	(Goswami et *al.* 2016) (Khare 2007)
Alpha-ketoglutaric, oxaloacetic and pyruvic acids (pollen and pollen tubes)	-	(Khare 2007) (Samajdar & Ghosh 2017)
Sterols, triterpenes. Flavonoids (wood)	Petroleum ether and chloroform. Ethyl acetate	(Nirmal et *al.* 2012)
Alkaloids, carbohydrates, proteins, phytosterol,	Methanol and	(Mythili &

phenol, flavonoids, fixed oil and gum (stem and root)	ethanol	Ravindhran 2012)

Conclusion

S. sesban is a leguminous tree native to Chad used to increase crop yields and vegetation in some desert areas. The local population and particularly pastoralists plant it in arid zones to increase the plant cover, to obtain shade for humans and their animals, and to use its wood for construction. The local population also uses *S. sesban* to enrich soil fertility for increasing yields of crops such as rice, maize, and sorghum. The species is used also as a medicinal plant to treat breast cancer, wounds and oedema. However, some important problems exist which threaten *S. sesban* and other leguminous trees in Chad. Robert and Abdel-Hamid (2005) pointed out that around cities such as Ndjamena; the high demand for fuelwood threatens the sustainability of supply. Although, they also explained that this demand for fuelwood does not need to be a problem, and woodfuel can also be an engine of economic growth, particularly in rural areas.

Land degradation, decline of soil fertility and carbon stocks, and reduced availability of fuelwood and livestock feed are key problems in Chad as well as throughout Africa. Nwilo et *al.* (2020) noted that vegetation in northern Nigeria including the region of Lake Chad declined by 49.3% between 1984 and 2016. The causes included agricultural activities such as extensive grazing and annual cropping, deforestation, and variations in climate (Nwilo et *al.* 2020). Excessive exploitation poses risks to the conservation of the whole flora in these and other tropical and subtropical regions (Rukangira 2001, Ribeiro et *al.* 2017). 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). Rukangira (2001) noted that policy makers, other stakeholders, and citizens need to support conservation and help increase awareness of the problem. The collection of plant material and documentation, botanical identification, and preparation of 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). As reported by Mosier et al., (2021) restoring soil fertility on degraded lands to meet food, fuel, and climate security needs perennial cropping systems using perennial vegetation and thus can simultaneously provide additional ecosystem services. These alternative combinations of ecosystem services are climate change mitigation (bioenergy cropping systems), animal protein production (intensive rotational grazing), and biodiversity restoration (conservation plantings). Finally, this review paper demonstrates that *S. sesban* has considerable potential for addressing problems such land degradation, decline of soil fertility and carbon stocks and reduced availability of fuelwood and livestock feed as well as for improving human and livestock health and treating diseases. It also has important uses in particular niches, such as on saline soils, constructed wetlands, and for phytoextraction of metals. This paper contributes to the knowledge base on *S. sesban* and will hopefully help in its protection, use, and value for future generations. Although the plant grows naturally in and around N'Djamena, but it has become rare in N'Djamena and surroundings and needs to be replanted in order to avoid its complete disappearance in future.

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