academicJournals

Vol. 7(10), pp. 468-475, October 2013
DOI: 10.5897/AJPS2012.0716
ISSN 1996-0824 ©2013 Academic Journals
http://www.academicjournals.org/AJPS

African Journal of Plant Science

Review

Sesbania sesban (L.) Merrill: Potential uses of an underutilized multipurpose tree in Ethiopia

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Accepted 29 July, 2013

***Sesbania sesban* (L.) Merrill is the most productive multipurpose tree widely distributed in tropics and subtropics; and usually planted by smallholder farmers mostly for its fodder and soil improvement values. The objective of the present study was to review the various aspects (with emphasis on its importance) of *S. sesban* and generate comprehensive technical information for scholars who wish to study the plant in detail. Different parts of *S. sesban* is reputed for various purposes such as weed control, phytoremediation, anti-inflammation and antioxidant effect, abortion and antifertility agent, antimicrobial activity, firewood source, livestock feed and pasture improvement, green manure, mosquito repellant, live support and *Schistosoma* control. Having these and other multiple uses, *S. sesban* can contribute to sustainable livelihoods by improving household food, nutrition and health security.**

Key words: *Sesbania sesban*, phytoremediation, anti-inflammation, antioxidant, livelihood.

INTRODUCTION

Ethiopia is an agriculture based country where the majority of the population engage in subsistence level crop and livestock production (Nigussie, 2012), that is, mixed crop-livestock farming systems. Soil nutrient depletion and poor nutritive forage are the major causes of low crop and animal productivity in smallholders' farms in Ethiopia, especially in highland areas. As small-scale farmers cannot afford to use chemicals (Wakjira et al., 2011) and improved feeds in their agricultural production system, they resort to the use of natural ways of replenishing soil fertility and feeding livestock through agroforestry.

It is since 1970s that different exotic multipurpose fodder trees like *Sesbania sesban* got promoted by different organizations in Ethiopia to alleviate feed shortages (Mekoya et al., 2009b), maintain soil fertility and prevent land degradation.

In the highland part of Ethiopia, *S. sesban* an N-fixing and deep rooting shrub with good-quality foliage is one of the most promising species for short-duration cover cropping (Desaeger and Rao, 2001) and serve as protein supplement to poor quality roughages or as substitute for commercial protein supplements (Mekoya et al., 2009). Apart from this, its capacity to control soil erosion and hence restore and maintain soil fertility makes it a useful component of traditional agroforestry (Degefu et al., 2011). The authentic product or by-product served by *S. sesban* to human beings is not limited to this, it includes medicinal role to cure diseases and relieve physical sufferings. Therefore, promoting *S. sesban* in Ethiopia, where more than 80% of the people are dependent on plants for their health service (Wondimu et al., 2007), could seem right. Keeping this in mind, the aim of the present work was to blend existing information on the various attributes and potential uses of *S. sesban* for its application in health, agriculture and other sectors.

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Figure 1. *S. sesban* trees, leaves, flowers and pods.

BOTANICAL DESCRIPTION

The species, *S. sesban* (L.) Merrill belongs to the sub-family Papilionoideae, family Leguminosae or Fabaceae (Dinendra and Azad-ud-doula, 2001; Pandhare et al., 2011; Gupta et al., 2011) under the tribe Robinieae (Forni-Martins and Guerra, 1999) with 2n = 12 chromosome (Gillett, 1963; Heering, 1995) and n = 6, 7, 8, 12 and 14 haploid chromosome (Heering, 1995).

The genus *Sesbania* Scop. (*Leguminosae*) contains about 50 species, which are widely distributed in the tropics and subtropics. The majority of *Sesbania* species are annuals, and some are relatively short-lived woody perennials. The greatest species diversity occurs in Africa (distributed widely in northern, eastern, southern and central Africa) with 33 species described (Gillett, 1963; Degefu et al., 2011; Yang et al., 2003; Vadivel et al., 2012; Gupta et al., 2011). Five varieties of *S. sesban* are recognised botanically (Mani et al., 2011; Gutteridge, 1993) viz., *S. sesban* var. *sesban, S. sesban* var. *bicolor, S. sesban* var. *nubica, S. sesban* var. *zambesiaca* and *S. sesban* subsp. *punctata.* The first three varieties are all similar and have been noted for their vigorous growth and high yields, while the rest are less known varieties (Gutteridge, 1993).

S. sesban is a narrow-crowned, deep-rooting single or multiple stem shrub or short-lived tree, which may grow up to 8 m (Hang et al., 2011; Mani et al., 2011) and up to 20 cm stem diameter. The plant is fast growing (Makatiani and Odee, 2007) and it grows 4.5 to 6.0 m high in one year (Siddiqi et al., 1985); and normally flowers and produces ripe pods within the first year after planting (Heering, 1995). If the trees planted are widely spaced they usually develop many side branches. The many branches give the tree a shrubby appearance (Orwa et al., 2009). Leaves are paripinnate, long (compound 12 to 18 cm long) and narrow; leaflets in many pairs (made up of 6 to 27 pairs of leaflets) (Mani et al., 2011), rounded or oblong, usually asymmetric at the base, often glaucous and stipules are minute or absent (Figure 1).

S. sesban tree has up to 20 flowers which are yellow with purple or brown streaks on the corolla. Flowers are attractive, yellow (Pandhare et al., 2011; Mani et al., 2011), red, purplish, variegated or streaked, seldom white, large or small on slender pedicels, solitary or paired in short axillary racemes, usually unpleasantly scented; all petals are long clawed, standard orbicular or obovate. Pods are pale yellow and linear (Pandhare et al., 2011) or slightly curved with 10 to 20 cm long and 5 mm wide containing up to 50 seeds. Seeds are oblong or sub-quadrate, brown or dark green mottled with black (Orwa et al., 2009; Pravin Gomase et al., 2012; Mythili and Ravindhran, 2012).

Origin

The exact origin of *S. sesban* is unclear, but it is widely distributed and cultivated throughout tropical Africa and Asia. It has also been introduced in tropical America (Mani et al., 2011; Heering et al., 1996; Wiegand et al., 1995). It is an exotic plant to Ethiopia (Mekoya et al., 2009a; Orwa et al., 2009) and is originally from east Africa.

Local names

S. sesban is known by different vernacular names such as rivierboontjie (Afrikaans); girangire (Amharic); sesaban (Arabic); jainti or jayant (Bengali); Egyptian sesban (Dande et al., 2010), common sesban, Egyptian rattle pod, frother, river bean, sesban or sesbania (English); dien-dien (Vietnamese); umsokosoko (Zulu); janti, jayanti or puri (Indonesian); Añil francés, tamarindillo (Spanish); and mubimba or muzimbandeya (Luganda) (Orwa et al., 2009; Pravin Gomase et al., 2012).

Nutritional profile

The seeds of *S. sesban* are reported to contain 30 to 40% crude protein (Hossain and Becker, 2001), 5 to 6% of crude lipid and 2.7 to 3.3% of ash (Hossain and Becker, 2002). Debela et al. (2011) reported that the

crude protein contents of *S. sesban* fractions varied from 194 g/kg dry matter in twigs to 297 g/kg dry matter in leaves. In addition, Akkasaeng et al. (1989) found that the *in vitro* dry matter digestibility of *S. sesban* was 75%.

Phytochemical properties

S. sesban seed contains various antinutritional factors such as tannins, saponins and trypsin inhibitors. These antinutritional factors are the major problems when the seed is used as animal feed (Hossain and Becker, 2001). Phytochemical investigations in the seeds led to the isolation of oleanolic acid, stigmastane-5.24(28)-diene-3β-O-β-D-galactopyranoside and galactomannan (Das et al., 2011). The extracts had a high content of phenols, flavonoids and anthocyanins (Kathiresh et al., 2012).

The pods and leaves contain campesterol and beta-sitosterol. Flowers contain cyanidin and delphinidin glucosides. Pollen and pollen tubes contain alpha-ketoglutaric, oxaloacetic and pyruvic acids (Pandhare et al., 2011). From the root extracts of *S. sesban,* Das et al. (2011) isolated Oleanolic acid 3-β-D-glucuronide and found that it has potential spermicidal activity. Among the glucuronide derivatives of oleanolic acid, saponin was responsible for the molluscicidal activity of the plant (Vadivel et al., 2012).

On their phytochemical screening study, Mythili and Ravindhran (2012) found that the stem and root extracts of *S. sesban* contain alkaloids, carbohydrates, proteins, phytosterol, phenol, flavonoids, fixed oil and gum. Moreover, the leaf extract showed the presence of all these except phenol and fixed oil.

Ecological adaptation

S. sesban can be found in areas with a semi-arid to subhumid climate (Heering, 1995; Degefu et al., 2011), with a rainfall between 500and 2000 mm per year (Heering, 1995; Orwa et al., 2009) and temperature of 18 to 23°C (Orwa et al., 2009). In the regions with low precipitation however, they occur primarily on poorly drained soils which are subjected to periodic water-logging or flooding. Because of its good tolerance to low temperatures (Heering, 1995), it can be grown at an altitude of 100 to 2300 m (Orwa et al., 2009). It has moderate shade tolerance as well, and it is adapted to a wide variety of soil types, ranging from loose sandy soils to heavy clays. Furthermore, it has an excellent tolerance to waterlogging and flooding (Heering, 1995) as well as saline, acidic, alkaline soils (Orwa et al., 2009) and soils laden with heavy metals (Gupta et al., 2011).

Pests and diseases

S. sesban is attacked by nematodes, insects, fungi and viruses. *Mesoplatys ochroptera,* the leaf-eating beetle, has been reported as a serious pest of *S. sesban* in Ethiopia, Kenya, Malawi, Mozambique, Tanzania, Zambia and Uganda; while the other leaf eating beetle, *Exosoma* and *Ootheca* spp., has been reported so far only from Malawi and Zambia (Sileshi and Hailu, 2006). *M. ochroptera* can reduce forage yield or completely defoliate leading to mortality, if controlling measures were not taken during establishment (mostly 2 months after planting) (FAO, 2007; Orwa et al., 2009). Insects such as *Anoplocnemis curvipes*, *Exosoma* sp., *Formicomus* sp., *Hilda patruelis* and *Medythia quaterna*, have also been reported to attack *S. sesban* in southern Africa (Sileshi et al., 2000). *Alcidodes buho* is a weevil that damages the plant. The larvae of *Azygophelps scalaris* attack the plant boring the stems. The bacterium, *Xanthomonas sesbaniae* affects the stems and foliage. The seeds are often destroyed by a number of bruchid and other beetles (FAO, 2007; Orwa et al., 2009).

USES OF *Sesbania sesban* (L.) Merrill

S. sesban is a multipurpose tree with different parts of the plant (bark, root, seed, leaf and stem) used for various purposes:

Green manure

S. sesban is a fast growing nitrogen-fixing leguminous tree species which has the capacity of rapid decomposition when incorporated into soil serving as a green manure (Patra et al., 2006) in alley cropping (Heering, 1995) which could bring about substantial increment in crop available nitrogen and soil organic carbon (Table 1).

Forage source

S. sesban tree has a high level of foliage nitrogen and is an excellent supplement to protein-poor roughage (Sabra et al., 2010; Manaye et al., 2009; Orwa et al., 2009). The leaves and tender branches of this tree have high levels of protein (with 20 to 25% crude protein), and easily digestible when consumed by ruminants (Pravin Gomase et al., 2012). It has a long history of use as a source of cut-and-carry forage (Naik et al., 2011). In Ethiopia, feeding *Sesbania* leaves and young twigs have become increasingly important as a protein rich supplement to a basal diet of either grass or poor quality forage for ruminants (Tessema and Baars, 2004). For example, Manaye et al. (2009) reported that the sheep fed with diet containing 300 g/kg *S. sesban* foliage showed 103 g/day average daily body weight gain.

Table 1. Uses of *Sesbania sesban* (L.) Merrill.

Use	Type of use	Parts used	References
Agricultural uses	Reproduction and milk production enhancement	Leave and young twigs	Sabra et al., 2010; Mekoya et al., 2009a; Mekoya et al., 2009b
	Green manure	Whole tree	Patra et al., 2006; Heering, 1995
	Forage source	Leaves and young twigs	Sabra et al., 2010; Manaye et al., 2009; Orwa et al., 2009; Pravin Gomase et al., 2012; Naik et al., 2011; Tessema and Baars, 2004; Manaye et al.; 2009
	Nitrogen fixation	Whole tree	Shaheen et al., 2004; Degefu et al., 2011
	Controlling *Striga asiatica*	Leaves	Gomba and Kachigunda, 2005; Matata et al., 2011; Sikwese et al., 2003
	Live support	Tree	Kathiresh, 2011; Orwa et al., 2009; Naik et al., 2011; Orwa et al., 2009; Sarkar and Prodhan, 2001
	Weed control	Leaves	Tamado and Milberg, 2000
Medicinal uses	Anti-inflammatory effect	Leaves	Nirmal et al., 2012; Shaikh Sajid et al, 2012
	Traditional medicine	Leave and root	Dande et al., 2010; Pravin Gomase et al., 2012; Pravin Gomase et al., 2012; Orwa et al., 2009; Vadivel et al., 2012; Orwa et al., 2009
	Anti-diabetic role	Leaves and seeds	Anil Boddupalli et al., 2012; Pandhare et al., 2011; Ramdas et al., 2010; Ramdas et al., 2012; Vadivel et al. (2012)
	Antioxidant effect	Flower	Kathiresh et al., 2011; Mani et al., 2011
	Antimicrobial activity	Flower	Kathiresh et al., 2012; Mythili and Ravindhran, 2012; Vadivel et al., 2012; Alagesaboopathi, 2012
	Antifertility agent	Seed	Tirkey, 2006; Singh, 1990; Saravanan et al., 2012; Das et al., 2011
	Ethnoveterinary use	Leaves	Vadivel et al., 2012; Orwa et al., 2009; Wondimu et al., 2007; Harun-or-Rashid et al., 2010
Other uses	Bioenergy source	Stem and thick branches	Heering, 1995; Orwa et al., 2009; Naik et al., 2011; Pravin Gonase et al., 2012; Sileshi et al., 2000; Orwa et al., 2009; Pravin Gonase et al., 2012
	Stimulant effect	Bark	Naik et al., 2011; Pravin Gomase et al., 2012
	Schistosoma control	Wood	Nirmal et al., 2012; Mahmoud et al., 2011; Hasheesh et al., 2011
	Fiber source	Bark	Orwa et al., 2009
	Decorative food ingredient	Flower	Kathiresh et al., 2011; Orwa et al., 2009; Pravin Gomase et al., 2012
	Polluted water and soil treatment	Whole tree	Indieka and Odee, 2005; Dan et al., 2011; Dan and Brix, 2009; Indieka and Odee, 2005; Dan et al., 2011; Dan and Brix, 2009; Yang et al., 2003; Gupta et al., 2011.

Anti-inflammatory effect

S. sesban leaf is reported to be used in the treatment of inflammatory rheumatic conditions (Nirmal et al., 2012; Shaikh et al., 2012).

Reproductive and milk production enhancement

Supplementation of ration with *S. sesban* is reported to improve the reproductive performance of sheep; and its inclusion up to 30% of the ration improved feed intake, growth rate, onset of puberty and sexual development (Sabra et al., 2010; Mekoya et al., 2009a). Moreover, ewes supplemented with *S. sesban* at 30% of the ration showed a 13% increase in milk production over ewes supplemented with concentrates (Mekoya et al., 2009b).

Nitrogen fixation

In symbiosis with *Rhizobium* (nitrogen fixing bacteria), *S. sesban* can fix up to 542 kg N ha^{-1} (Shaheen et al., 2004). Even, Degefu et al. (2011) reported nitrogen fixation level of 500 to 600 kg N/ha/year and is particularly promoted for soil fertility replenishment through 'improved fallow' agroforestry practice.

Bioenergy source

The stem and thick branches of *S. sesban* is popular for firewood and charcoal production because it produces a relatively smokeless, quick kindling and hot burning woody biomass in a short time (Heering, 1995; Orwa et al., 2009; Naik et al., 2011; Pravin Gonase et al., 2012).

S. sesban has been found to yield 10 to 20 t ha^{-1} of fuelwood when planted as pure fallows, and up to 2 t ha^{-1} in relay intercropping (Sileshi et al., 2000). The calorific yield for a 3-years-old tree is approximately 4350 kcal/kg (Orwa et al., 2009). Because of its rapid growth, the plant also has a potential for pulpwood production (Pravin et al., 2012).

Ethnomedicine

The cataplasm prepared from leaves of *S. sesban* facilitates discharge of boils and abscesses and absorption of inflammatory rheumatic swellings (Dande et al., 2010; Pravin et al., 2012). In addition, juice of fresh leaves is credited with anthelmintic properties (Pravin et al., 2012; Orwa et al., 2009). The fresh root of *S. sesban* is also said to be an excellent remedy for scorpion stings (Vadivel et al., 2012; Orwa et al., 2009).

Anti-diabetic role

Different research works (Boddupalli et al., 2012; Pandhare et al., 2011; Ramdas et al., 2010, 2012) reported that the aqueous leave extract of *S. sesban* have anti-diabetic effect which could be associated with the presence of flavonoids. More specifically, to manage type II diabetes (Vadivel et al., 2012) recommend the use of *S. sesban* seeds as a natural source of dietary antioxidants.

Controlling *Striga asiatica*

Studies have reported that exposing *S. asiatica* to the leaf crude extracts obtained from *S. sesban* reduced the germination of the parasite by 50 to 100%. This property of *S. sesban* makes the plant with contributory effect on the control of *Striga asiatica* as a parasite of economic importance (Gomba and Kachigunda, 2005). Application of *S. sesban* manure to the soil is also reported to reduce the *Striga* infestation or incidence by 88% (Matata et al., 2011). Furthermore, other research works reported various mechanisms through which *S. sesban* control *Striga* in an intercropping system like trapping or catching crops to the parasite in a rotation, shading the *Striga* from receiving enough sunshine to proliferate (Sikwese et al., 2003) and stimulating suicidal germination of *Striga* seeds (Matata et al., 2011).

Stimulant effect

The crude drug extract obtained from the bark of *S. sesban* have been examined and found to have a potential central nervous system stimulant effect that can be explored for therapeutic advantage as an alternative treatment in medical conditions associated with dizziness and sedative (Naik et al., 2011; Pravin et al., 2012).

***Schistosoma* control**

Shade, dried and coarsely powdered wood of *S. sesban* is reported to have potent antinociceptive activity (Nirmal et al., 2012). The dry powder of the plant *S. sesban* exhibited an acceptable toxic effect against the snails which can make the plant good candidate for interrupting and minimizing the transmission of *Schistosoma mansoni* (Mahmoud et al., 2011; Hasheesh et al., 2011).

Fiber source

The bark of *S. sesban* can be used for making ropes and fishnet (Orwa et al., 2009).

Antioxidant effect

The flower petals of *S. sesban* may be valuable natural antioxidant sources that protect the cells against the effect of free radicals by scavenging them and retard the progress of many chronic and degenerative diseases such as cardiovascular diseases and cancer (Kathiresh et al., 2011). This activity is attributed to the presence of saponins and flavonoids (Mani et al., 2011) which make the plant potentially applicable in both pharma and food industry (Kathiresh et al., 2011).

Ethnoveterinary use

One of the most promising uses of *S. sesban* is as mosquito repellant. Washing the bodies of animals with its water extract can serve as protection against mosquito bites (Vadivel et al., 2012). Orwa et al. (2009) reported the use of decoctions of leaves of this plant as a drench for cattle to repel tsetse fly from cattle by the Hausa people of Ghana. *S. sesban* in Southeastern Ethiopia, is also reported for its veterinary use in crushed and homogenized water form (Wondimu et al., 2007). Moreover, the leave of this plant has been used by Bangladesh farmers to treat retention of urine (Harun-or-Rashid et al., 2010).

Decorative food ingredient

Flowers of *S. sesban* are known to be added to stews and omelets in some areas, perhaps mainly as a decorative or festive ingredient in foods (Kathiresh et al., 2011; Orwa et al., 2009; Pravin et al., 2012).

Antifertility agent

Inserting *S. sesban* seed paste (15 g) placed in cotton swap into vagina causes abortion in females (human beings). In addition, taking fresh root decoction twice a day for 3 to 4 days following menstrual phase serve as an antifertility agent (Tirkey, 2006). Therefore, *S. sesban* seed powder hinder the ovarian normal function, change the uterine structure and prevent implantation, thus, control the fertility of female (Singh, 1990; Saravanan et al., 2012). With this respect, Das et al. (2011) reported that the Kandha tribe of India uses the root extracts as contraceptive.

Antimicrobial activity

Studies also witnessed that extracts from *S. sesban* flower petals serve as antimicrobial activity (Kathiresh et al., 2012; Mythili and Ravindhran, 2012). In traditional medicine system of Nigeria, the plant is pounded in milk and taken as an internal remedy for Guinea worm (Vadivel et al., 2012). Furthermore, Alagesaboopathi (2012) reported that decoction of the leaf is mixed with hot milk and given once a day for seven days for treatment of diarrhea, itches and skin diseases.

Live support

S. sesban can be used as a live support for black pepper, grapes, cucurbits and betel vine. In addition, its spreading canopies can serve as a shade tree for coffee, tea, cocoa and turmeric (Kathiresh, 2011; Orwa et al., 2009; Naik et al., 2011). It has also been used as a windbreak for bananas, citrus and coffee (Orwa et al., 2009) and as fencing materials (Sarkar and Prodhan, 2001).

Polluted water and soil treatment

The ability of *S. sesban* to grow at different ammonium concentrations soil culture has been studied by different workers (Indieka and Odee, 2005; Dan et al., 2011; Dan and Brix, 2009), and it was shown that its seedlings can tolerate ammonium concentrations up to 800 mg/L. This high tolerance suggests that this plant has a potential for use in treatment systems of waste or polluted water (Indieka and Odee, 2005; Dan et al., 2011; Dan and Brix, 2009) and removal of heavy metals from soil, that is, phytoremediation of sites contaminated with heavy metals (Yang et al., 2003; Gupta et al., 2011).

Weed control

Leaf aqueous extract and dry residue of *S. sesban* could serve in the inhibition of germination and seedling growth of parthenium, which is currently considered as the most serious weed in Ethiopia in both arable and grazing lands as it caused severe crop losses (Tamado and Milberg, 2000).

CONCLUSION

S. sesban (L.) Merrill is an extremely versatile plant which has significant contribution in attaining rural household food security in Ethiopia through its contribution to production, service and ethnomedicinal functions (for example, weed control, phytoremediation, anti-inflammation and antioxidant effect, abortion and antifertility agent, antimicrobial activity, firewood source, livestock feed and pasture improvement, green manure, mosquito repellant, live support and *Schistosoma* control) to the subsistence crop-livestock mixed farming system. It is a species of wide-ranging soil and climatic adaptations. Currently, the use of the plant as animal feed and manure has been reported in Ethiopia by many researches and its further use need to be explored for its better utilization in the present mixed farming system.

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