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THE BIOLOGY OF EGYPTIAN WOODY PERENNIALS
4. *Dalbergia sissoo* Roxb. ex DC.

Kamal H. Shaltout and Amr E. Keshta

Botany Department, Faculty of Science, Tanta University, Tanta, Egypt

REVIEW ARTICLE:

ABSTRACT:

The present article is the fourth in a series of review articles deal with the biology of Egyptian woody perennials. Available literatures dealt with the biology of the invasive tree *Dalbergia sissoo* Roxb. ex DC. in Nile Delta was reviewed. The area of natural distribution is the foothills of the Himalayas from eastern Afghanistan through Pakistan and India to Nepal. *Dalbergia sissoo* was introduced to Egypt by Ibrahim Basha in the age of Mohamed Ali (1805-1848) for ornamental and timber purposes. This review includes the nomenclature and taxonomy of the plant, its distribution, morphology, habitat and environment, phytomass production, control measures, propagation and management, pests and diseases, economic uses and ecological importance. Ecotypic variability among its local populations needs further studies, particularly the physiological and genetical adaptations along the prevailing environmental conditions.

INTRODUCTION:

***Dalbergia sissoo* was introduced to Egypt by Ibrahim Basha in the age of Mohamed Ali (1805-1848) for ornamental and timber purposes (Othman 1939). El-Hadidi and Boulos (1988) described it as a deciduous tree, up to 25 m high, bark grayish-brown, leaves pale green, imparipinnate, leaflet 3-5, pale yellow flowers appear in spring, The area of natural distribution of this plant is the foothills of the Himalayas from eastern Afghanistan through Pakistan and India to Nepal (Appanah *et al*., 2000). El-Sheikh (1989, 1996) recorded *Dalbergia sissoo* along the terraces of highway roads and canals in Nile Delta, but not along the drain banks. Slima (2006) recorded it along the canal terraces and slopes in Nile Delta. This plant reproduces by seeds and root suckers (Neelu *et al*., 2002, James 2002). The strategy of reproduction by seeds and root suckers and the rapid growth rate lead to increase the plant dissemination into new regions. Now, this tree has become a weed and spread rapidly in other terrestrial habitats of the Nile Delta such as roadsides, railways and wastelands (Fahmy 2007 & Keshta 2010). This may cause**

obstruction and difficulties in some habitats of this region.

The present article is the fourth in a series of review articles dealing with the biology of Egyptian woody perennials (see Shaltout 2003, Shaltout *et al*., 2006, Shaltout and Slima 2007). It aims to review the available literatures dealt the its biology in Nile Delta, assessing its distribution in different habitats and evaluate its ability to adapt with different environmental conditions. Such type of review articles may focus the attention of the Egyptian plant biologists to fill the gaps of information about the local populations of the woody perennials in the Egyptian flora and to innovate the earlier studies.

NOMENCLATURE AND TAXONOMY:

Generic name *Dalbergia* honours the Swedish brothers Nils and Carl Dalberg, who lived in the 18th century. The former was a botanist and the latter explored Surinam (Lanzara & Pizetti 1978). It is a pan tropical genus with 100 species distributed in different parts of tropical Asia, America and Australia (Thothathn 1987). Its vernacular names include sarsoo, shisham, sissoo, sisu, tahli and Indian Rosewood (Bekele-Tesemma *et al*., 1993). Its synonym is *Amerimnon sissoo* (Roxb. ex DC.) Kuntze. *Dalbergia* is a large genus of small to medium-size trees, shrubs and lianas (family Fabaceae, subfamily Faboideae). Javaid *et al.* (2004) reported nine varieties of *Dalbergia sissoo* that identified on the basis of physical appearance of the plant, branching pattern, pod characters, leaf and leaflet size and shape, branching and leaf density and stem surface characteristics. The genetic variability of these varieties was confirmed through DNA finger printing. *Dalbergia sissoo* has the following taxonomic hierarchy (Wunderlin & Hansen 2002): Kingdom: *Plantae* (plants), Subkingdom: *Tracheobionta* (vascular plants), Super division: *Spermatophyta* (seed plants), Division: *Magnoliophyta* (flowering plants), Class: *Magnoliopsida* (dicotyledons), Subclass: *Rosidae*, Order: *Fabales*, Family: *Fabaceae*, Genus: *Dalbergia* L. f. and Species: *Dalbergia sissoo* Roxb. ex DC.

DISTRIBUTION:

The area of natural distribution is the foothills of the Himalayas from eastern Afghanistan through Pakistan and India to Nepal. It is a primary coloniser of new alluvial soils along riverbanks and forms forest, either pure or mixed with other species. It often occurs in association with *Acacia catechu* (Appanah *et al*., 2000). Native range includes Pakistan, Oman, Bhutan, India, Nepal and Myanmar. Uncertain native status includes Iran, Afghanistan, Bangladesh and Malaysia; while known introduced range includes United States (Florida and Arizona), Puerto Rico, Costa Rica, Cyprus, Benin, Cameroon, Ethiopia, Gabon, Ghana, Kenya, Mauritius, Nigeria, Senegal, South Africa, Sudan, Tanzania, Togo, Zimbabwe, Australia, Indonesia, Thailand, Sri Lanka, Taiwan and Palestine (Duke 1983, Pallewatta *et al*., 2003, Wu *et al*., 2003, GBIF 2007, USDA-NRCS 2007, AWC undated). It is increasingly planted as a street tree in southern

Florida, and now it is becoming an invasive species (Parrotta 1989).

MORPHOLOGY:

1-Macromorphology:

El-Hadidi and Boulos (1988) described *Dalbergia sissoo* as a deciduous tree, up to 25 m high, bark grayish-brown, leaves pale green, imparipinnate, with zigzag rachis; leaflet 3-5, alternate, broadly ovate to sub-orbicular, entire, acuminate, terminal leaflet long stalked; pale yellow flowers appear in spring, sub-sessile, in short axillary panicles; calyx bell shaped, with 5 short teeth; petals much longer than the calyx; ovary hairy, style glabrous, strap shaped (Fig. 1). In a recent study by Keshta (2010), he reported the prescence of some evergreen *Dalbergia sissoo* population in Minufiya and Kalyobia governorates. Duke (1983) in West Lafayette (Indiana-USA) described this plant as a deciduous tree with an open spreading crown that reaches a height between 15-35 meters. The primary root long, tapering, lateral roots numerous distributed down main roots; nodule present and has long superficial roots, which sends up to suckers where injured (Troup 1921). It has a long taproot and an extensive lateral root system, often at the soil surface and producing suckers (PIER 2006). The leaves are alternately arranged, compound and oddly pinnate (Gilman & Watson 1993), with 3-5 glabrous, leathery leaflets, elliptical to ovate, tapering to a point and 2.5-3.6 cm in diameter (ICRAF undated). PIER (2006) reported that flowers are sessile, arranged in axillary panicles, 2.5-3.7 cm long, inconspicuous, white to dull yellow and fragrant. In addition, Bangarwa (1996) reported that flowers bisexual, small, pale yellow, in 10-15 cm long panicles that are conspicuously hairy when young. Pain and Roy (1981) reported that flowers are whitish to pink, 1 cm long and in dense clusters, 5-10 cm in length; while MacDicken (1994) reported that flowers 5-8 mm long, pale white to dull yellow, racemes 2.5-3.7 cm long in short axillary panicles.

El-Hadidi & Boulos (1988) described pod as thin, yellowish-brown when ripe, 1-4 seeded. The pods of *sissoo* when ripe contain 1-3 seeds, indehiscent, reniform flat, light brown, with delicate papery testa (Zabala 1990). Fruit is 5-7 ×0.08×1.2 cm, strap-shaped, pale brown, mostly 1-seeded, less often 3-seeded (Alam *et al*., 2001). Pods are 4.5-10×0.07×1.5 cm, linear-oblong, indehiscent, stipulate, glabrous, apex acute to obtuse, conspicuously reticulated against the seeds, usually 1-4 seeded (PIER 2006). The length of pods varies from 5-10.5 cm according to the number of seeds. Pods with 1-4 seeded were observed, amongst these 2-seeded pods are common, followed by 1-seeded and 3-seeded (Fig. 1); while 4-seeded pods are very rare (Kanak & Sahai 1994). Fruits are indehiscent, 5-7.5 cm long and 8-13 mm wide (ICRAF undated), rounded with minute points, pale brown in color (PIER 2006), and persistent on the tree (Gilman & Watson 1993). Seeds (8-10)× (4-5.5) mm, brown to brownish black, reniform and compressed (Tewari 1994). The seeds are 6-9 mm long and number of seeds per kg. is 44000 in Africa (Leloup 1956), 53000 in Bangladesh

(Banik 1992) and 55000 kg in Arunachal Pradesh (Beniwal & Singh 1989).

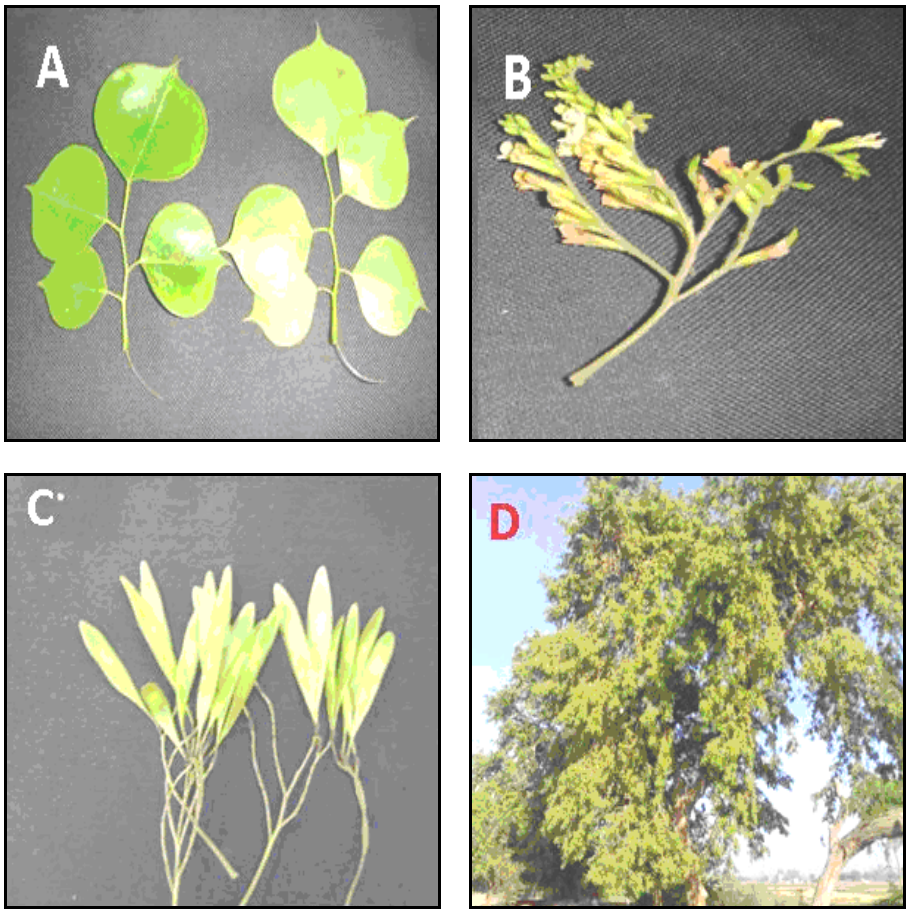

Fig. 1: *Dalbergia sissoo*. A: leaves, B: flowers, C: fruits and D: *Dalbergia sissoo* tree in Abo Al-Akhdar canal at Zagazig

2-Micromorphology:

A-Stem:

The epidermis of stem has a single layer of cells which are tubular in cross section. They are closely packed without intercellular spaces. Under epidermis there are patches of lamellar collenchyma cells. Cortex consists of 4-6 layers of spherical parenchyma cells with intercellular spaces (Fig. 2). Also, there are patches of extra-xylary pericycle fibers above the main vascular bundle. Phloem tissues are present between pericycle fibers and vascular tissue. Secondary xylem is formed from xylem vessels and fibers and xylem phloem ray parenchyma present between main vascular bundles which are radial as the stem is old dicot vine stem. Cambium is present between xylem and phloem tissues. In the centre of the stem, pith cells present which are spherical in shape with intercellular spaces.

B-Root:

Cortex of old root is wider than that in the stem, and endodermis is destroyed due to the

presence of secondary xylem tissues (Fig. 3). The stele is made up of radially arranged strands of xylem and phloem and the pith is very compressed in the centre. Arms of primary xylem are present in the centre of the root and very compressed due to formation of secondary xylem.

C-Deciduous leaf:

Leaf of the plant is bifacial with flat upper and lower epidermis (Fig. 4). The leaf is made up of upper and lower epidermis with the mesophyll in the middle which is made of parenchyma cell. There are thin layer of cuticle covered the epidermis layer. Epidermis is made up of one layer of closely backed tubular cells with thin walls. In the lower epidermis, there are stomata which are present in grooves. In the midrib region, the vascular bundle is present in rows in an inverted form. In the midrib region and below upper and lower epidermis, there are cartilaginous collenchyma cells.

D-Deciduous leaf petiole:

There are thin layer of cuticle covered the epidermis layer (Fig. 5). Epidermis is made up of one layer of closely backed tubular cells with thin walls. Cortex is made up of 3-5 rows of spherical parenchyma cells. Vascular bundle is in the form of circle and made up of phloem followed by cambium tissues and xylem is arranged in rows separated by secondary fibers. Outside the vascular bundle, there are patches of cartilaginous collenchyma cells. Pith in the centre is made of spherical parenchyma cells with intercellular spaces.

E-Evergreen leaf:

Leaf of the plant is bifacial with flat upper and lower epidermis (Fig. 6). The leaf is made up of upper and lower epidermis with the mesophyll in the middle which is made of parenchyma cells. There are thin layer of cuticle covered the epidermis layer. Epidermis is made up of one layer of closely backed tubular cells with thin walls. In the lower epidermis, there are stomata which are present in grooves. The vascular bundle is present in the midrib region in rows in an inverted form. In the midrib region and below upper and lower epidermis, there are cartilaginous collenchyma cells. There are circle ring of fibers in the midrib region that surround the vascular bundle.

F-Evergreen leaf petiole:

There are thin layer of cuticle covered the epidermis layer (Fig. 7). Epidermis is made up of one layer of closely backed tubular cells with thin walls. Cortex is made up of 3-5 rows of spherical parenchyma cells. Vascular bundle is in the form of circle and made up of phloem followed by cambium tissues and xylem is arranged in rows separated by secondary fibers. Outside the vascular bundle there are extra-xylary fibers in the form of patches upon the main vascular bundle. Pith in the centre is made of spherical parenchyma cells with intercellular spaces.

G-Pod punches petiole:

Epidermis is made up of one layer of closely backed tubular cells (Fig. 8). There are 2-3 layers of cork above the epidermis. Cortex is made up of 4-6 rows of spherical parenchyma cells. The first two rows of cortex forming ring of cartilaginous collenchyma cells. Vascular bundle is in the form of circle and made up of phloem followed by cambium tissues, and xylem is arranged in rows separated by secondary fibers. Outside the vascular bundle there are ring of extra-xylary pericycle fibers. Pith in the centre is made of spherical parenchyma cells with intercellular spaces.

H-Fruit petiole:

Epidermis is made up of one layer of closely backed tubular cells. Thin layer of cuticle cover the epidermis (Fig. 9). Cortex is made up of 4-5 rows of spherical parenchyma cells. Six-seven vascular bundles in the form of circle and made up of phloem followed by cambium tissues and xylem is arranged in rows. Outside the vascular bundle, there are patches of extra-xylary pericycle fibers upon each vascular bundle. Pith in the centre is made of spherical parenchyma cells with intercellular spaces.

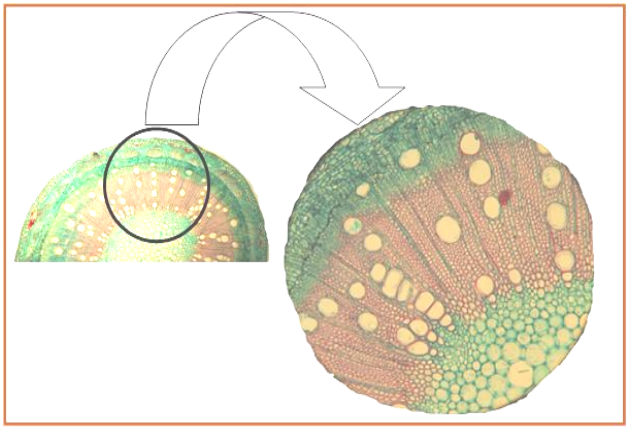

Fig. 2: Transverse section through the old stem of *Dalbergia sissoo* Roxb. ex DC

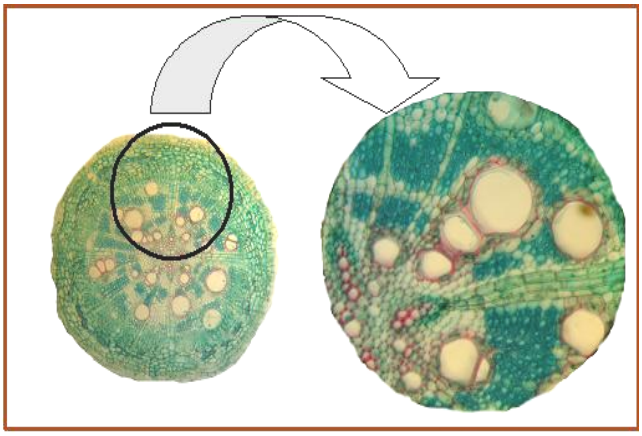

Fig. 3: Transverse section through the old root of *Dalbergia sissoo* Roxb. ex DC

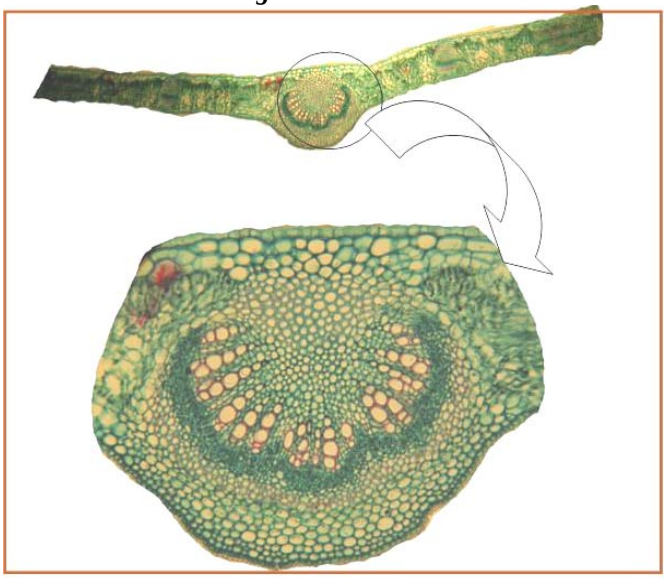

Fig. 4: Transverse section through the deciduous leaf of *Dalbergia sissoo* Roxb. ex DC

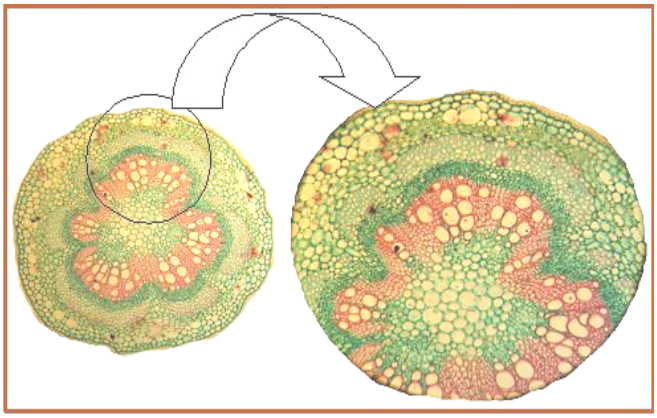

Fig. 5: Transverse section through the deciduous leaf petiole

of *Dalbergia sissoo* Roxb. ex DC

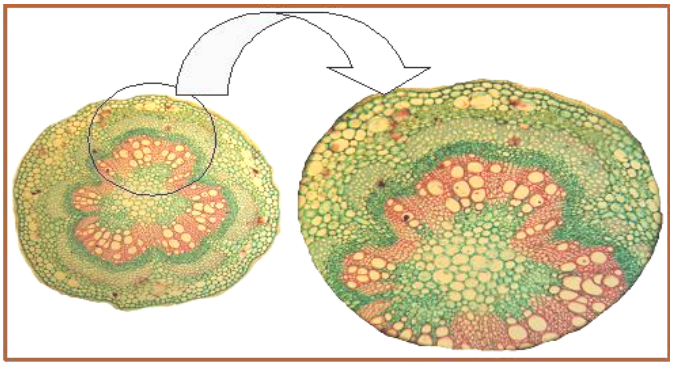

Fig. 6: Transverse section through the evergreen leaf of *Dalbergia sissoo* Roxb. ex DC

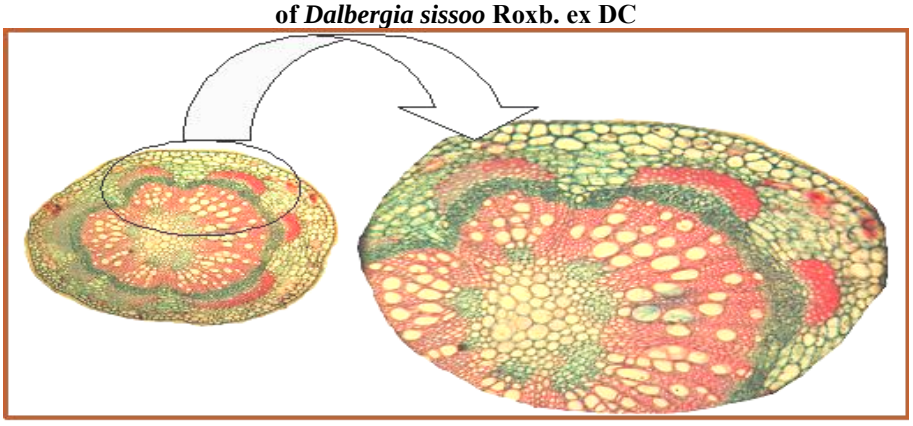

Fig. 7: Transverse section of the evergreen leaf petiole of *Dalbergia sissoo* Roxb. ex DC

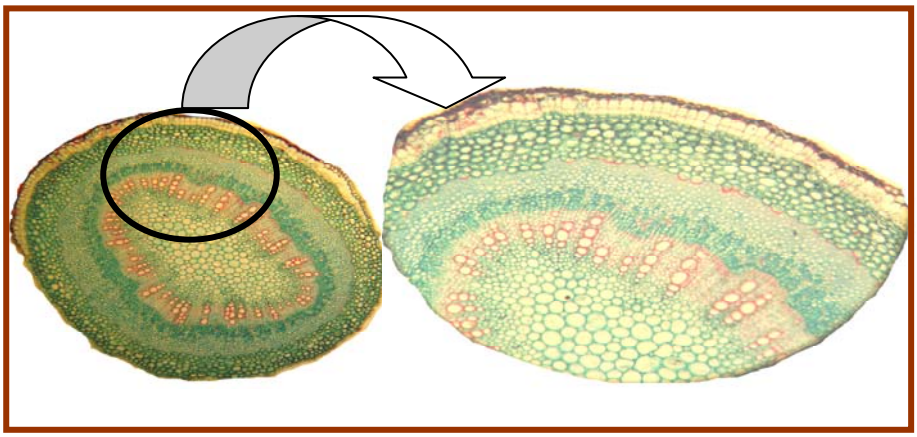

Fig. 8: Transverse section through the pod punches petiole of *Dalbergia sissoo* Roxb. ex DC

Fig. 9: Transverse section of the fruit petiole of *Dalbergia sissoo* Roxb. ex DC

HABITAT AND ENVIRONMENT:

Distribution of *Dalbergia sissoo* ranges from sea level to >1500 m above sea level, it can stand temperatures from below freezing to nearly 50°C. It is adapted to savanna woodlands where annual rainfall is 7-20 mm (NAS 1979 & Sheikh 1989). The trees are distributed from Bhutan in the East to Afghanistan in the west. In Nepal it is distributed from the terai up to 1400 m (Napier & Robbins 1989). Sissoo is native to the foothills of the Himalayas of India, Pakistan and Nepal. It is expected to tolerate annual precipitation of 6 to 40 mm, annual temperature of 21 to 28°C, and pH of 6-8. It prefers well drained, alluvial soils near rivers and streams. In its native range, the temperature averages 12-22°C, and annual rainfall 500-2000 mm. It is distributed in a monsoonal pattern with droughts of 3-4 months. Soils range from pure sand and gravel to rich alluvium of river banks; it can grow in slightly saline soils. Seedlings are shade intolerant (Nadkarni 1954 & Sheikh 1989), but mature trees can tolerate moderate shade and the species has a low salt tolerance (Black & Meerow 1993). *Dalbergia sissoo* is found in tropical to sub-tropical climates in natural and planted forests, mainly along forest margins near streams and rivers, hammocks, canopy gaps, agricultural areas, disturbed sites and roadsides (Langeland & Stocker 2001, Duke 1983 and Sharma *et al*., 2000). It grows best in porous well-drained soils like sands, sandy loams, gravels, and alluvial soils; but does poorly in heavy clay and waterlogged soils (Sharma *et al*., 2000). In India, abundant moisture and lack of competition is the key to its successful regeneration; it is therefore found in riverine environments where sunlight and moisture are plentiful, associated with *Pinus roxburghii*, *Acacia catechu* and *Shorea robusta* (Hocking 1993).

***Dalbergia sissoo* has a unique property in that it hardly regenerates under the old mother trees. It is pioneer in nature and often grows in clumps in new well-drained alluvial sites near river/stream beds. The natural *D. sissoo* populations have come under considerable pressure from human disturbance. Very few**

remnant populations still exist in the riverine plains of the Terai and Siwaliks. East Nepal had considerable populations until late 1980s, but now they are confined to a few natural patches in far-western Nepal, in a very threatened state (except in Protected Area Systems).

PHYTOMASS PRODUCTION:

Conserving of sissoo tree aims at improving the quality of production and services from the operational plantations. Nepal's ninth five-year plan emphasizes development of large-scale tree plantations (30000 ha) through participatory planning and implementation. Tree improvement should have an important role to play in such a process, especially when diseases and pests are affecting one of the major plantation species of the country (ICRAF undated). According to the Wealth of India, irrigated plantations of sissoo yield fair quantities of timber and fuel. In irrigated plantations trees may attain a girth of 1.2 m in 25 years. A height of 7 m has been reported in 20 months. Based on studies of 40 natural riverine sites, it was concluded that 10-year stands yield about 10 m^3 ha^{-1}, 20-year stands 100 m^3 ha^{-1} (5m^3 ha^{-1} yr^{-1}), 30-year stands 210 m^3 ha^{-1} (7 $m^3$$ha^{-1}$ yr^{-1}), 40-year stands 280 m^3 ha^{-1} (7 m^3 ha^{-1} yr^{-1}), 50- year stands 370 m^3 ha^{-1} (7.5 m^3 ha^{-1} yr^{-1}), and 60-year stands 460 m^3 ha^{-1} (7.5 m^3 ha^{-1} yr^{-1}) (CSIR 1976). In Nepal, a 9.5-year stands thinned to 867 trees ha^{-1} at 6.5 years, produced an annual increment of 18.1 m^3 (Jackson 1987). A 10-year irrigated plantation in Peshawar, spaced at 2×2, 3×3 and 4×4 m produced a total wet weight of main stem, branches, leaves and roots of 510, 231 and 244, ton ha^{-1}, respectively (Sheikh 1988a). A permanent watertable of 7 m below the soil surface made the site very favorable. Sissoo should therefore be used in areas where a high-value timber market is available (NAS 1983, Sheikh & Haq 1982 and Sheikh 1988b).

PROPAGATION AND MANAGEMENT:

1-Propagation methods:

Seeds remain viable for only a few months when exposed to air, but can be stored for up to 4 years in sealed containers (Jackson 1987). It is not necessary to extract seeds from pods, which can be broken into one-seeded segments and sown. Seeds should be soaked in water for 48 hours before sowing, and 60-80% germination can be expected in 1-3 weeks (Jackson 1987). The seeds are not hard coated and scarification is not necessary. Soaking for 24-48 hours in cold water before sowing improves germination. The seeds (pod segments) are sown in March-April in lined raised seed-beds and watered two times every day. Germination starts after about one week and is completed after three weeks. When the seedlings are about 5 cm tall, they are transplanted into containers. For production of stumps, 12-16 months are required in the nursery (NFTA 1992). After collection, the pods are dried in the sun and, broken into segments each containing one seed. The segments are then cleaned by winnowing to remove empty pieces of pods (Tewari 1994). The seeds are orthodox and when properly dried and stored in airtight containers they will retain high viability for several years even at room temperature, they live longer if stored at 5°C.

While seeds may be sown without pretreatment, it is recommended that they be soaked in water at room temperature for 24-48 hr, inoculated with *Rhizobium* after soaking and sown immediately. Sissoo rarely regenerates under the parent canopy. Natural regeneration is nonetheless abundant along streams and riverbanks where the pods have been carried by floods. Ripe pods may be collected manually by climbing trees and picking them or by shaking the branches and picking them from the ground. Propagation by root suckers is done best by cutting stems just below the soil surface. While it is difficult to propagate using stem and branch cuttings without hormone treatments, exogenous application of auxins (IAA, IBA and NAA) have been found to improve survival and growth rates (Taylor & Macdicken 1990).

Stump planting is widely employed in irrigated plantations in India. Trenches are dug 1.5 m apart, earth thrown a little away from the trenches and the berms used for sowing seed or pod segments (Duke & Wain 1981). Stumps are planted in spring, not earlier than the third week of March or April. Where subsoil water is low or rainfall poor and uncertain, irrigation is essential (Gohl 1981). Stumps are planted along trenches or on berms of pits and the field are irrigated. Under proper irrigation, sissoo roots tap the subsoil water within 2 years (Kirtikar & Basu 1975). Wood cuttings planted in May and June failed completely, while those planted in August achieved up to 20% success (Vidaeovic 1968). When summer planted, Pain and Roy (1981) reported 100, 80 and 60% rooting success with IBA, NAA and IPA treatment for 30 seconds respectively. There has been some success with tissue culture (Jackson 1987).

2-Tree management and silviculture:

Sissoo is a fast-growing species of growth rates of 3.7 m in one year, 5.0 m in 3 years, 11.0 m in 5 years and 15.0 m in 10 years. Plantations are established in block or strip plantations at 1.8×1.8 m to 4×4 m, closer spacing is used for straight timber of good quality. When the canopy closes, at about 6 years, 30-40% of the stems are thinned to selectively remove suppressed, diseased and badly formed trees. Thinning is recommended every 10 years where the rotation is 30-60 years. There is evidence that the stumps begin to lose vigour after 2 or 3 rotations when managed as a coppice crop. It coppices vigorously up to about 20-year (White 1990). In Pakistan at spacing of 4×4 m, 3×3 m and 2×2 m, sissoo height and diameter at the breast height (dbh) after 6 years were 8.4 m and 11.3 cm, 8.7 m and 10.1 cm, and 8.7 m and 8.6 cm, respectively (Sheikh 1984). Differences were not significant, but the 2×2 m spacing produced trees with fewer branches and more fuel wood. After 9 years, height and dbh for the three spacing were 15.1 m and 18.9 cm, 13.4 and 15.6 cm, and 13.9 m and 14.2 cm.

Thorough weeding is important during the first 2-3 years. In a trial at Adabhar (Nepal), mean height at 18 months was 3.8 m in fully cultivated plots and 1.3 m when weeding was confined to a 50 cm diameter circle around the plants (Jackson 1987). Protection against browsing animals and fire also is essential if the plant is to become a tree. Irrigation is very

important for establishment of sissoo in semiarid areas. Sissoo should be able to tap sub-soil water within a couple of years if irrigated properly. Shallow and frequent irrigation or constant flooding induces superficial root formation. Fertilization with various combinations and amounts of NPK did not show significant effects on dbh or height over 5-6 years on a rich soil (Sheikh & Cheema 1986). Phosphate would normally be expected to promote early growth on poor soils.

Sissoo tolerates disease, drought, frost, insects, porous soils, salt, sand, savanna, sewage, and wind. On the clay soils, its growth is stunted. Seed storage behavior is orthodox; viability is maintained for 4 years in hermetic storage and 1-2 years when stored in airtight containers under dry cool conditions of 5-22°C (Vogt 1995). *Dalbergia sissoo* reproduces through seed production and vegetatively through suckers arising from the root system (Fig.10).

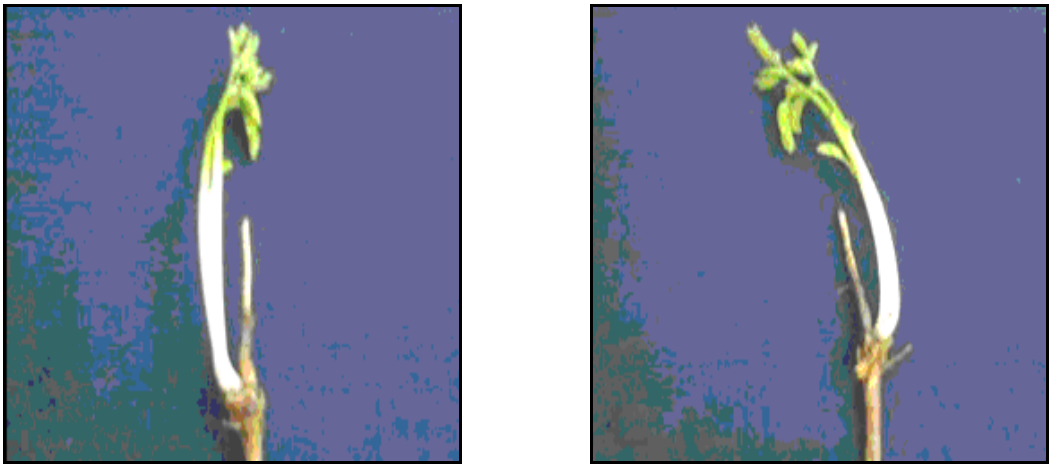

Fig. 10: *Dalbergia sissoo* reproducing by suckers arising from the root system

The pollination mechanism is theorized to be through insects. Regeneration is rare under the shade of the parent canopy and seed dispersal is through wind or water (ICRAF undated). In North America, *Dalbergia sissoo* begins to produce flowers after nine months, with flowering closely associated with leaf flush in April-May (Painter 2006). The mature pods are persistent on the tree for 7-8 months; however seed remains viable for a few months once exposed to air, and germinates in 1-3 weeks during spring (Sheikh 1989). Trees reach maturity around 19-21 years of age (Sangha & Jalota 2005) with a natural rotation of about 60 years (Sharma *et al*., 2000). The small bisexual flowers are borne on small branches from the leaf axis. Flowering follows leaf flushing; leaves fall and young flower buds appear with new leaves followed by complete pod formation and maturity. Mature pods remain attached to the tree for 7-8 months and are then dispersed by wind and water (Kamaluddin 1995).

Within the area of natural distribution, the leaves are shed in November-December and new leaves appear in January-February. The first flowers appear together with the new leaves and the flowers open in March-April. By the end of April, young green pods appear, and in October when the dry season sets-in the fruits begin to ripen (Tewari 1994). Seed production starts when the trees are 3-4 years old and normally a good crop is produced every year with yields of 1-3 kg per tree. Sissoo being partial selfing and partial out-crossing, a type of breeding system often found in pioneer species. The rate of out-crossing has been estimated to 60-90%, it varies between populations and for the single population over time (White 1994). Ripe fruits can be harvested from December to March. The fruits should be collected from the tree by climbing or by shaking the fruits onto a tarpaulin on the ground. It is not advisable to collect from the ground as the seeds are often infected. 1.25 kg pods contain about 1 kg seed (Jøker 2002).

ESTS AND DISEASES:

leaf defoliator *Plecoptera reflexa*, leaf roller *Dichmeria eridantis*, wood borer *Stromartium barbatum*, powder post beetles *Sinoxylon anale* and *Lyctus africanus* are insects that have been reported to cause considerable damage. The fungus, *Ganoderma lucidum*, which causes root and butt rot, is common. *Fusarium solani* and *Polyporus gilvus* cause similar diseases. Sissoo suffers minor damage from two foliage rusts and a powdery mildew (Jackson 1987). Leaf diseases include the powdery mildew fungus, leaf spot *Cercospora sissoo*, leaf blight fungus *Colletotrichum sissoo*, and leaf wilt *Fusarium solani dalbergiae*. Wood pathogens recorded include wood rot fungus *Daedalea flavida* and stump rot fungus *Fomes durissimus* (Singh 1982). *Brachytrypes portentosus* causes nursery damage and termites attack young trees. Parasitic plants reported to cause considerable damage to sissoo include *Loranthus longiflorus* and *Tapinenthus dodoneifolius* in alluvial forests; climbers like *Dregea volobilis, Cryptolepis buchanani* and *Acacia pennata* cause the same damage. It is reported to have pesticidal properties. Aqueous extracts from the

leaves, stems and roots inhibit the reproduction, growth and development of the insect pest *Utethesia pulchella*. Mixed with *Azadirachta indica* oil cake, sawdust from *D. sissoo* reduces egg laying and increases larval mortality in *Melodogyne javanica*. Methanol extract from the roots has insecticidal properties, especially against *Diacrisia obliqua, Spodoptera litura* and *Argina cubrania*. The seeds can be infested by the pea beetle, *Bruchus pisorum*. Infestation is initiated in the field, but breeding can continue during storage (White 1994).

CONTROL MEASURES:

Preventing introduction through strict quarantine and inspection stations is the primary preventative measure. Education of the public on identity, impact, and control of the species is necessary to ensure public support for keeping the species from being introduced. Research and testing, on what kind of impact and what invasion potential the species has on the environment, will determine if the species can be safely cultivated in the country (Langeland & Stocker 2001). In Florida, herbicide applications to the base of the trunk of *D. sissoo* are recommended for control (Langeland & Stocker 2001). Other chemical applications can be made on the cut stump, basal bark or as a stem injection (PIER 2006). There is no available literature on a host specific organism that is being researched or tested as a biological control agent for *D. sissoo*, however several species of fungi, insect and bacteria cause mortality or reduced growth of the tree. Species of fungi that attack and commonly kill sissoo are *Fusarium* spp., *Ganoderma lucidum* and *Phellinus gilvus*; all of which attack the root and vascular system (Sharma *et al*., 2000). Several defoliating moths such as *Plecoptra reflexa* and *Dichomeris eridantis* can cause significant biomass reduction in sissoo. Other insect species that attack it are *Stromartium barbatum, Sinoxylon anale*, and *Lyctus africanus* (Sheikh 1989).

GOODS AND SERVICES:

1-Folk medicine and medicinal uses:

***Dalbergia sissoo* is reported to be a stimulant used in folk medicine and remedies (Nadkarni 1954). It is a folk remedy for excoriations, gonorrhea, and skin ailments (Duke & Wain 1981). Ayurvedics prescribe the leaf juice for eye ailments, considering the wood and bark abortifacient, anthelmintic, antipyretic, apertif, aphrodisiac, expectorant, and refrigerant. They use the wood and bark for anal disorders, blood diseases, burning sensations, dysentery, dyspepsia, leucoderma, and skin ailments. Its wood is used for blood disorders, burning sensations, eye and nose disorders, scabies, scalding urine, stomach problems, and syphilis. The alterative wood is used in India for boils, eruptions, leprosy and nausea (Kirtikar & Basu 1975). Its leaves are boiled and given to animals for bilious disorders (Baquar 1989). The tree has many reputed medicinal properties and has been used culturally for a variety of ailments including: skin diseases, blood diseases, syphilis, stomach problems, dysentry, nausea, eye and nose**

disorders, aphrodisiac, expectorant, among others (Duke 1983). The alcohol extract of the green branches of aerial parts showed a dose-dependent inhibitory effect on the motility of rabbit duodenum, pronounced bronchodilation, as well as significant anti-inflammatory, antipyretic, analgesic, and estrogen-like activities (Sarg *et al*., 1999). An aqueous extract of the leaves of *Dalbergia sissoo* has been used for the treatment of gonorrhea in Arabic countries (El-Dagwy 1996). Oil obtained from the seeds is used to cure skin diseases. The powdered wood, applied externally as a paste, is used to treat leprosy and skin diseases (Mbuya *et al*., 1994). The isoflavones irisolidone, biochanin-A, muningin, tectorigenin, prunetin, and prunetin-4-O-galactoside, the flavone nor-artocarpotin, and ß-amyrin, ß-sitosterol and stigmasterol were isolated and identified from the green branches of aerial parts of *Dalbergia sissoo* using silica gel column chromatography and spectral analysis. Also, 13 fatty acids were identified and isoflavonoids and neoflavonoids have been reported from *D. sissoo* (Seshadri 1972, Sharma *et al*., 1979, 1980 and Ingham *et al.,* 1983).

2-Wood uses:

The wood of *Dalbergia sissoo* is highly durable with excellent finishing color and smoothness; used for veneer, furniture, cabinets, panelling, carving, small timber, plywood, ornamental turnery, tool handles, sprouting goods and musical instruments (ICRAF undated and Lowry & Seebeck 1997). The sawdust works in the absorption of nickel ions and has the potential of removing these heavy metals from industrial and commercial waste water sources (Habib-ur-Rehman *et al*., 2006). The wood has a high caloric content and is an important fuel wood and charcoal source (Sheikh 1989). The wood fibers are processed into a pulp that is further made into paper (ICRAF undated). Heartwood yields 5.4% of oil, which approaches the texture of vaseline after cooling. It is suitable as a lubricant for heavy machinery (Browne 1968, ICRAF undated). The wood is excellent for heating and cooking. The calorific value of the sapwood is about 4900 kcal kg^{-1}, and that of heartwood is about 5200 kcal kg^{-1}. The sapwood is also used for pulp making (White 1994). Its wood is well and does not warp or split; it is extremely durable and is one of the timbers least susceptible to dry-wood termites in India. Wood offers resistance to sawing and cutting but is excellent for turnery, takes a good polish and finishes to a smooth surface. Its root wood is used for tobacco pipes. In village industry, *D. sissoo* is popular for doors and windows. The heartwood is extremely durable (the specific gravity is 0.7–0.8 g cm^3) and is very resistant to dry-wood termites; but the sapwood is readily attacked by fungi and borers. It is a useful source of honey, but the flowers are only lightly attached to the flower branch and fall easily. The bees are therefore not able to take full advantage of the large number of flowers. The honey produced is dark amber with a strong flavour. Sulphate pulp from wood is used in producing writing and printing paper (Parkash & Hocking 1986).

3-Leaves and young shoot uses:

The leaves, young shoots and green pods are used as good fodder for livestock and grazing animals, typically in winter seasons when other fodder is not available (Sheikh 1989). April to May is the best time for the production of high-quality fodder (Jackson 1987). Based on dry weight, the leaves of *Dalbegia sissoo* in India contain up to 24.1% crude protein, 4.9% fat, 26.1% crude fiber and 12.0% ash (Table 1, after Gohl 1981). The fodder value is highest in April and May, when other sources of green fodder are scarce (Tewari 1994). Although this fodder has no known undesirable compounds, feeding green leaves sometimes causes digestive disorders which can be prevented by making silage (Jackson 1987). Some ethnic groups in Cameroon are said to relish eating fresh young leaves of sissoo (Nadkarni 1954).

Table 1: Nutritive values of *Dalbegia sissoo* leaves in India (after Gohl 1981)

Nutritive value	Range and mean values (based on dry weight)		
	Minimum	Maximum	Mean
Crude Protein (%)	12.6	24.1	18.4
Fat (%)	2.0	4.9	3.5
Nitrogen -free extract (%)	42.1	54.8	48.5
Crude Fiber (%)	12.5	26.1	19.3
Ash (%)	6.6	12.0	9.3
Calcium (mg)	840.0	2870.0	1855.0
Phosphorus (100 g^{-1})	120.0	420.0	270.0

4-Ecological importance:

Sissoo provides numerous services to the landscape and environment and is commonly employed in agro-forestry (Lowry & Seebeck 1997). It is used as a windbreak and shelter belt and as a shade tree in intercropping of orchards, mango, tea and coffee plantations. Since it has an aggressive root system and is prone to suckering, it is commonly used for erosion control and soil stabilization along stream and river banks. It is widely planted in its native countries for reforestation programs (ICRAF undated and Sharma *et al*., 2000). It is also valued for its ability to increase soil fertility through nitrogen fixation and is intercropped for these reasons as well. Due to its fragrant flowers and shade, it is planted in urban areas along roadsides and in gardens as an ornamental plant (El-Hadidi & Boulos 1988, El-Sheikh 1989, 1996 and Gilman & Watson 1993). It also has been used for landscaping along the sea shores of Galilee (Kayastha 1985).

The leaf litter that accumulates and decomposes also contributes to soil fertility by adding additional nitrogen, potassium, iron, manganese and organic carbon (Keay 1989). In India, plant species diversity was much higher in the native *D. sissoo* monocultures than in the exotic *Eucalyptus tereticornis* ones (Sangha & Jalota 2005). In its native range, sissoo is a host to a variety of orchid species (ICRAF undated). It is therefore found in a variety of wastelands, like in south Asia, where it is known as a colonizing species. The sub-Himalayas, the

homeland of *D. sissoo*, abound with a variety of orchids, many of which are known throughout the world for their beauty (Parrotta 1989). Although sissoo trees can negatively effect crop production due to competition for nutrients, moisture and light; studies have shown that the net value of intercropping sissoo and wheat is higher than wheat monocropping (White 1994). The ease of propagation by self-seeding, coppice, root suckers and stumps and the many environmental and socio-economic benefits makes it one of the most valued tree species by farmers in the region (Tewari 1994).

Sissoo is one of the most trees used in greenbelt, which is defined as the mass plantation of pollution tolerant trees and shrubs in an area for the purpose of minimizing air pollution by filtering, intercepting and absorbing pollutants in an effective manner for improvement of the environment. The effectiveness of the greenbelt depends on the several factors such as climatic conditions, design, selection of plant species and its characters and type of pollutants. The importance of greenbelt can be ascertained from the estimate of cleaning capacity of 3.7 ton of CO_2 from atmosphere and supply of 2.5 ton of oxygen from one hectare of sissoo woodland (Sharma & Roy 1999).

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بيولوجية النباتات الخشبية المعمرة في مصر
٤- نبات السرسوع ***Dalbergia sissoo*** **Roxb. ex DC.**

كمال شلتوت، عمرو قشطه

قسم النبات – كلية العلوم – جامعة طنطا – مصر

يهدف هذا المقال المرجعى إلى استطلاع المراجع المتعلقة ببيولوجية نبات السرسوع، ويعتبر الرابع في سلسلة من البحوث المرجعية التي تتناول بيولوجية النباتات الخشبية المعمرة في مصر. مثل هذه الدراسات توجه اهتمام علماء بيولوجية النبات المصريين، ليس فقط نحو استكمال النقص في المعلومات عن جماعات النباتات البرية المصرية، ولكن أيضاً لتحديث القديم منها. مجال التوزيع الطبيعي لهذا النبات هو سفح جبال الهيمالايا من شرق أفغانستان عبر باكستان والهند إلى نيبال. قام إبراهيم باشا في عهد محمد علي بإدخال هذا النبات لمصر لأغراض الزينة والأخشاب، وقد أصبح من النباتات المتجنسة في مصر حيث يغزو حواف القنوات، جوانب الطرق، مفترق الطرق، حواف الحقول والمصارف.

يشتمل هذا المقال على معلومات عن تصنيف وتسمية نبات السرسوع، توزيعه العالمي والمحلي، شكل وتشريح النبات، بيئة النبات، الكتلة الحية، التكاثر والإدارة، الاستخدامات الاقتصادية والطبية والبيئية. وقد دل استطلاع المراجع على وجود نقص في المعلومات المتعلقة بالتغير في فسيولوجية النبات وتركيبه الوراثي علي امتداد التدرجات البيئية المصاحبة للنبات، كما أن تقييم التغيرات على مستوى الأشكال البيئية لجماعات هذا النبات تحتاج أيضاً لدراسات مستقبلية.