

## A CRITICAL REVIEW ON ANOGEISSUS PENDULA: AN IMPORTANT SPECIES OF ARID ZONE

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### Abstract

*Anogeissus pendula* is a multipurpose tree species with immense ethno-ecological importance. The tree has ecological significance for the Aravallis and other hilly areas of the country. The tree of *Anogeissus pendula* is socially acceptable and economically viable to the farming community. It is valued for timber and regarded as the third toughest timber in the world. Also used as a source of fuel wood, fodder and gum. However, *Anogeissus pendula* has some constraint also such as seed germination capacity and seedling growth is very slow. Due to its very slow growing nature it forms bushy appearance which reduces the value of the timber. Alternatively, attempts have been made to propagate this tree through in vitro approaches. In this communication, we emphasize the research progress made with respect to *Anogeissus pendula* on various aspects, and suggest some future directions of research.

**Keywords:** *Anogeissus pendula*; Ethno-ecological context; Conservation status; Timber species.

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### Introduction

*Anogeissus pendula* (family: Combrataceae), commonly known as dhok/kardhai is a tree of arid region and is distributed in tropical Asia and Africa. It grows in the dry and hot regions of India reported by A.C. Gupta [1]. This species is recognized as climax species of Aravalli hills and grows up to 9–15m in height and 1cm in girth. It is an important tree species of the fragile ecosystem. Its seeds are very small, highly recalcitrant and germination is less than 2 percent. This tree species is drought hardy and has ecological significance, social acceptance and economic viability for the farming community of the Aravallis and other hilly areas of the country. It yields timber, fodder, fuel, and other products.

Its wood is very tough, it has a lot of mechanical strength, and is regarded as the 3rd toughest timber in the world. The timber is used for making furniture, doors and window panels, house constructions, agricultural implements, poles for fencing and roofing. The wood is also a source of charcoal of high calorific value. D. Hocking [2] reported that owing to good calorific value the fuel wood of this species is sold in the market at higher rate as compared to other fuel wood species. Being an excellent fodder crop, this species is heavily grazed. Bark of the tree yields a gum called gatti also known as Indian gum. The main value of the tree lies in its afforestation purposes, majorly for afforesting the semi-rocky and rocky terrains of arid regions. The dry wood is used as fire-wood and green and fresh leaves are used as a fodder.

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However, *Anogeissus pendula* has some constraint, firstly, seed germination capacity is very low, and growth of seedling is very slow. Secondly, due to its very slow growing nature it forms bushy appearance. Thirdly, as so many branches emerge from the base itself as well as main, its bole is mostly crooked.

As it is an important species of Aravallis range of arid and semi-arid region therefore an attempt has been made to review and summarize the information available about the species.

### ***Taxonomic classification***

Kingdom:	Plantae
Phylum:	Tracheophyta
Class:	Magnoliopsida
Order:	Myrtales
Family:	Combretaceae
Genus:	<i>Anogeissus</i>
Species:	<i>Pendula</i>

### ***Distribution***

*Anogeissus pendula* Edgew., locally known as *Kardhai*, is distributed throughout the tropical Asia and Africa. It grows in dry, hot regions of India, commonly occurring in the dry tropical forests and dry mixed deciduous forests of Rajasthan, part of Gujarat, Madhya Pradesh, Haryana and Bundelkhand region of Uttar Pradesh, reported by *A.C. Gupta* [1]. *Anogeissus pendula* is a dominant tree of the Aravalli hills of Rajasthan and of Sabarkantha and Banaskantha divisions of Gujarat, where it forms a pure forest. Further, it is distributed northwards to Jhansi, Hamirpur and Banda districts of the Bundelkhand region of Uttar Pradesh as also southwards to the river Narmada in Nimar district of Madhya Pradesh. *R.V. Singh* [3] reported that it is very common in Gwalior and Shivpuri forests and abundant in many parts of Rajasthan, particularly in Ajmer-Marwar forests. It grows naturally in crevices of rocks in the Bundelkhand region of Uttar Pradesh (Fig. 1).



**Fig. 1.** Natural Plantation of *Anogeissus pendula* (Dhok)

### ***Botanical description***

*Anogeissus pendula* is a slow growing, small to medium sized deciduous tree species belonging to the family Combretaceae. In a study *D. Hocking* [2] quoted that it usually forms nearly pure crops, often quite well stocked and seldom attains a height of 9–12m and girth

of 1.5m. *C.M. Mathur* [4] reported that it hardly reaches the maximum height of 9.39m and DBH 12.22cm even in 50 years of growth in Rajasthan. The bark of the tree is extremely variable, smooth and silvery at first, becoming grey and rough with dark, chapped patches on old trees. The branches are pendulous or drooping. The leaves are small, usually only 1–2cm long, narrowed at both ends, arranged in opposite or near opposite pairs. New leaves are soft and silky with silvery hairs, gradually becoming smooth. The flowers are tiny, massed together in spherical heads 8–14 mm in diameter, greenish-yellow, with the stamens sticking out in all directions, no petals, and the calyx cup is shaped and prominent. The fruits are flat and nearly circular in outline, with a long beak packed together in round heads. The leaf fall period of *Anogeissus pendula* is December to March, flowering during August to September and fruiting occurs in November, as observed by *P. Krishen* [5].

#### Growing season and type

*D. Singh et al* [6] reported that the soil is the most important factor controlling the distribution, composition, production and forest trees. He observed that *Anogeissus pendula* appears to occur on sites relatively much poor in C/N ratio (10 or less). *R.K. Gupta* [7] accounted that it grows well on soils having pH range of 5.5–7.0, silt plus clay proportion of 10–30%, base exchange capacity of 2.2–10.4mcq/100g, organic matter of 1.7% and available phosphorous around 140–180kg/ha, K<sub>2</sub>O of 220–300kg/ha and total nitrogen of about 0.003–0.004%. *A.C. Gupta* [8] described that the tree grows in different soil types in Bundelkhand region where the parent rock is mainly gneiss giving rise to a thin layer of coarse sandy red soils and where bare rocky outcrops also common *A.C. Gupta* [8]. However, good growth is obtained where the soil is deep and the underlying rocks gneiss and schist was observed by *O.P. Bhargava* [9]. *Anogeissus pendula* grows in tropical climate where the annual rainfall ranges from 400 to 950mm. The maximum temperature varies from 44–47°C and the minimum temperature from -1 to 3°C, as accounted by *R.S. Troup* [10]. *P.S. Srivastav et al* [11] and *A. Rai* [12] reported that the species can withstand a temperature regime of 23–47°C.

#### Relatives

*Anogeissus pendula* is most commonly found in the Aravallis and the Vindhyan ranges. *G.S. Puri and S.K. Jain* [13] have made studies on *Anogeissus pendula* and found that the frequency of occurrence of the species varies at different places considerably. *S.K. Verma* [14] observed that *Anogeissus pendula* is also growing in association with other species like *Grewia populifolia*, *Euphorbia*, *Zizyphus*, *Gymnosporia*, *Acacia catechu*, *Acacia Lecucophloea*, *Wrightia tinctoria*, *Bauhinia racemosa*, *Diospyros melanoxylon*, *Dichrostachys cinerea*, *Flaocourtia ramontchii* *Anogeissus acuminata*, *A. latifolia*, *A. sericea* sub sp. *sericea*, *A. sericea* sub sp. *nummularia*, and *Terminalia spp.* *R.V. Singh* [3] surveyed Bundelkhand area of U.P and observed that *Anogeissus pendula* grows in quartz ridges in association with *Diospyros melanoxylon*, *Acacia catechu*, *Zizyphus xylopyrus*, *Bauhinia racemosa*, *Odena wodier* and *Butea monosperma*. At Abu in the southwest end of Aravalli hills, it is associated with other species of the genus such as *Anogeissus sericea*, *A. latifolia* and with tall shrubs and trees of *Carissa* and *Euphorbia*. In the Vindhyan ranges such as in Shahabad in Kota, *Anogeissus pendula* is the most dominant species on hill slopes. The upper parts of slopes have *Anogeissus latifolia* mixed with *Anogeissus pendula*. The lower parts have *Acacia catechu* mixed with it, but the middle slopes have at places pure communities of *Anogeissus pendula*. *Grewia* and *Nyctanthes* are the commonest in the under-growths. In some areas the canopy of the forest is dense and undergrowth is poor. *R. Mathur and P.S. Bhatnagar* [15] reported *Anogeissus pendula* was the major plant species of Ambagarh forest divisions of Jaipur (Rajasthan) along with other plant species *Parkinsonia aculeata*, *Zizyphus nummularia*, *Acacia tortilis*, *Acacia nilotica*, *Holoptelia integrifolia*, *Prosopis cineraria*, *Adathoda vasica*, *Dichrostachys cinerea*, *Prosopis juliflora*.

### Economic Importance

*Anogeissus pendula* has multiple uses. The tree is valued for timber. The timber obtained from this species is very hard, tough, strong, and durable and is equivalent to teak in terms of transverse strength. It does not decay and discolour. Its timber has great potential value because of its strength and working qualities. It is used as poles and rafters in construction, for picker's arms, shuttles and bobbins, cart axles, wheel spokes and frames and on furniture making. In central India, *Anogeissus Pendula* is commonly used as timber for agricultural implements and for huts. The calorific value of the sapwood is 4.837 kilocalories and that of the heartwood 4.739 kilocalories. The heartwood is blackish purple, heavy ( $946\text{kg/m}^3$ ), hard, difficult to see, shock resistant and makes the best tool handles was reported by D. Hocking [2]. V.D. Limaya [16] reported that *Anogeissus pendula* breaks the world record in a toughness test. The specific weight, crushing strength, stiffness, retention of shape, hardness, sheerness strength of teak were:  $0.683\text{g/cm}^3$ ,  $468\text{g/cm}^2$ ,  $80.2\text{t/cm}^2$ ,  $702.33\text{kg/cm}^2$ ,  $527\text{kg}$ ,  $91.89\text{kg/cm}^2$  respectively as reported by R.S. Troup [17]. R.S. Troup [10] accounted that when these parameters was compared with *Anogeissus pendula* it was found to be: 124–141, 103–112, 85–88, 64–70, 151–169, 136–151 percent, respectively. In old growth stands of *Anogeissus pendula* in Alwar and Swai Madhopur, humus layers are seldom built to a depth of more than 5cm, beneath which is a grey leached layer of sandy soil 7–14cm thick overlying a brownish layer of sandy soil a few meter thick in cracks and crevices of hills. Oven dried weight of forest litter of *Anogeissus pendula* in a 12 month period averaged 8700–12000kg/ha in a stand of 30–35 year ago; the composition of the same was CaO 2.12–2.30%, MgO 0.43–0.44%,  $\text{K}_2\text{O}$  0.33–0.36%,  $\text{P}_2\text{O}_5$  0.16–0.19%,  $\text{SiO}_2$  0.79–0.86%, Silica 5.91–6.61%, and the ash contest 14.62–15.50% on dry matter basis. Since the trees do not have straight boles, they are generally used as fuel or for making charcoal. The wood is of moderately good fuel efficiency. D. Hocking [2] has reported it as excellent firewood (5300kcal/kg) and it is sold at premium prices in the market as compared to other fuelwood trees. The tree yields the Ghatti or Indian Gum which is edible and has medicinal value.

The leaf yields a dye producing a dark green color. *Anogeissus pendula* is very useful in agroforestry system. It is suitable for Bundelkhand area where soil are gravelly and rocky. Due to its hardness property, water requirement is very low. Thus, it grows easily in Bundelkhand region and it has been observed that some of the area of Bundelkhand it is grown as a boundary plantation. The leaf fall period of *Anogeissus pendula* is December to March. In summer May to June when animal get require green fodder, it become lush green. The wood is very good fuel efficiency.

**Table 1.** Medicinal uses of different parts of *Anogeissus pendula*

Parts used	Uses	References
Leaves Twigs	Decoction is applied on burn part of the body to clear the spot, Paste is use in swellings externally	R. Yadav and R.K. Khare [18], R. Vardhana [19]
Bark	Anemia, Dysentery	A.K. Dashahre et al [20], V. Nath and P.K. Khatri [21]
Fruit	Urticaria, Hiccough, and Constipation	A.K. Dashahre et al [20]

### Phytochemistry

The tree leaves contains tannins and alkaloids. The leaves are considered to be excellent fodder. They are moderately palatable and nutritious as described by K.C. Sen and S.N Ray [22] and contain 7.60% crude protein, 19.00% crude fiber, 65.30% N free extract, 8.10% ash, 0.10% phosphorus, 3.50% calcium and 0.30% magnesium as quoted by B.N Ganguli et al [23]. The higher crude protein value of leaves (13.61%) has also been reported by P. Rai et al [24], R.K. Gupta [7]. The seeds possess haemagglutinating property against the human A, B and O red cells.

***Insect pests and diseases of Anogeissus pendula.***

Insects and diseases are integral components of forest dynamics, in which they fulfil important roles. However, occasionally the populations grow rapidly to damaging proportions. Natural stands of *Anogeissus pendula* suffer with a serious infestation caused by defoliator, affected patches of trees exhibited the symptoms of severe skeletonized leaves reflecting infestation of a lepidopteran out-break. *Eutectona machaeralis* (Lepidoptera: Pyralidae) which is most pernicious pest of teak responsible for epidemic defoliation regularly in nurseries, plantations and natural forests.

S.K. Verma [25] reported two species of longicorn borer, namely, *Olenecamptus anogeissi* Gardener and *O. indianus* Thompson which attack the dead and dying trees and bore tunnel through sap wood and sometimes hardwood also. Studies on Vesicular arbuscular mycorrhizae (VAM) in *Anogeissus pendula* at the farm of NRCAF Jhansi revealed 100% colonization of VAM presence. However range of colonization index varied from 11.3-78.8 as described by A. Kumar [26].

S. Bhatnagar et al [27] in a close examination of the drying trees revealed association of several insects in the aerial portion viz., Leaf miner, leaf blotcher (Dipera), Myllocerus leaf weevil (Curculionidae), leaf webber, bark eating caterpillar (Lepidoptera), shoot borer (Coleoptera) and termites (Isoptera). Two foliar pathogens were identified as *Nigrospora* species (Leaf Spot) and *Pestalotiopsis* species (Foliar Blight). Root pathogens were identified to be *Ganoderma lucidum* and *Macrophomina phaseolina*.

***Seed purity and Germination:***

C.D. Athaya [28] observed that seeds of *Anogeissus pendula* are smaller and lighter which can easily be dispersed. A.S. Yadav and J.P.Tripathi [29] observed that seeds of *Anogeissus pendula* are winged with a terminating beak. The weight of the seeds ranged from 1mg to 17mg depending upon the size and volume. Number of seeds per gram in the seed lot of Kardhai ranged from 100 to 275 depending on their individual weight. The seeds of *Anogeissus pendula* varied greatly in their length, width and thickness ranging from 4.66mm to 7.00mm, 3.28mm to 5.68mm, and 1.06mm to 2.06mm respectively. The fresh seeds contain 13.4% moisture by weight, which ranged in between 9% to 19%, depending on the level of seed maturity. In biochemical staining the seeds, on an average, exhibited 15% viability. S.K. Saxena [30] reported production of unfertile seeds seems to be a major factor for the poor germination percentage in *Anogeissus pendula*.

***Propagation***

Regeneration through seeds is extremely difficult and is not so much in practice as the viability of seeds is very low (0.2-0.4%). O.P. Bhargava [9] stated that since the germination of this species is very low their establishment through vegetative propagation techniques has a great importance. Vegetative propagation of *Anogeissus pendula* through stem cuttings and air layering is possible with the help of IBA solution of different concentrations (50–1200ppm) in the rainy and spring seasons under normal nursery conditions was accounted by V.K. Gupta and R.V. Kumar [31]. M.S. Joshi et al [32] carried out studies on micropropagation of *Anogeissus pendula* were carried out with in vitro germinated four week old seedlings on MS medium supplemented with various concentrations of cytokinins and auxin. Success has been achieved in developing a complete protocol for mass propagation of *Anogeissus pendula*. Seeds cultured on plant growth regulator-free, semisolid Murashige and Skoog (MS) medium germinated within 5–6 weeks and formed 4–6cm long shoots. The shoots multiplied on MS + 4.4 $\mu$ M benzyladenine (BA) + 5.7 $\mu$ M indoleacetic acid (IAA) + casein hydrolysate (100mgL<sup>-1</sup>) + ascorbic acid (50mgL<sup>-1</sup>) + sucrose (3%) + agar (0.8%). A majority of the genotypes rooted with more than 90% efficiency when 5–6cm individual shoots were cultured on 1/2MS (only major salts reduced to half strength) + 2.3 $\mu$ M IAA + 2.5 $\mu$ M indolebutyric acid (IBA) + sucrose (3%)

+ agar (0.8%) for 15 days. Those 10% (approx.) genotypes that did not root well on the above medium could be rooted with ease by increasing the concentration of IAA in the rooting media from 2.3 to 5.7  $\mu\text{M}$ . The in-vitro-raised plants were successfully transferred to the soil with a success rate of over 85%. Using this protocol, over 560000 tissue-cultured plants of these two species have been produced and dispatched to various state forest departments for field trials and routine plantations by *S. Saxena and V. Dhawan* [33].

*S. K. Tiwari et al* [34] made an attempt for standardizing the propagation technique of this species through stem branch cutting by optimizing the best concentration of IBA (root promoting hormone) for rooting of cuttings under mist chamber. Different sized cuttings were selected for optimizing rooting response. The best rooting response was obtained in hard wood cutting (20–25cm length and width 0.5–2.5cm) in 1000ppm of IBA within 60–70 days from April to June.

## Discussion

*Anogeissus pendula* is a suitable tree species with a wide range of adaptability and can be introduced in different systems of agroforestry specially silvipastoral system in rocky-gravelly land for enhancing the total biomass production and soil improvement. The wood has a lot of mechanical strength and very tough. The timber is used for furniture, agricultural implements, tool handles of all kinds, poles, rafters, for carts, spokes of wheels, toys, shuttles and bobbins, tool handles etc. The leaves are used as fodder. The main value of the tree is in its use for afforesting the semi- rocky and rocky terrains of arid regions. Literature search has shown that this plant has ecological significance, social acceptance and economic viability for the farming community for the Aravallis and other hilly areas of the country.

Regeneration is extremely difficult through seeds and viability of seeds is very low. Therefore vegetative propagation technique has a great importance in propagation of this important multipurpose tree species of the Aravalli range.

In general the number of tree species is very limited in arid zones, and are very slow growing due to limitations of environmental conditions. But they are so intricately associated with the life of human beings in arid areas that peoples in arid zones have developed production systems in which woody perennials have a very important role, both from productivity as well as a resource conservation point of view. Thus trees helps in reducing the adverse effects of frequent droughts.

*Anogeissus pendula* is an important species of the Aravalli range of the arid and semi-arid region, reputed for its fuel, fodder, timber and medicinal properties. *Anogeissus pendula* cover more than half of the total forest area in the state of Rajasthan as quoted by *M. Sharma and A. Kumar* [35].

*Anogeissus pendula* is one of the dominant tree species of the Aravalli range, and shares an intricate relation with environmental and socio-economic conditions of arid zones. Forest departments, conservationists and physicians dedicated to medicinal plants should join hands to save this natural resource of the arid region. NGOs should take voluntary measures for the conservation and propagation of such an important multipurpose tree species, preventing it from extinction in the near future.

## Conclusion

In the present review we have made an attempt to explore and provide the maximum information of botanical description, its relatives, economic importance, phytochemistry, insect's pests and diseases, seed germination and propagation of *Anogeissus pendula*.

Suggestion is made for an ecological study of *Anogeissus pendula* populations, for the people who depend on its products for their daily needs and are most directly disturbed by loss of trees could get assured for future livelihood. Also studies on the effect of the biotic disturbances, particularly from the over exploitation of tree resources for fuel and fodder, generally causing negative impact on species diversity should be made for conservation of tree species.

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