

Teak supporting soils of India: a review

Abstract

Natural teak forests occur on black and red soils developed from the underlying rock viz. sandstone, granite-gneiss, and basalt in different parts of India including Madhya Pradesh, Maharashtra, Tamil Nadu, Karnataka and Kerala besides Uttar Pradesh, Gujarat, Orissa and Rajasthan. The variation in the growth, quality and distribution of teak is mostly dictated by soil-site characteristics. In general teak is ideally suitable where Deccan trap i.e. basaltic rock is common since it is a calcareous plant, whereas sandstone produces teak of poor quality. Teak is susceptible to poor drainage conditions and thus soil moisture is one of the most critical factors affecting teak growth. Soil texture is the most influential physical parameter as it affects water retention, drainage, infiltration rate and aeration. Soil reaction (pH) value governs to a great extent the entire chain of biochemical processes in a soil, so it is an important chemical parameter in determining the suitability of teak. Organic carbon is higher at the surface than the sub-surface which is attributed to the litter fall. Base-rich soils with high organic carbon and exchangeable calcium are highly suitable for teak. Recycling of nutrients specifically exchangeable calcium and magnesium is common in teak forests.

Keywords: organic carbon, recycling of nutrients, calcareous plant, soil texture, magnesium, geographical area, forest survey, plantation tree species, ecological, socio-economic, climate, geology, tree growth, forest vegetation, soil properties

Volume 2 Issue 3 - 2018

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Received: January 18, 2018 | **Published:** June 08, 2018

Introduction

Forest occupying a substantial portion of India's area the forest cover in the country is 70.17 million ha which accounts for 21.42 per cent of the total geographical area.¹ *Tectona grandis* family *Verbenaceae* is one of the major plantation tree species of the world, which is naturally distributed in Southeast Asia. It is a unique species whose timber is the most aristocratic amongst the timbers of India. Teak is a species of significantly ecological and socio-economic importance throughout the tropics. Though the teak plantations account for 5-8% of the total forest area in the tropics,² about 90% of the quality hardwood plantations for timber production belongs to teak only. In India, the localities where most important teak forests are found are Madhya Pradesh, Maharashtra, Tamil Nadu, Karnataka and Kerala besides Uttar Pradesh, Gujarat, Orissa and Rajasthan.³ The distribution of teak is largely controlled by climate, geology and soil wherein soil plays an inevitable role in the growth and development of teak forests. Therefore, differences in soil properties can influence both the composition of forest vegetation and the rate of tree growth.⁴ Knowledge of forest soil properties is important for proper management of the environment and utilization of forest resources. Variations in wood quality with tree growth are strongly related to physical and chemical properties of the soil.

Geology

The variation in the quality and distribution of teak has been reported by many workers with the nature of the soil and the underlying rock from which it is formed. Soil-site characteristics are mainly responsible for such variation in the distribution of the teak forests³ gave a number of examples to show that forest vegetation in India is related with geological and soil conditions⁵ correlated the geology and the forest types of North Chanda division, Madhya Pradesh and observed superior growth of teak on trap formations, metamorphic rocks and the Vindhyan sandstones. He further found

that in case of the sedimentary rocks it was the physical and not the chemical nature of the soil which controlled the occurrence of teak. Quartz-schist developed stony unfertile soils bear scrubs, whereas moderately drained soils support mixed forest and black cotton soils support thorny forests. His observation was that "teak can be seen wherever the geological conditions are favorable to it and if teak does not exist anywhere, it is certain that the geology of the locality is not suited to it"⁶ attempted to clarify the position on the relation of teak with the rock and the soils in Madhya Pradesh. The soils originating from Deccan trap possess substantially a much higher water-holding capacity as those formed from crystalline porous rocks or sandstone. Under the prevalent climatic conditions of Madhya Pradesh, where long dry spell follows the rains, trap retains sufficient moisture during the growing season of teak. Sandstones are intermediate between the trap and crystalline rocks in retaining moisture⁷ reported the relationship of teak to geological conditions in Madhya Pradesh. He found that the Gondwana system consisting of fresh sedimentary deposits do not bear teak but basaltic rocks are ideally suited for teak^{8,9} studied the relationship between parent rock and variation in teak growth in Mysore. He observed that teak avoids those places where late rite is common. Teak is common where trap is present but where sandstone is present, teak is of a very poor quality¹⁰ has made an intensive study of rocks and soils in Madhya Pradesh and found that teak requires certain minerals which are present in the igneous rocks and which have been lost in the sandstones.

These minerals would include the bases chiefly calcium which is abundantly found in the soils derived from the igneous rocks¹¹ reported that basalt has a good supply of exchangeable Ca^{2+} and other nutrients which favored the growth of teak in Madhya Pradesh^{12,13} while working on the teak area of south Chanda district of Maharashtra suggested that sediment under natural teak were derived from acid igneous and metamorphic rock. The soil could not be typified by any particular mineral. However, concentration of iron ores indicated of

intense weathering before deposition or during soil formation stated that the decrease in Fe and Mn in sub-soils may interfere with growth of teak¹⁴ reported that soils developed over basalt mainly support teak in Mandla district having sub-humid, subtropical climate with mean annual rainfall of 1400 mm and mean annual air temperature of 26.9°C studied the mineralogy and nutrient status of teak growing soils and pointed out that the impeded drainage, high clay content along with shrink-swell property, calcareous concretions, paralithic contact and high pH are the factors responsible for the poor growth of teak¹⁵ characterized and classified teak-growing soils of Central India. They pointed out that shallow solum, high swelling clay and low CEC are the limitations for growth of teak.

Soil moisture and drainage

The distribution, extent and growth performance of teak forest is influenced to a considerable degree by soil drainage and its adequacy. Teak is susceptible to poor drainage conditions and thus imperfectly drained soils are not suitable for teak. Impeded drainage restricts the development of roots and thereby affects the growth of tree¹⁰ observed that teak avoids excessive dryness on the one hand and water-logging on the other. He also reported direct correlation between teak growth and soil factors such as pH, exchangeable calcium, magnesium and phosphorus, whereas no significant correlation was found between organic matter content and teak growth.

Soil texture

Among the physical parameters, the texture is considered as most important one that influences the tree growth. It influences the water retention, total available water capacity, drainage infiltration rate and aeration. Sandy clay loam, well-drained soil seem to be more ideal for teak growth.¹¹ In Chandrapur district of Maharashtra, reported that *Tectona grandis* grows well on sandy soils overlying pyroxene, gneisses and associated quartz schist with breccias and with relatively deep water table¹⁶ studied influence of soil texture on growth and stock of naturally occurring tree species and found that *Tectona grandis* are very sensitive to coarse soil texture and require medium textured soil¹⁷ suggested that soil nutrient at surface are related to existing vegetation and amount of clay in sub-surface. They reported high amount of organic matter in teak plantation. It was concluded that teak plantation site had significant positive relationship between soil depth and soil characters, except organic matter, sand and silt had inverse relationship. Positive significant correlation between depth and clay content of soil under teak indicates that leaching of clay is pronounced under prevailing environment.

Chemical properties

Amongst the Physico-chemical properties of a soil no single property occupies such an important place as pH in directing the intimate relation between the soil and the plant. Soil reaction (pH) value governs to a great extent the entire chain of biochemical processes in a soil, leading to either fertility or infertility. Although, pH itself depends upon so many factors, yet it is the most important single value index in determining the suitability or otherwise of a soil for the growth of a specific plant. Soil reaction is the most important chemical parameter which is responsible for the irregular distribution of teak.⁷ He also reported that in M.P teak is largely confined to soils with a pH range of 6.7 to 7.5 and below pH 6.0 teak is practically absent from natural forests. It was also pointed out that beyond pH 8.5 the presence of excessive alkalis or alkaline earths in the soil seems

to be definitely toxic towards the teak growth¹⁸ attempted a study in Nilambur forests and reported that both good and bad teak existed at all pH ranges and areas bearing good quality teak had pH values even as low as 5.5.

Studied the calcium content in rocks⁷ in relation to frequency and occurrence of teak in northern slopes of Satpuras. He concluded that lime is an essential major constituent of practically all the rocks such as the trap, metamorphic and conglomerate which are capable of yielding a good teak crop, but is badly deficient in those such as Gondwana sandstone which bare only miscellaneous forest. He also concluded that teak is a calcicolous species exhibiting its best growth on soils rich in bases¹⁰ attempted to ascertain the role of surface geology and the soil in relation to the growth of teak mainly on the basis of the mineral content, especially calcium, of the underlying rock. He suggested that most of the soils formed from the rocks rich in bases support teak. His findings indicate that teak grows well on igneous rocks and Bagra conglomerates simply because these rocks contain good deal of calcium¹⁹ reported that higher value of CEC (22.5 to 22.7 cmol (p⁺) kg⁻¹) in the soil under *Tectona grandis* may be due to higher amount of organic matter containing fairly good reserve of bases returned from leaf litter²⁰ reported that teak attains better quality on a moist soil developed from basalt which is acidic and has an adequate amount of exchangeable calcium and satisfactory phosphorus availability¹¹ reported that soil with a good amount of organic carbon (0.8 to 1.0 per cent) and higher CEC is favorable for teak growth.

They also pinpointed that the soils of teak zone had higher cation exchange capacity which confers on it the property of retaining high exchangeable calcium and renders condition more favorable for its growth²¹ reported the absence of teak and failure of teak plantation in Hoshangabad forest division of Madhya Pradesh on the soils deficient in exchangeable Ca and Mg.²² observed that total bases at surface soil under teak is highest but under mixed species much lower²³ reported that pH under teak plantation was slightly lower than under the adjoining natural forests²⁴ observed significant increase in pH and base saturation of soil under teak after 12 years of plantation and after 28 years, pH and base saturation further increased and soil was transformed from Inceptisols to Mollisol at order level^{25,26} studied the soils of Bori forest, Madhya Pradesh. The soils were mildly acidic to neutral in reaction. The organic matter content of soils was high at the surface and gradually decreased down the profile. Ca as compared to Mg is more recycled from lower to a horizon. High Ca: Mg ratios in the upper layer relative to lower ones elucidate the active role of teak in the pedogenesis. Organic carbon under teak sites ranged from 3.57 to 0.2% throughout the depth. The soils were classified as Mollisols¹⁷ observed that the teak species can grow well in soils having moderate to deep solum, acidic pH, loamy texture and also having appreciable amount of organic carbon, total N and exchangeable Ca²⁺. In Tarai area of Darjeeling,¹⁷ found that teak-growing soils are acidic and contain appreciable amount of organic carbon, total N and exchangeable Ca. They also reported that teak can grow in soils having moderate to deep solum depth, acidic, loamy texture and appreciable amount of organic carbon provided with cool tropical climate²⁷ reported that exchangeable Ca and Mg generally greater at all ages of teak than in fallow and agriculture soils.

Acknowledgements

None.

Conflict of interest

The authors declare there is no conflict of interest.

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