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Growth and carbon stock assessment of different aged mahogany plantations in hilly zone of Karnataka

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Abstract
Swietenia macrophylla is an economically important tree species. Its moderately fast growth and adaptability to different environmental conditions and good economic returns has made it a popular tree species in Karnataka. The present study aims to know the growth and carbon sequestration of mahogany tree in hilly zone of Karnataka. Twenty-five trees selected from each age gradation of one and half year to four and half year old were selected and evaluated for the growth and carbon estimation. A significant difference is observed among one and half year to four and half year-old mahogany trees for growth parameters such as height (2.73 to 5.11 m), GBH (10.80 to 28.04 cm) and the volume (2.20 to 24.18 m^3/ha). Growth pattern of mahogany showed an increasing trend with tree age. Carbon sequestration also varied with tree age. Maximum carbon sequestered by four and half year-old plantation (8.07 t ha^{-1}) compared to the rest.

Keywords: Growth assessment, carbon stock estimation, mahogany, *Swietenia macrophylla*, hilly zone

Introduction
Swietenia macrophylla is one among the three genuine mahogany species belongs to the family meliaceae. It is large evergreen tree native to southern Mexico to Peru and Brazil. It is known in several names such as Honduran mahogany, big-leaf mahogany, Brazilian mahogany. *S. macrophylla* has become a promising tree species for industrial plantations as well as for reforestation and afforestation. The number of smallholder *S. macrophylla* plantations is increasing in India owing to its high-quality wood used for making of cabin, furniture, sports goods and musical instruments. In 1795, mahogany was introduced to India at botanical garden, Kolkata. Later this species has grown widely in southern states of India [1]. It grows up to 30 m with a diameter at breast height of more than 1.5 m. Young tree possess a narrow crown whereas old trees have broader crown. The leaves are usually paripinnate, sometimes imparipinnate, 12-45 cm long, and are made up of 3-6 pairs of lanceolate or ovate leaflets. The leaflets are asymmetrical, 5-12 cm long and 2-5 cm wide, with a whole margin and an acute or acuminate apex. It can tolerate a wide range of soils and environmental conditions. It grows well on deep, fertile, well-drained soils with a pH of 6.5-7.5. It requires a optimum annual rainfall is between 1000 and 2500 mm with a dry period of 0 - 4 months and mahogany can grow at elevations of 0-1500 m above sea level, in areas with a mean annual temperature of 20-28 °C [2]. Despite of its excellent timber and multiple utility the tree has not been known to many people for long time.

Due to the increasing demand of wood and the development of forest-based industries in India, plantation of fast-growing tree species became important for meeting the industrial wood raw material [3]. Fast growing agroforestry plantations can be a possible solution for meeting the demand of wood requirement [4]. In the current scenario mahogany has got some attention due to its deep rooting, adaptation to environment fluctuations, adoptability, better wood qualities and higher returns[5]. Hence the present study was carried out to know effect of age on the tree growth and carbon sequestration potential of *Swietenia macrophylla*.

Material and Methods
The present study was conducted at Mundgod of Uttara Kannada district in Karnataka. Twenty-five trees have been selected by laying the plot of 15 × 15 m in plantation of one and half year to four and half year-old with a spacing of 3 × 3 m. The study area belongs to tropical climate characterized by fairly hot summer and warmer monsoon with heavy rainfall. Soils are red sandy loam to lateritic in nature. The average annual rainfall is 2500 mm. Measurements of 25 trees averaged in to five replications. Height of the tree was measured by using a Ravi

altimeter and GBH was measured by using a measuring tape at 1.37 m from the base.

Basal area was measured by using the formula [6] $gbh^2/4\pi$. Volume of the tree was calculated by multiplying the basal area, height and form factor and the results were expressed to per hectare [6]. Above ground biomass was calculated by multiplying the volume with wood density [7]. Since it is a non-destructive analysis, standard wood density was applied (530 kg m^{-3}). Below ground biomass was obtained by multiplying 0.26 with above ground biomass [8]. Total biomass was calculated by sum of the above ground and below ground biomass and carbon sequestration was calculated by multiplying 0.5 with total biomass [7].

Results and Discussion

Tree height of mahogany was significantly differed due to age are presented in Table 1. The maximum height was observed in four and half year-old mahogany (5.11 m) and the minimum height was observed in one and half year-old mahogany (2.73). Girth at breast height was increased from one and half year to four and half year. The maximum girth at breast height of mahogany was observed in four and half year-old plantation (28.04 cm) and the minimum in one and half year-old plantation (10.80 cm). An increasing trend of tree height and girth at breast height from one and half year to four and half year was observed. Similar kind of results were obtained in *Acacia auriculoformis* [9], in eucalyptus [10] and in Ailanthus [11].

Table 1: Effect of age on the growth parameters of mahogany

Age of the plantation (yr)	Tree height (m)	GBH (cm)	Basal area (m^2 ha^{-1})	Volume (m^3 ha^{-1})
1.5	2.73	10.80	1.03	2.20
2.5	3.72	15.51	2.13	5.86
3.5	4.53	23.02	4.69	14.88
4.5	5.11	28.04	6.96	24.18
CD at 5%	0.08	0.97	0.42	1.39
SE(m)	0.02	0.31	0.14	0.45

Basal area differed significantly with age of the tree (Table 1) and it was ranged from 1.03 m^2 ha^{-1} (one and half year) to 6.96 m^2 ha^{-1} (four and half year). The volume of mahogany plantation was maximum at four and half year (24.18 m^3 ha^{-1}) whereas minimum in one and half year old plantation (2.20 m^3 ha^{-1}). Volume is increased with increase in age, similar results were reported in eucalyptus [10].

Table 2: Effect of age on biomass and carbon sequestration of mahogany

Age of the plantation (yr)	Above ground biomass (t ha^{-1})	Below ground biomass (t ha^{-1})	Total biomass (t ha^{-1})	Carbon sequestered (t ha^{-1})
1.5	1.17	0.30	1.47	0.74
2.5	3.11	0.81	3.92	1.96
3.5	7.89	2.05	9.94	4.97
4.5	12.81	3.33	16.15	8.07
CD at 5%	0.73	0.19	0.93	0.46
SE (m)	0.24	0.06	0.30	0.15

Above ground biomass, below ground biomass and total biomass were differed significantly due to age of the plantation and are presented in Table 2. Maximum above ground biomass (12.81 t ha^{-1}) below ground biomass (3.33) and total biomass (16.15) were recorded in four and half year-old plantation whereas minimum above ground biomass (1.17), below ground biomass (0.30) and total biomass (1.47) were recorded in one and half year-old plantation. Carbon sequestration was highest in four and half year-old plantation (8.07) and lowest in one and half year-old plantation of mahogany (0.74). Carbon stock was increased as age increased. Similar findings were reported in eucalyptus [10] and acacia [9].

Conclusion

Present study concludes that growth in terms of height and girth at breast height increased as age increases. Carbon stock of mahogany plantation was significantly increased from one and half year to four and half year. This indicates that this species can be effectively used for mitigating Climate change because of its fast growth and good carbon sequestration potential.

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