

Growth Performance of Native Tropical Tree Species on a Coal Mine Spoil on Singrauli Coalfields, India

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Abstract

A study was conducted to assess the growth performance of eight native tropical tree species planted on a coal mine spoil on Singrauli Coalfields, India. Of all the investigated tree species *Acacia catechu*, *Albizia lebbek*, *Dalbergia sissoo* and *Millettia pinnata* were represented by the leguminous species while *Azadirachta indica*, *Gmelina arborea*, *Tectona grandis* and *Terminalia bellerica* were represented by the non-leguminous species. The overall performance of the leguminous tree species was greater than the non-leguminous tree species. Among all the studied tree species, the leguminous *Albizia lebbek* was the best performing species while the non-leguminous *Terminalia bellerica* was the poorest performing tree species on coal mine spoil. *Gmelina arborea* and *Azadirachta indica* were the best performing tree species among the non-leguminous species.

Keywords

Coal Mine Spoil, Growth Performance, Singrauli Coalfields

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1. Introduction

Mine spoils are drastically disturbed and physically, nutritionally and microbiologically impoverished habitats [1, 2]. It needs to be stabilized to prevent erosion and contamination of rivers and adjoining agricultural lands from harmful leachates. Natural revegetation of mine spoils is a slow process [3, 4] but it can be accelerated by planting suitable tree species. Therefore, evaluation of tree performance is crucial in selection of suitable species for revegetation of mine spoils for their prompt recovery. Several studies have been conducted in India and abroad to evaluate the performance of trees on mine spoils [5-9]. The main objective of the present investigation was also to evaluate the growth performance of eight native tropical tree species planted for revegetation of a coal mine spoil in a tropical dry environment.

2. Material and Methods

2.1. Site Description

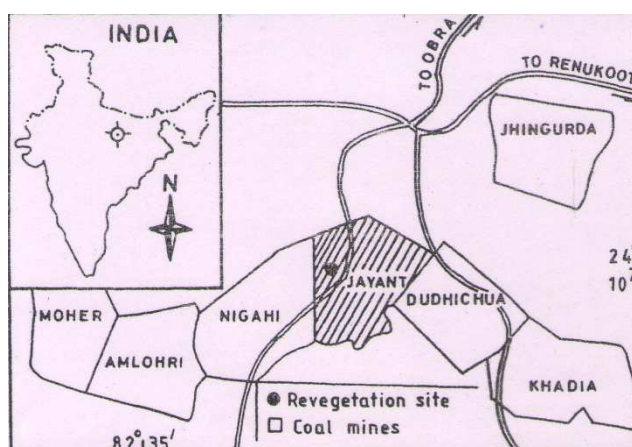


Fig. 1. Location of study site within Jayant coal mine of Singrauli Coalfields, India.

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The study was conducted at the Jayant coal mine on the Singrauli Coalfields, Madhya Pradesh (India) (Fig. 1). The Singrauli Coalfields cover an area of about 2200 km² (23°47'-24°12' N, 81°48'-82° 52' E and elevations of 280-519 m above mean sea level), of which 80 km² lies in Uttar Pradesh and the rest in Madhya Pradesh. The climate is tropical monsoonal with temperature reaching up to 42°C during June and lowering to down to 5°C in January. Rainfall varies from 90-100 cm confined during monsoon months from June to September. Winter rains are negligible. The potential natural vegetation is a tropical dry deciduous forest [10].

2.2. Experimental Design and Methods

Nursery-raised 1-year-old individuals of the following eight tree species were planted on fresh flat coal mine spoil in July 1993: *Acacia catechu* Willd., *Albizia lebbek* (L.) Benth., *Azadirachta indica* A. Juss., *Dalbergia sissoo* Roxb., *Gmelina arborea* Roxb., *Millettia pinnata* (L.) Panigrahi, *Tectona grandis* L. and *Terminalia bellerica* Roxb. The seedlings were planted in 20 m x 20 m plots with a spacing of 2 m x 4 m. The within row spacing distance was 2 m whereas the between row spacing distance was 4 m. Three replicate plots were maintained for each species.

The texture of the spoil material was 80% sand, 10% silt, and 10% clay, with a pH of 7.4, total N 0.018% and total P 0.010% [11]. Soil cores to a depth of 10 cm consisted for 75% of

particles greater than 2 mm in diameter.

A total of 9 individuals for each species, distributed equally between the three replicate plots selected at random were used for growth measurements. Height and diameter measurements were made in April 1996 (33 months after plantation) and in December 1997 (53 months after plantation). Diameter (d) was measured at 20 cm above the ground surface. Height (h) was measured using a scaled bamboo stick. Volumes of the trees (V) were calculated as a cone ($V = d^2h$).

Annual growth rate was assessed as increments in height, diameter and volume from the values measured in April 1996 and December 1997.

3. Results and Discussion

The data on height diameter and volume of the tree species for both the years are depicted in Table 1, while the data for annual height, diameter and volume increments are depicted in Table 2. The height, diameter and volume of 2-years and 9 months-old tree species ranged between 1.59 to 4.25 m, 4.41 to 9.29 cm and 3503 to 36238 cm³, respectively. Similarly the height, diameter and volume of 4-years and 5-months-old trees varied between 2.09 to 6.72 m, 6.40 to 13.93 cm and 9645 to 129727 cm³.

Table 1. Height, diameter and volume of planted tree species at two different age on a coal mine spoil on Singrauli Coalfields, India.

S. No.	Tree species (Family)	33 months after plantation			53 months after plantation		
		Height (m)	Diameter (cm)	Tree volume (d ² h) cm ³	Height (m)	Diameter (cm)	Tree volume (d ² h) cm ³
1.	<i>Acacia catechu</i> Willd. (Fabaceae)	2.84 ± 0.16	6.06 ± 0.60	12055 ± 3198	4.44 ± 0.23	8.52 ± 0.82	36814 ± 9176
2.	<i>Albizia lebbek</i> (L.) Benth. (Fabaceae)	3.90 ± 0.37	9.12 ± 0.63	35357 ± 6642	6.14 ± 0.53	13.93 ± 0.92	129727 ± 25354
3.	<i>Azadirachta indica</i> A. Juss. (Meliaceae)	2.65 ± 0.18	5.92 ± 0.31	9714 ± 1250	4.09 ± 0.28	9.82 ± 0.52	41198 ± 5287
4.	<i>Dalbergia sissoo</i> Roxb. (Fabaceae)	4.25 ± 0.36	8.24 ± 0.53	24994 ± 5414	6.72 ± 0.57	11.94 ± 0.77	102372 ± 17274
5.	<i>Gmelina arborea</i> Roxb. (Lamiaceae)	3.66 ± 0.31	9.29 ± 0.85	36238 ± 6865	5.10 ± 0.43	12.04 ± 1.03	83491 ± 15518
6.	<i>Millettia pinnata</i> (L.) Panigrahi (Fabaceae)	3.06 ± 0.11	5.88 ± 0.33	10993 ± 1458	4.35 ± 0.15	7.60 ± 0.40	26166 ± 3471
7.	<i>Tectona grandis</i> L. (Lamiaceae)	2.45 ± 0.17	5.37 ± 0.31	7714 ± 1611	3.07 ± 0.21	7.26 ± 0.42	17624 ± 3629
8.	<i>Terminalia bellerica</i> Roxb. (Combretaceae)	1.59 ± 0.14	4.41 ± 0.30	3503 ± 704	2.09 ± 0.17	6.40 ± 0.44	9645 ± 1904

(Mean ± 1 SE)

The growth rate i.e. annual height, diameter and volume increments ranged between 0.30 to 1.48 m yr⁻¹ tree⁻¹, 1.03 to 2.89 cm year⁻¹ tree⁻¹ and 3685 to 56622 cm³ year⁻¹ tree⁻¹, respectively. Thus the result of the study indicates that *T.*

bellerica was the poorest performing tree species while the *A. lebbek* was the best performing tree species among all the eight tree species growing on coal mine spoil. The *D. sissoo*, *G. arborea* and *A. indica* were the other good performing tree

species on coal mine spoil.

Table 2. Annual height, diameter and volume increments (yr^{-1} tree $^{-1}$) in planted tree species on a coal mine spoil on Singrauli Coalfields, India.

S. No.	Tree species (Family)	Height increment (m yr^{-1})	Diameter increment (cm yr^{-1})	Volume increment ($\text{cm}^3 \text{yr}^{-1}$)
1.	<i>Acacia catechu</i> Willd. (Fabaceae)	0.95 ± 0.05	1.47 ± 0.15	14860 ± 3645
2.	<i>Albizia lebbek</i> (L.) Benth. (Fabaceae)	1.35 ± 0.12	2.89 ± 0.19	56622 ± 10627
3.	<i>Azadirachta indica</i> A. Juss. (Meliaceae)	0.86 ± 0.06	2.34 ± 0.12	18890 ± 2423
4.	<i>Dalbergia sissoo</i> Roxb. (Fabaceae)	1.48 ± 0.13	2.24 ± 0.15	42925 ± 7252
5.	<i>Gmelina arborea</i> Roxb. (Lamiaceae)	0.86 ± 0.07	1.64 ± 0.12	28352 ± 5194
6.	<i>Milletia pinnata</i> (L.) Panigrahi (Fabaceae)	0.78 ± 0.03	1.03 ± 0.05	9104 ± 1208
7.	<i>Tectona grandis</i> L. (Lamiaceae)	0.37 ± 0.02	1.15 ± 0.07	5946 ± 1212
8.	<i>Terminalia bellerica</i> Roxb. (Combretaceae)	0.30 ± 0.02	1.19 ± 0.08	3685 ± 721

(Mean ± 1 SE)

A. lebbek was the best performing tree species in terms of diameter and volume growth rate while *D. sissoo* was the best performing tree species in terms of height growth rate among the leguminous species. Furthermore, another leguminous species *A. catechu* has shown average growth performance on mine spoil. *M. pinnata* was the poorest performer on coal mine spoil among the leguminous species.

Comparative growth study between leguminous and non-leguminous species reveals that the average annual height, diameter, and volume increments for leguminous tree species were 1.14 m, 1.90 cm and 30878 cm^3 , respectively whereas the same for non-leguminous tree species were 0.59 m, 1.58 cm and 14218 cm^3 . Thus the leguminous species have a greater annual height, diameter and volume increments than the non-leguminous tree species. The leguminous tree species have a greater annual growth rate than the non-leguminous tree species on mine spoil in a dry tropical environment [7].

A large degree of variation was reported in tree volume (d^2h), which frequently figures as a proxy variable for biomass [12, 13]. Thus the variability was greater among the non-leguminous tree species than the leguminous tree species. However, contrary to the present finding greater volume variability was reported in the leguminous tree species than the non-leguminous tree species planted on coal mine spoil [7, 14].

4. Conclusion

It can be concluded from the study that tree species differ in their growth performance on nutrient deficient mine spoil. However, the overall performance of the leguminous tree species is greater than the non-leguminous tree species. The study reveals that the non-leguminous trees *G. arborea*, and *A. indica* and the leguminous trees *A. lebbek* and *D. sissoo* are the most suitable species for the revegetation of coal mine spoils in a tropical dry environment.

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