A comparative study on initial growth and nodulation potential of seven multipurpose leguminous tree species grown in Chittagong, Bangladesh

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Seven multipurpose tree legumes, namely *Acacia auriculiformis, Albizia lebbeck, Acacia mangium, Acacia nilotica, Albizia procera, Gliricidia sepium* and *Leucaena leucocephala* were grown in the nursery containing the soil of barren areas to study their comparative growth and nodulation status with an aim to select the most suitable species for the reforestation programmes in the degraded hilly areas of Bangladesh. Initial growth responses determined from shoot length, collar diameter, root length and total dry weight of the harvested seedlings were found to be highest in *Gliricidia sepium*. However, the nodule number was significantly higher in *Acacia auriculiformis* followed by *Albizia lebbeck* and nodule dry weight was significantly higher in *Albizia lebbeck*.

Keywords: Bangladesh, Multipurpose tree legumes, Nodulation potential.

Bangladesh has an immense scope for expanding plantations in its barren degraded hilly lands. But low fertility in these areas is creating a major problem for their successful establishment. The situation has been further aggravated by existing silvicultural system of clearfelling followed by artificial regeneration. It is a well-established fact that intensive harvesting of forest resources decreases the nitrogen and organic matter contents from the forest floor. For maintaining the soil fertility in such areas, either fresh supply of fertilizers should be increased which are costly and scarce or plant such tree species which enrich the soil nitrogen regularly (Chaukiyal *et al.* 2000). Srivastava *et al.* (1999) reported that most of the leguminous species form nodules in their root with symbiotic association of *Rhizobium* spp. and fix atmospheric nitrogen biologically, which is a cheap renewable source (Chaukiyal *et al.* 1999). It is estimated that annual global biological contribution of nitrogen is 122×10^6 ton year (Newton and Burgess, 1983). Tewari (1998) emphasized that the afforestation might be accomplished in barren areas by using nitrogen-fixing trees.

The family Leguminosae (now divided into three families) has about 700 genera and about 14000 species (Ghosh and Basu, 2000) but unfortunately, only 8-9% of those have been studied so far for nodules (Jordan, 1984). Moreover, studies were concentrated on legume herbs. The nodulation potential of many tree legumes has not been examined so far (Purohit *et al.*, 1997) and the studies on nitrogen fixation by such plants have been few (Farnsworth *et al.*, 1978). Mahmood and Iqbal (1994) suggested that for increasing the effectiveness of biological nitrogen fixation, there is a need to carry out studies on nodulation and nitrogen fixation in the existing legume flora in different parts of the world. In Bangladesh, information on comparative seedling growth and nodulation of legume tree species are very scanty. Legume multipurpose tree species are a major tree component in agroforestry and other participatory forestry practices. Keeping this in mind, seven important multipurpose legume tree species, viz. *Acacia auriculiformis, Albizia lebbeck, Acacia mangium, Acacia nilotica, Albizia procera, Gliricidia sepium* and *Leucaena leucocephala* were selected for the nursery trail. The main aim of the study was to determine their comparative initial growth and nodulation potential; capable of growing in degraded barren soil of hilly areas of Bangladesh.

Materials and methods

This study was carried out at the nursery of Institute of Forestry and Environmental Sciences, University of Chittagong, Chittagong, Bangladesh. Potting soil was collected from the barren hilly areas of the University Campus. Polybags of 25 cm × 15 cm were used for the experiment. The soil was sieved (≤ 2 mm) to remove stones, roots and other debris. In total, 126 polybags were filled and arranged in the nursery in 7 sets with 18 replicates in a randomized block design.

Healthy, mature and ripen seeds of seven multipurpose tree legumes were procured from Silvicultural Research Division of Bangladesh Forest Research Institute (BFRI), Chittagong, Bangladesh. Seeds of uniform size were selected for the study purpose as seedling vigor is often found to be positively correlated with seed size. All the seeds were treated with hot water for 1 minute

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followed by overnight soaking in cold water to improve germination. The seeds were sown on petri dishes over a moist filter paper. The germinating seeds were then transferred to polybags in the nursery and the seedlings were allowed to grow. Adequate watering was done regularly.

At the age of four months, three seedlings from each species were randomly selected and brought to the laboratory. The polybags were gently torn after which root and shoot components of the seedlings were separated carefully. The nodulated roots were separated from the soil with the help of regulated water pressure to avoid physical damage. The nodules were then separated from the root using a forcep and washed with clean water and finally with distilled water. After counting the nodule number, measurement of seedling components (shoot, root and leaf) and nodule dry weight were taken after drying the samples at 70° C for 48 hours. The data were subjected to Analysis of Variance (ANOVA) to test for significant difference in different parameters among the species studied. The means were compared using the Duncan's Multiple Range Test (DMRT).

Results and discussion

Growth of the seedlings was measured in terms of shoot length, collar diameter, root length and total oven dry weight of seedlings parts (leaf, shoot and root), while nodulation was studied in terms of nodule number and its dry weight. Data on those parameters have been presented in Table 1. The study revealed that shoot length, collar diameter, root length and total dry weight of seedling parts were found to be highest in *Gliricidia sepium*. The shoot length of this species was 74.33 cm, which was not significantly different from *Acacia mangium* (71.66 cm), *A. nilotica* (61 cm) and *Leucaena leucocephala* (60 cm) seedlings. The lowest shoot length was found in *Albizia procera* (23 cm). *Gliricidia sepium* obtained significantly higher collar diameter (12.3 mm) followed by *Leucaena leucocephala* (8.40 mm). The lowest collar diameter was observed in *Acacia nilotica* (5.8 mm). Similarly, though *Gliricida sepium* and *Leucaena leucocephala* possessed significantly higher root length (44.5 cm and 41.65 cm respectively) than the roots of other species, they did not differ significantly. *Acacia nilotica* obtained the lowest root length (23 cm). Except in *Gliricidia sepium*, there was no significant difference in collar diameter, leaf dry weight, shoot dry weight and total dry weight among all the species. Similarly, the root dry weight in *Gliricidia sepium* and *Albizia lebbeck* was not significantly different. Considering the total dry weight, *Gliricidia sepium* produced significantly higher dry weight (64.81 gm) than the seedlings of all the other species. The lowest seedling dry weight was found in *Acacia auriculiformis* (7.67 gm). On the contrary, nodule number and its dry weight were found to be highest in *A. auriculiformis* and *Albizia lebbeck* respectively. These findings reveal that nodulating ability varies within different leguminous species. The finding is similar with the study conducted by Thatoi *et al.* (1995). Purohit *et al.* (1997) found that at the age of nine months, nodulation in terms of nodule number was highest in *Dalbergia sissoo* (18) followed by *D. sericea* (15); and the nodule weight was highest in *Acacia stipulata* (285.6 gm) in comparison to *Dalbergia Sericea, D. sissoo, Albizia stipulata, A. Lebbeck* and *Ougenia dalbergiodes.*

Chaukiyal *et al.* (1999) in one year old seedlings found that the maximum nodule number per plant was in *Acacia nilotica* and maximum nodule biomass was in *A. suma* among *A. auriculiformis, A. catechu, A. ferruginea, A. nilotica, A. planifrons, A. robusta, A. suma* and *A. tortilis.* Balasundaran (1987) observed that after a growth period of six months in one square meter micro- plots among eight *Acacia* species, four *Bauhinia* species, *Cassia nodusa, Calophospermum mopane, Dichrostachys nutans, Leucaena leucocephala, Parkinsonia aculeata, Prosopis juliflora, Tamarindus indica*, natural nodulation took place only in four species viz. *A. tortles, A. farnesiana, A. nilotica* and *Leucaena leucocephala.* Hardy *et al.* (1968) and Waughman (1977) reported that the variation exists in the nitrogen fixing activities within the species under prevailing climatic condition in which plant exists.

From the data, it was difficult to know the response of plants in chronological order if all the parameters were considered at a time. Therefore, a numerical ranking system was followed taking consideration of the total number of plants and the parameters studied. All the seven species were graded one to seven considering their responses from higher to lower order for the individual parameter and finally the scores obtained by each plant for all the parameters were added and percentage value was calculated. From this percentage scoring, performance ranking was prepared as given in Table 2. From this table, it was found that *Gliricidia sepium* was in the highest rank followed by *Albizia lebbeck*. The other species secured much less score. The poorest performer was *Albizia procera.* Considering all these, *Gliricidia sepium* followed by *Albizia lebbeck* are best-suited species for the plantation programmes in degraded soils in the hilly areas of Bangladesh. However, further research should be carried out on more multipurpose tree legumes at field level and at different ages.

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Table 1: Comparative growth and nodulation of seven tree legumes at the age of four months grown in degraded soil in Chittagong, Bangladesh.

Species	Shoot length (cm)	Collar dia. (mm)	Root length (cm)	Oven dry weight (gm)			Total oven dry weight (gm)	Nodule No.	Nodule oven dry weight (gm)
				Leaf	Shoot	Root			
Acacia auriculiformis	46.00 b	6.83 b	29.00 b	3.14 b	1.55 b	2.97 b	7.67 b	132 a	0.48 b
Albizia lebbeck	56.33 b	8.20 b	24.62 bc	6.64 b	6.62 b	19.01 ab	32.26 b	118 a	1.44 a
Acacia mangium	71.66 a	6.33 b	24.40 bc	6.09 b	4.15 b	8.88 b	19.11 b	38 b	0.77 b
Acacia nilotica	61.00 ab	5.80 b	23.00 c	1.30 b	5.06 b	3.23 b	9.60 b	36 b	0.70 b
Albizia procera	23.00 c	5.87 b	23.66 bc	1.39 b	1.73 b	16.95 b	20.06 b	11 b	0.50 b
Gliricidia sepium	74.33 a	12.30 a	44.50 a	15.43 a	14.73 a	34.62 a	64.81 a	66 b	0.40 b
Leucaena leucocephala	60.00 ab	8.40 b	41.65 a	2.88 b	4.03 b	4.87 b	11.78 b	28 b	0.20 b

Note: Means followed by the same letter(s) in the same column do not vary significantly at P<0.05. *Duncan's Multiple Range Test (DMRT).*

Table 2: Comparative performance gradation of seven tree legumes at the age of four months grown at degraded soil in Chittagong, Bangladesh.

Species	SL (cm)	CD (mm)	RL (cm)	Oven dry weight (gm)			Total dry wt. (gm)	Nod. No	Nod. Dry wt. (gm)	Total points	Percent	Rank
				Leaf	Shoot	Root						
Acacia auriculiformis	2	4	5	4	1	1	1	7	3	28	44.44	5
Albizia lebbeck	3	5	4	6	6	6	6	6	7	49	77.78	2
Acacia mangium	6	3	3	5	4	4	4	4	6	39	61.90	3
Acacia nilotica	5	1	1	1	5	2	2	3	5	25	39.68	6
Albizia procera	1	2	2	2	2	5	5	1	4	24	38.10	7
Gliricidia sepium	7	7	7	7	7	7	7	5	2	56	88.89	1
Leucaena leucocephala	4	6	6	3	3	3	3	2	1	31	49.21	4

SL- Shoot length, CD- Collar diameter, RL- Root length, Nod. No.- Nodule number, Nod. dry weight- Nodule dry weight