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Performance of Eleven Multipurpose Tree Legume Seedlings Grown in the Hill Soils under Nursery Conditions in Bangladesh

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ABSTRACT

Seedlings of *Acacia auriculiformis, A. catechu, A. mangium, Albizia lebbeck, A. procera, A. saman, Cassia fistula, C. siamea, Gliricidia sepium, Dalbergia sissoo and Leucaena leucocephala* were raised in polybags containing the soil of barren hilly areas of Chittagong University campus situated at the south-eastern part of Bangladesh. The study was conducted to evaluate comparative germination, growth, leaf' pigments and nodulation status with a view to select suitable species for the afforestation and reforestation programmes in the degraded hilly areas of the country. Initial growth response determined from shoot and root length, collar diameter, dry weight of shoot and root of the seedlings were found highest in *G. sepium* followed by *A. lebbeck* and *A. procera*. However, the nodule number was significantly ($p<0.05$) highest (143) in *A. saman* followed by *A. procera* and *G. sepium*, but the dry weight of nodules were maximum (1.54 g & 0.52 g respectively) in *A. procera*. The size of the nodules varied from 2.7 mM x 2.6 mM in *D. sissoo* to 6.3 mM x 3.5 mM in *A. mangium*. Most of the species possessed nodule of both in single and aggregated forms. Maximum leaf pigment (106.51 mg/L) was recorded in *G. sepium* followed by *L. leucocephala* and *A. catechu.* In comparison, *G. sepium, A. lebbeck* and *A. procera* possessed better growth performance while *C. fistula* was the poorest growth performance.

Key Words: Legume; Nodule; Pigment concentration; Vigor index

INTRODUCTION

The hill forests of Bangladesh comprising an area of 1.4 million ha are mostly distributed in Chittagong, Chittagong Hill Tracts and Sylhet districts of the east and south-eastern part of the country (Anonymous, 1992). Due to high population pressure, the forest is experiencing problems like illicit felling, encroachment, shifting cultivation, incendiary or accidental fire which leads to soil erosion, declining soil fertility, land degradation and denudation. Most of the forests lands are now barren and the Forest department is raising plantations by clear felling of scrub bush forests followed by artificial regeneration mainly with fast growing leguminous multipurpose tree species. Though there is an immense scope for expanding forest plantations in its barren degraded hilly lands, low fertility of the area is (Rashid, 1991) creating a major problem for the successful establishment of some important timber species.

It is well-established fact that intensive harvesting of forest resources decreases the nitrogen and organic matter content from the forest floor. It is necessary to add chemical fertilizers for maintaining the soil fertility in such areas, which is costly and expensive (Hossain *et al*., 2001) and sometimes environmentally hazardous. Planting leguminous trees may be an important option to enrich the soil nitrogen status since most of the leguminous species form nodules in their root with symbiotic association of *Rhizobium* and fix atmospheric nitrogen (Chaukiyal *et al*., 1999, 2001).

Growth and biomass production potential of multipurpose tree species including leguminous trees vary from site to site (Radoglou & Teskey, 1997). The family Leguminosae (which has recently been splitted into three families *i.e.* Papilionacease, Ciselpinnaceae and Mimoosaceae) consists of about 700 genera and 14000 species (Ghosh & Basu, 2000) of which only 8-9% species have been studied for nodule (Jordan, 1984). Mahmood and Iqbal (1994) suggests that for increasing the affectivity of the biological nitrogen fixation there needs to carry out studies on the 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 legumes are very scanty (Aryal *et al.*, 2000). Again, the information on leaf pigment of forest tree seedlings in nursery condition is also very scanty. Therefore, an experiment was established in the barren hill soils with eleven tree legumes under nursery conditions with an aim to find out potential species for degraded hilly areas of this region.

MATERIALS AND METHODS

The experiment was carried out over a period of six months from March to August, 2001 in the nursery of the Institute of Forestry and Environmental Sciences, University of Chittagong, Bangladesh lies between $22^0 30'$ N Latitude and $91^0 50'$ E Longitudes. Seeds of *Acacia auriculiformis, A. catechu, A. mangium, Albizia lebbeck, A. procera, A. saman, Cassia fistula, C. siamea, Gliricidia*

sepium, *Dalbergia sissoo* and *Leucaena leucocephala* were collected from the seed orchard division of Bangladesh Forest Research Institute (BFRI). The soils collected from the barren hills of the University Campus was sieved well (<3mM) and mixed with decomposed cow dung in a ratio of 3:1. Polybags of 15 cm x 10 cm (6"x 4") in size were filled with the prepared mixture and a layer of coir (1 cm) was provided in each of the Polybags as a top layer of the polybag media to reduce the evaporation. A total of 550 polybags were arranged in nursery with 50 seedlings for each species in a randomized block design. Three seeds of a particular species were sown in each polybag and a single seedling was maintained per polybag after germination. Adequate watering and care was taken regularly.

The seedlings were allowed to grow for three months from the time of seed sowing. After three months, five representative seedlings from each species were selected for measuring physical parameters. Shoot and root length, collar diameter, shoot and root dry weight, number of nodules and their size and shape, form and dry weight were recorded. Germination was recorded daily from the date of seed sowing and continued up to last germination. Shoot, root and nodule was dried in an oven at 70^{o}C for 48 h till the constant weight was obtained. Vigor index was calculated according to Abdul-Baki and Anderson (1973).

The pigment contents (chlorophyll *a*, chlorophyll *b* & carotenoid) of the fresh leaves of seedlings of different species were determined with the fresh leaves collected from the second, third and fourth leaves from the top. Ten leaf discs were made with a cork borer (inside diameter 5 mM), weighed immediately after cutting and dipped in 5 mL 100% acetone in test tube with stopper. After 24 h of incubation, the supernatant colored solution from the top was decanted carefully in 25 mL volumetric flask. The leaf discs were then cursed with a blunt glass rod gently and 5 mL fresh acetone was added to the test tube and left for 15 minutes. Then the supernatant solution from the top was again decanted to the same volumetric flask very carefully, avoiding the fragmented plant tissues. The process was repeated until the leaf fragments became colorless. Finally the volume was made up to 25 mL with fresh acetone and measurement was taken immediately after the preparation of solution. The measurement of chlorophyll *a*, chlorophyll *b* and carotenoid were made at 662 nm, 644 nm and 440.5 nm respectively with a spectrophotometer (Spectronic-20). The concentrations of pigments in the extract were calculated by following the formula of Wettstein (1957).

All the data collected were analyzed statistically by using the computer software package SPSS and were subjected to analysis by DMRT.

RESULTS AND DISCUSSION

Germination and growth of seedlings. The highest germination (82%) was found in *G. sepium* followed by *A. lebbeck* (67%) and *A. mangium* (61%), while the lowest (48%) was found in *A. catechu* (Table I). The highest shoot growth (53.8 cm) was observed in *G. sepium* but highest root growth (31 cm) was found in *L. leucocephala*. Vigor index was maximum (6601) in *G. sepium* and minimum (1744) in *C. fistula* (Table I). Collar diameter was reported maximum (7.1 mM) in *A. saman* but was not significantly (p<0.05) different from *G. sepium*, *A. lebbeck* and *A. procera*. Dry weight of shoot and root were highest (5.2 & 3.1 g, respectively) in *G. sepium* and was significantly (p<0.05) different from other species (Table I). Physical growth parameters of *A. auriculiformis*, *A. mangium*, *A. lebbeck*, *A. procera*, *G. sepium* and *L. leucocephala* closely support the finding of Hossain *et al.* (2001) where he showed comparative growth of those species for three months old seedlings in the nursery.

Nodulation status of seedling. Maximum number of nodule (143) was recorded in *A. saman* followed by 121 in *A. procera* and 64 in *G. sepium*. Nodule number was minimum (26) in *L. leucocephala* (Table II). Dry weight of nodule was maximum (0.52 g) in *A. procera* followed by *A. saman* and minimum (0.13 g) in *D. sissoo*. Nodules of most of the species were elongated to ovate and round in shape.

Table I. Comparative germination (%), seedling length, vigor index, collar diameter and leaf number of three months old seedlings of eleven tree legumes grown in the nursery

Name of the species	Germination	Length (cm)			Vigor index	Collar diameter	Dry weight (g)		
	(%)	Shoot	Root	Total		(mm)	Shoot	Root	Total
A. auriculiformis	55 c *	22.9 c	26.3 ab	49.2 cd	2706 cd	3.5 cd	1.8 d	0.8 cd	2.6 d
A. catechu	48 d	45.4 b	22.6 bc	68.0 b	3264 c	3.9 cd	2.3 cd	0.8 cd	3.1 cd
A. mangium	61 c	27.3 bc	28.5 ab	55.8 c	3404 c	4.190 c	2.1 cd	1.0 c	3.1 cd
A. lebbeck	67 b	42.0 b	25.4 abc	67.4 b	4515 b	5.5 abc	4. 8 bc	2.0 b	6.8 b
A. procera	55 c	31.5 bc	24.7 abc	56.2 c	3091 cd	5.3 abc	3.1 c	1.9 b	5.0 c
A. saman	57 c	29.6 bc	17.6 c	47.2 cd	2690 cd	7.1 a	3.1 c	1.1 c	4.2 c
C. fistula	49 d	18.1 d	17.5 c	35.6 d	1744 e	3.2 d	1.3 d	0.8 cd	2.1 d
C. siamea	53 cd	17.4 d	18.6 c	36.0 d	1908 de	3.1 d	0.9 e	0.5 d	1.4 d
D. sissoo	52 cd	26.7 c	21.1 bc	47.8 cd	2486 de	3.9 cd	1.5 d	0.5 d	2.0 d
G. sepium	82 a	53.8 a	26.7 ab	80.5 a	6601 a	6.4 ab	11.7 a	3.1 a	14.8 a
L. leucocephala	59 c	28.4 bc	31.0 a	59.4 c	3505 c	5.2 bc	1.8 d	1.2 c	3.0 cd

*Means followed by the same letter (s) are not significantly different at P<0.05, according to Duncan's Multiple Range Test (DMRT)

Table II. Number of nodule, their size, shape form and dry weight of three months old seedlings of eleven tree legumes grown under nursery condition

Name of the species	Nodule				
	Number	Shape	Size (mm)	Form	Dry weight (g)
A. auriculiformis	61 c *	Ovate to obovate	6.1 x 3.2	S	0.30 c
A. catechu	53 cd	Elongated to ovate	5.5 x 2.4	A	0.16 d
A. mangium	57 c	Ovate to obovate	6.3 x 3.5	S	0.26 c
A. lebbeck	56 c	Elongated to ovate	4.1 x 3.7	A	0.37 b
A. procera	121 b	Elongated to ovate	4.8 x 2.6	A	0.52 a
A. saman	143 a	Elongated	4.7 x 2.5	S & A	0.49 a
C. fistula	----	----	----	----	----
C. siamea	----	----	----	----	----
D. sissoo	33 d	Round to ovate	2.7 x 2.6	S & A	0.13 d
G. sepium	64 c	Round to ovate	4.2 x 4.1	S	0.39 b
L. leucocephala	26 e	Elongated	5.6 x 2.3	A	0.15 d

*_ Means followed by the same letter (s) in the same column do not vary significantly at p<0.05, according to Duncan's Multiple Range Test (DMRT); *S: single* and A: aggregated

The size of the nodules varied from 2.7 mM x 2.6 mM in *D. sissoo* to 6.3 mM x 3.5 mM in *A. mangium*. Most of the species possessed nodules both in single and aggregate forms (Table II). Similar observations were reported by Athar and Mahmood (1990), Mahmood and Iqbal (1994), and Singh and Pokhriyal (1998). However, a variation in the present study in respect to nodule number and their dry weight were reported by Hossain *et al.* (2001) and Aryal *et al.* (2000) which might be due to the seasonal variation and the age of the seedlings. Similarly, Waughman (1977) found the variation in the nitrogen fixing activity within the species under prevailing climatic condition.

In the present study there was no nodule formation in *C. siamea* and *C. fistula* (Table II). Failure to find nodules on a given plant at any time does not necessarily mean that the plant is always non-nodulated (Mahmood, 1994), but the non-nodulating habit of *C. siamea* and *C. fistula* was confirmed by Mahmood and Iqbal (1994), Ty (1996) and Aryal *et al.* (2000).

Pigment concentration of fresh leaf. Pigment concentration of fresh leaf of the seedlings of different species is shown in Table III. Chlorophyll a was highest (52.1 mg/L) in *G. sepium* followed by 42.7 mg/L in *L. leucocephala* and 40.8 mg/L in *A. catechu*. Similarly, chlorophyll b was reported highest (31.5 mg/L) in *G. sepium* and was significantly (p<0.05) different from all other species. Carotenoid was recorded maximum (35.6 mg/L) in *L. leucocephala* but was not significantly (p<0.05) different from *A. catechu, A. lebbeck, A. saman, A. procera* and *D. sissoo*. However, total pigment concentration of leaf was recorded maximum (106.5 mg/L) for *G. sepium* followed by 106.0 mg/L in *L. leucocephala,* 98.8 mg/L in *A. catechu* and 81.0 mg/L in *A. lebbeck* and minimum (37.4 mg/L) in *C. fistula*. There might be a positive relationship between the growth parameters and the concentration of leaf pigments of seedlings (Table I, II, III). This was supported by Gordon and Wheeler (1978) who reported a positive correlation of net rate of photosynthesis with both nodule fresh weights per plant and nitrogenase activity in *Alnus glutinosa*. The amount of photosynthesis available is considered to be one of the major factors controlling rates of nitrogen fixation.

Table III. Comparative pigments concentration of fresh leaf of three months old seedlings of eleven tree legumes grown in the nursery

Name of the species	Pigments concentration of leaf (mg/L)			
	Chlorophyll a	Chlorophyll b	Carotenoid	Total
A. auriculiformis	26.4 c*	7.9 d	12.5 c	46.8 d
A. catechu	40.8 ab	25. 7 b	32.4 a	98.9 ab
A. mangium	31.5 bc	9.0 cd	14.4 c	54.9 c
A. lebbeck	37.5 b	12.4 c	31.1 a	81.0 b
A. procera	34.5 bc	10.5 cd	27.6 ab	72.6 bc
A. saman	38.8 b	12.8 c	28. 7 ab	80.3 b
C. fistula	16.5 d	7.4 d	13.5 c	37.4 d
C. siamea	22.3 c	11.6 c	21.9 b	55.8 c
D. sissoo	39.4 b	13.6 c	27.3 ab	80.3 b
G. sepium	52.1 a	31.5 a	22.9 b	106.5 a
L. leucocephala	42.7 ab	27.7 b	35.6 a	106.0 a

* _ Means followed by the same letter (s) in the same column do not vary significantly at p<0.05 according to Duncan's Multiple Range Test (DMRT).

CONCLUSION

From the present study, it is very 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 into consideration the total number of plants and parameters studied (Thatoi *et al.*, 1995). All the eleven plants were graded one to eleven 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 (Thatoi *et al.*, 1995). From this percentage scoring it was found that *G. sepium* scored highest followed by *A. lebbeck, A. procera, A. saman, A. mangium, L. leucocephala, A. catechu, A. auriculiformis, D. sissoo, C. siamea* and *C. fistula*, respectively. Considering all these, *G. sepium* is the

most suitable species for the plantation programmes followed by *A. lebbeck* in degraded soils of the hilly areas of Bangladesh. However, further research should be carried out with more leguminous multipurpose tree species at the field level before going for large scale plantation programmes.

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