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Nodulation Behaviour and Biomass Productivity of Three Leguminous Plant Species at Nursery Stage in Chittagong University Soils

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Abstracts: A study was conducted to investigate the comparative nodulation and biomass productivity of *L. leucocephala, P. juliflora* and *A. procera* in the Chittagong University sites using seeds received from New Forest Project. All the three studied species were found nodulated. Abundant nodules were found in *L. leucocephala*. *P. juliflora and A. procera* were found as moderately nodulated. Variation in nodule color, structure and distribution were observed among the species. Highest (45) nodules/plant were recorded from *L. leucocephala* followed by *P. juliflora (35 nodules/plant)* and *A. procera* (30 nodules/plant). Bigger (3.5x2.6mm) nodules were found in *P. juliflora* and the smallest was recorded in *L. leucocephala* (2.1x2.5mm). Highest dry weight of nodules (1.38gm) was recorded with *P. juliflora* followed by *L. leucocephala* (1.25gm) and *A. procera* (1.14gm). Highest shoot height (277cm), root length (74cm) and biomass production was recorded with *L. leucocephala*. The shoot length difference between *P. juliflora* and *A. procera* was not significant.

Key words: Nodulation, Biomass, Legumes, *L. Leucocephala, P. Juliflora, A. Procera* and Chittagong University.

INTRODUCTION

Bangladesh, a densely populated country (834 persons per km^2) with an area of about 14.4 million hectors and a population of 123.1 million[1], is one of the poorest countries in the world. Her forest cover is about 14.85 percent of the land area[1]. Village forests, covers about one- seventh of the country contributes 89% and 80% of the countries total fuel wood and saw or ply logs supply respectively[2]. Despite a very low per capita consumption of wood (fuelwood 0.06 m^3 and timber 0.018 m^3)[1], the supply from the forest is inadequate and far beyond the demand. There remains a wide gap between the supply and demand of forest products (5 million m^3)[4]. The present forest system of Bangladesh is unable to meet the demand of forest products for its people. To mitigate the problem the Government of Bangladesh has given priority in restoring forestlands and growing trees on every space available on farms and homesteads. Side by side people of rural Bangladesh became much more tree conscious. Tree plantation program through Government and private initiatives has got a momentum through out the country. The available sites for plantation are not that much fertile as it required. In case of agricultural land people can feel the negative effects of the chemical fertilizer on the soil. The soil fertility has declined dramatically. According to Bangladesh Agricultural Research Council NPK (Nitrogen, Phosphorus and Potassium) in the soil is depleting quite rapidly. The content of organic matter in the soil is estimated at less than one percent where the critical level is three percent. As a result the soil is becoming hard[5]. Peoples prefer fast growing multipurpose trees specially Nitrogen Fixing Trees (NFT) for plantation programs. In this regard it was found that Legumes are the best because of their fast growing, nitrogen-fixing, coppicing behavior, ability to adapt in wide range of environment. Of all tropical legumes, *Leucaena leucocephala* probably offers the widest assortment of uses. Due to its multipurpose utility and wide range of ecological amplitudes (especially suitable to Bangladesh Environment) the species is recommended for road side as well as cropland along with forest land[6]. *Prosopis juliflora* is a promising species and highly recommended in dry areas of North Bengal and in degraded hills of Chittagong Hill Tracts due to its prolonged drought resistance, nitrogen fixing ability, good palatability to domestic animals, coppicing ability, easy propagation, wide and deep root penetration behavior. *Albizia procera* is also a preferred plantation species due to its timber,

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fodder and good calorific value, wide range of distribution through out the country. Almost every year the Chittagong University Plantation Unit plants *L. leucocephala* and *A. procera* along with other tree species for its annual plantation program. *P. juliflora* species has a great potential to be included in the plantation species of CU areas. Information on the comparative initial growth performance, Nodulation and biomass productivity is not available. So the present study is an attempt to investigate the comparative nodulation and biomass productivity of *L. leucocephala*, *P. juliflora* and *A. procera* in the Chittagong University sites.

MATERIALS AND METHODS

The study was conducted in the nursery of Institute of Forestry and Environmental Sciences, University of Chittagong (IFESCU) campus, Chittagong, Bangladesh. The area is situated in the south-eastern part of Bangladesh that lies approximately at the intersection of 91°50' east latitude to 22°30' north longitude[7]. The nursery site enjoys a tropical monsoon climate characterized by hot, humid summer and cool, dry winter. The average monthly mean temperature varied 29.75° C maximum and between 21.14° C minimum[8]. Relative humidity was generally the lowest(64%) in February and highest (95%) in June-July-August and September. The soil used in the nursery was moderately coarse to fine textured. It has a grey to olive grey color; sandy loams sub soil with moderate coarse and medium angular blocky structure. The seeds of the experiment were obtained from the New Forest project, U.S.A. Polybags of 10" X 6" size in the nursery were arranged following a Randomized Complete Block Design with three blocks and four replicates, each replicates contained 10 polybags. Before sowing *Leucaena* seeds were immersed in hot water for 3 minutes followed by soaking in cold water for 12 hours[9]. *Albizia* seeds were placed in boiling water for one minute, followed by soaking them in cool water for 24 hours[10] and *Prosopis* seeds were soaked in concentrated sulfuric acid for 20 minutes and soaked in cold water fir 24 hours[11]. In each bag two seeds were sown at the end of March. Hence a total of 240 seeds (80 for each) were sown at equal depth and 10 cm apart from each other. When germination completed only 120 healthy seedlings (one in each polybag) were kept and others were removed carefully so that the seedlings do not get injured. Watering was carried regularly by fine shower which could not disturb the seedlings physically. Removal of weeds, grasses etc. were done as far as possible. Proper care and maintenance were given for one year. NPK (4:2:3) Nitrogen @ 80 kg/ha, Phosphorus @ 40 kg/ ha and Potassium @ 60 kg/ ha were applied once on two months aged seedlings. When the seedlings reached at ten months at the end of the following January they were removed from the polybags. Shoot length were measured for each seedling and gently washed with the tape water followed by distilled water to remove the soil particles from the root. After measuring the root length nodules were separated from individual plants and further washed carefully to remove all the soil particles[12]. Nodule size, shape, color, structure, distribution were studied as done by Aryal *et al.*[13]. Fresh weight as well as dry weight of different plant parts was recorded. Duncan Multiple Range Tests were done to compare mean values of all the species following Zaman *et al.*[14].

RESULTS AND DISCUSSION

All the three studied species were found to be nodulated. The nodulation status, shape, color, distribution and structure of nodules of three surveyed species are reported in Table 1. and measurements of different parameters of nodules are presented in Table 2 and Table 3. Abundant nodules were found in *L. leucocephala*. *P. juliflora and A. procera* were found as moderately nodulated. Nodules of *L. leucocephala* were globose shaped and pink colored. Nodules of *P. juliflora* was pink to white colored oblate shaped and in *A. procera* they were recorded as brown to white colored with semi-globose shaped (Table 1). Variation in nodule structure and distribution were observed among the species (Table 1). Nodules found on both primary and secondary roots of *L. leucocephala* and *P. juliflora* where as in *A. procera* they were only distributed on secondary roots. Advanced indeterminate structured nodules were found in *P. juliflora* and *A. procera* but in *L. leucocephala* primitive to advanced indeterminate structured nodules were seen (Table 1). Number of nodules recorded from different species was significantly different from each other. Highest (45) nodules/plant were recorded from *L. leucocephala* followed by *P. juliflora (35 nodules/plant)* and *A. procera (30 nodules/plant).* Bigger (3.5x2.6mm) nodules were found in *P. juliflora* and the smallest was recorded in *L. leucocephala* (2.1x2.5mm). Highest dry weight of nodules (1.38gm) was recorded with *P. juliflora* followed by *L. leucocephala* (1.25gm) and *A. procera* (1.14gm) (Table 2). Highest (277cm) shoot height was recorded with *L. leucocephala.* Corresponding figures for *P. juliflora* and *A. procera* were 136cm and 80cm respectively. Similarly Highest (74cm) root length was recorded with *L. leucocephala* followed by *P. juliflora* (48cm) and *A. procera* (46cm). The shoot length

Table 1: Nodule Morphology and Characteristics of *L. leucocephala* , *P. juliflora* and *A. procera*

Species	Nodule				
	Status	Shape	Color	Distribution	Structure
L. leucocephala	Abundant	Globose	Pink	Primary and secondary roots	Primitive to advanced indeterminate
P. juliflora	Moderate	Oblate	Pink to white	Primary and secondary roots	Advanced indeterminate
A. procera	Moderate	Semi-globose	Brown to white	Secondary roots	Advanced indeterminate

Table 2: Nodulation status of *L. leucocephala* , *P. juliflora* and *A. procera*

Species	Nodule			
	Number/ plant	Av. Size (mm)	Fresh wt. (gm)	Dry weight (gm)
L. leucocephala	90a	2.1x2.5	1.98	1.25b
P. juliflora	63b	3.5x2.6	2.20	1.38a
A. procera	45c	3.1x2.5	1.60	1.14c

Values in the columns followed by the different letter are significantly different ($p < 0.05$) according to DMRT

Table 3: Biomass production and different growth parameters of *L. leucocephala* , *P. juliflora* and *A. procera*

Species	Length (cm)		Root Shoot ratio	Fresh wt. (gm)			Dry wt. (gm)			Total Biomass (gm)
	Shoot	Root		Leaf	Shoot	Root	Leaf	Shoot	Root	
L. leucocephala	277a	74a	4	90	315	95	43	150	47	240a
P. juliflora	136b	48b	3	36	76	27	16	32	15	63c
A. procera	80c	46b	2	108	79	105	49	36	48	133b

Values in the columns followed by the different letter are significantly different ($p < 0.05$) according to DMRT

difference between *P. juliflora* and *A. procera* was not significant. However highest (240gm) biomass production was recorded for *L. leucocephala*. Biomass for *A. procera* was recorded as 133gm and for *P. juliflora* was 63gm (Table 3).

The vast majority of nitrogen fixing trees is part of the legume family (Leguminosae), and most of these species are in the Mimosoideae (mimosoids) and Caesalpinioideae (ceasalpiniodes). Almost 98% of the mimosoids have found nitrogen fixing[15]. In the present study all three species are mimosoids and that supports the statement of Withington[15]. Present findings related to the nodule characteristics and status is supportive to the records of Aryal, *et al.*[13] where higher number (82 nodules/plant) of nodules in *L. leucocephala* was recorded compared to that of *A. procera* (41). At the same time nodulation status, color, distribution and structure also supportive to that of Aryal *et al.*[13]. The shape of nodules found in *L. leucocephala* of this study differs from that of Aryal *et al.*[13]. Findins of Uddin[16] and Lama[17] also supportive to the present findings. At the same time compared to the findings of other workers, the present results were similar to those of Allen and Allen[18], Halliday and Nakao[19] and Faria *et al.*[20]. Tewari[21] is also in agreement with present findings. Present finding regarding the nodule weight does not supportive to Pokhriyal *et al.*[22] who reported higher nodule weight per plant in *L. leucocephala* as compared to *Albizia, Acacia* and *Dalbergia.* Root hair growth can be affected by many biotic and abiotic factors in soil[23,24]. these in turn can affect nodulation[25]. The mode of infection, like nodule structure is largely host controlled. The rhizobial component is a vital part of establishment of effective nodules in the field[25]. Nodule biomass plays an important role in the nitrogen- fixing activity in the plants. Nitrogenous activity can contribute to the height growth and total plant biomass. In the present study lower nodule biomass as well as higher shoot and root growth and total biomass was recorded in *L. leucocephala* compared to other two species. It may be due to the faster growing behavior of *L. leucocephala* compared to other two studied species. Growth of a plant is an ultimate result of photosynthesis. Gordon and Wheeler[26] have reported a significantly positive correlation of net photosynthesis with both nodule fresh weight per plant and nitrogenous activity in *Alnus glutinosa*. The amount of photosynthesis is available is considered to be one of the major factors controlling rates of nitrogen fixation. Increases in height, nodulation in *L. leucocephala* may be attributed to the more effective starin of *Rhizobium* in the soil. A higher nodulation could result in a higher turn over of nitrogen in *L. leucocephala,* a greater rhizobial activity in soil and greater amount of nitrogen and phosphorus to increase soil fertility. This may cause reverse in *P. juliflora* and *A. procera* species showing comparatively less height growth and biomass production.

Conclusion: Deforestation, soil erosion, mono cropping, unplanned management of forest land and several other factors have caused serious degradation of our forest lands. Like all the natural forest areas Chittagong university campus hills are also subjected to several disturbances like deforestation, soil erosion, and unplanned management. The main reason of all these

problems is population explosion. For maintenance of long term production at sufficient levels to meet increasing demand, promotion of populations' awareness should be initiated. The necessity of developing ecologically sustainable production systems is realized. In the hilly areas of Chittagong University every year remarkable areas are being taken under tree plantation programs. Still there exist huge lands where local peoples have been practicing destructive agriculture like root crop production on the steep slopes. These promote the in loss of soil fertility and soil erosion and finally the lands are getting barren. For successful plantation program in such areas Nitrogen fixing multipurpose tree species should be given preference so that they could be a source of encouragement and model of replication for the rural peoples adjacent to the hill of Chittagong University campus as well as the visitors who have access to the hills. The environmental benefits from using Nitrogen Fixation are seen to be associated with the replacement of chemical based technologies with a biological system. Researches have shown that declines in soil fertility due to land degradation can be checked and soil sustainability can be maintained by planting Nitrogen fixing tree species. Knowledge on the symbiotic association of different microorganisms with tree legumes is still very limited and more extensive research is needed to find ways and means of exploring potential of legume trees in afforestation programs. Screening and grading of the nitrogen fixing tree species depending upon their nitrogen fixing capacities at different sites is essential for achieving successful afforestation. The present study has included two popular plantation species along with a promising exotic. This could be useful for developing successful model afforestation program for denuded and degraded hills adjacent to Chittagong University areas.

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