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Effects of phosphorous fertilizer on seedlings growth and nodulation capabilities of some popular agroforestry tree species of Bangladesh

Mohammad Belal Uddin[1], Sharif Ahmed Mukul[1]*, Mohammed Abu Sayed Arfin Khan[1], Mohammed Kamal Hossain[2]

[1] *Department of Forestry and Environmental Science, School of Agriculture and Mineral Sciences, Shahjalal University of Science and Technology (SUST), Sylhet 3114, Bangladesh*

[2]*Institute of Forestry and Environmental Sciences (IFES), Chittagong University, Chittagong 4331, Bangladesh*

Abstract: An experiment was conducted to assess the effect of Phosphorous (P) fertilizer (i.e. TSP or triple super phosphate @ 80 kg/hm^2) on seedling growth and nodulation capabilities of three potentially important agroforestry tree species (*Acacia auriculiformis*, *Albizia lebbeck* and *Albizia procera*) of Bangladesh. The study was conducted in nursery beds with six-month-old polybag seedlings of *A. auriculiformis*, *A. lebbeck* and *A. procera*. The effects of P fertilizer on seedling growth and nodulation were compared with that of the seedlings grown in control (i.e. unfertilized soil). The observations revealed that the seedling growth was enhanced significantly with the application of P fertilizer. The growth was found more pronounced in *A. auriculiformis*, whereas it was not apparent and shows depressed growth in case of *A. lebbeck*. The study also suggests that the nodulation in terms of nodule number and size was also increased significantly with the application of P fertilizer.

Keywords: Phosphorous fertilizer; TSP; Agroforestry; *A. auriculiformis*; *A. lebbeck*; *A. procera*; Growth parameters; Nodulation

Introduction

It is now well established that the application of commercial fertilizers accelerates the seedling growth of many agroforestry tree species (Walker *et al.* 1993; Sanginanga *et al.* 1989). They also enhanced the nodulation and nitrogen fixing capabilities of most legume species traditionally used as agroforestry components (MacDicken 1994). The high global population and the corresponding need for plant products have stimulated fertilizer production, especially nitrogen and phosphorous containing fertilizers (Stamford *et al.* 1997). Phosphorus is perhaps the most common limiting nutrient in many tropical areas where it plays an essential role in plant nutrition and energy transference (Ackerson 1985). Again, in case of leguminous agroforestry species, they require a large amount of phosphorus than any other plant, which markedly contribute in their nodulation and nitrogen fixing capabilities.

Acacia auriculiformis A. Cunn. *ex* Benth., *Albizia lebbeck* (L.) Benth. and *Albizia procera* (Roxb.) Benth., are three medium to large sized agroforestry tree species of Bangladesh, belonging to family Mimosaceae (Das *et al.* 2001). These species are popular among the rural farm holder of the country and have been extensively used as a potentially important agroforestry component. Yet again, in last years these leguminous agroforestry trees components gained wider attention of rural tree grower because of their promising economic importance particularly in tropical countries (NAS 1979). Although several studies have so far been done to assess the effect of inorganic fertilizer on growth and nodulation capabilities of various agroforestry species (Hossain *et al.* 2003; Hossain *et al.* 2001; Bhuiyan *et al*. 2000; Aryal *et al.* 2000; Hossain *et al.* 1996; Fakir *et al.* 1988; Prasad and Ram 1986 for example), detailed experiment yet had not been conducted on our three selected agroforestry tree species, particularly in respect to application of P fertilizer. Our study therefore aimed to report the effects of P fertilizer on seedling growth and nodulation capabilities of these three potentially useful agroforestry tree components of Bangladesh.

Materials and methods

Experiment environment

The entire experiment was conducted in nursery polybag (6 inch × 4 inch in size), with a mean monthly maximum temperature of 29.75°C and a minimum temperature of 21.14°C. The area is subjected to an average annual rainfall of 2500–3000 mm, mostly concentrating between June and September. Polybags was filled with soil of similar composition containing garden soil and farmyard manure in a 3:1 proportion.

The receptor species

Six-month-old healthy seedlings of three leguminous agroforestry tree species, i.e. *A. auriculiformis*, *A. lebbeck* and *A. procera*, were used as receptor species for the experiment. Seedlings were collected from the nursery, maintaining their phenotypical uniformity as far as possible.

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Biography: Mohammad Belal Uddin (1976-), male, Assistant Professor in Department of Forestry and Environmental Science, School of Agriculture and Mineral Sciences, Shahjalal University of Science and Technology, Sylhet 3114, Bangladesh (E-mail: romelahmed76@yahoo.com)

*Corresponding author: Sharif Ahmed Mukul (Email: sharif_a_mukul@yahoo.com)
Responsible editor: Zhu Hong

The control and treatments

TSP fertilizer [$Ca(H_2PO_4)_2$; containing 48% of P_2O_5] was applied as treatment at each polybag (@ 80 kg/hectare). No TSP fertilizer was used in the controls. Fertilizer was applied immediately after collection and arrangements of the seedlings in case of treatments. The following control (C) and treatments (T) were used:

C_{20}- Seedlings of unfertilized plants harvested after 20 days;
C_{40}- Seedlings of unfertilized plants harvested after 40 days;
C_{60}- Seedlings of unfertilized plants harvested after 60 days;
C_{80} - Seedlings of unfertilized plants harvested after 80 days;
T_{20}- Seedlings of fertilized plants harvested after 20 days;
T_{40}- Seedlings of fertilized plants harvested after 40 days;
T_{60}- Seedlings of fertilized plants harvested after 60 days ;
T_{80} - Seedlings of fertilized plants harvested after 80 days.

Experiment design and data recording

Altogether eight treatments (i.e. four controls and four treatments) were designed with three replicates for each species. Twenty-four seedlings of each species were collected. In total 72 polybag seedlings were arranged in four groups- 4 control and 4 treatments of each three receptor species. Groups of each species were arranged in such a manner so that plants can be harvested at every 20-day intervals up to 80 days with almost the entire root system in-tact. Collar diameter, root length, root diameter, shoot length, leaf number, nodule number and size of seedlings were recorded at each 20-days interval after every harvesting.

Care, maintenance and precautions

The seedlings were kept under nursery shade to protect strong sunlight and heavy rainfall. Proper care maintenance and precaution were followed during the whole study period. During the period of applying fertilizers, care was taken so that they were not superficially applied on the top of the polybags. Seedlings were watered in the morning of everyday and weeding was done in every third day.

Results

Shoot length

The shoot length of *A. auriculiformis* was significantly increased with the increase of harvest interval in both control and treatments, but that of *A. lebbeck* only had a significant increase in control, not in treatment (Table 1). Again, the shoot length of *A. procera* had no significant increase in both control and treatment groups. The highest (57.67 cm) shoot increment was recorded in *A. auriculiformis* at both T_{80} treatment and C_{80} control.

Table 1. Shoot length, root length, collar diameter and root diameter of *A. auriculiformis, A. lebbeck* and *A. procera* at different harvest intervals (days) in control and treatments (fertilized soil) under nursery conditions

Species	Shoot length (cm)							
	Harvesting at 20th day		Harvesting at 40th day		Harvesting at 60th day		Harvesting at 80th day	
	C_{20}	T_{20}	C_{40}	T_{40}	C_{60}	T_{60}	C_{80}	T_{80}
A. auriculiformis	22.47b*	22.40c	41.67a	36.67b	46.67a	42.33b	57.67a	57.67a
A. lebbeck	29.00b	31.43a	39.67b	49.00a	46.83a	48.00a	47.20a	34.17a
A. procera	43.00a	40.33a	45.00a	51.33a	53.33a	53.00a	51.00a	54.33a

Species	Root length (cm)							
	Harvesting at 20the day		Harvesting at 40th day		Harvesting at 60the day		Harvesting at 80the day	
	C_{20}	T_{20}	C_{40}	T_{40}	C_{60}	T_{60}	C_{80}	T_{80}
A. auriculiformis	26.83a*	32.17a	39.00a	32.67a	28.00a	28.33a	28.67a	28.33a
A. lebbeck	14.33b	16.33a	21.33ab	20.00a	28.00a	13.00a	20.67ab	17.33a
A. procera	26.83a	20.33b	24.00a	19.00b	34.00a	36.00a	36.33a	36.67a

Species	Collar diameter (mm)							
	Harvesting at 20the day		Harvesting at 40th day		Harvesting at 60the day		Harvesting at 80the day	
	C_{20}	T_{20}	C_{40}	T_{40}	C_{60}	T_{60}	C_{80}	T_{80}
A. auriculiformis	2.45c*	2.30c	4.17ab	4.50b	4.58a	4.30b	3.60b	5.87a
A. lebbeck	3.30c	3.42b	4.98b	5.53ab	6.48a	5.97ab	6.53a	7.30a
A. procera	4.30a	4.47a	4.08a	5.53a	6.02a	6.38a	5.92a	7.07a

Species	Root diameter (cm)							
	Harvesting at 20the day		Harvesting at 40th day		Harvesting at 60the day		Harvesting at 80the day	
	C_{20}	T_{20}	C_{40}	T_{40}	C_{60}	T_{60}	C_{80}	T_{80}
A. auriculiformis	4.00b*	3.95c	7.67a	7.67a	5.17b	5.17bc	6.00b	7.00ab
A. lebbeck	5.17a	5.50a	6.00a	6.33a	5.67a	5.00a	6.83a	4.83a
A. procera	7.67a	9.10a	6.67a	7.67b	7.00a	7.33b	6.17a	6.83b

Notes: *Values in the columns followed by the same letter (s) are not significantly different ($p<0.05$) according to Duncan's Multiple Range Test (DMRT)

Root lengths

In most cases, it was found that root lengths were significantly increased in treatment with the increase of harvest interval except in *A. lebbeck* where it was significant in control but not in treatment. *A. auriculiformis* had no significant increase in root length in both control and treatment. The largest root length (39.00 cm) was observed in *A. auriculiformis* at C_{40} control and the least root length (13.00 cm) was found in *A. lebbeck* at T60 treatment (Table 1).

Collar diameter

The collar diameters of three species were increased with the increases of harvest interval in both control and treatment, and the rate of increment was higher in treatment than in control (Table 1). For *A. procera,* there was no significant increment in both control and treatment. The largest observation (7.30 mm) was recorded in *A. lebbeck* at C_{80} while the least (2.30 mm) was in *A. auriculiformis* at treatment T_{20}.

Root diameter

In *A. lebbeck*, there was no significant variation in root dia. (cm) in both control and treatment. In *A. auriculiformis* it was increased significantly in both control and treatment and the rate of increment was more or less uniform. In *A. procera* it was significantly varied in treatment but not in control. The largest (9.10cm) root dia. was recorded in *A. procera* at treatment T_{20} and the largest (3.95 cm) in *A. auriculiformis* at treatment T_{20} (Table 1).

Number of leaves

The number of leaves of the selected agroforestry tree seedlings in nursery conditions is given in Table 2. In most cases it was observed that the number of leaves was increased significantly with the increase of harvest interval in both control and treatment. The highest numbers of leaves (31.67) were counted in *A. auriculiformis* at treatment T_{80} whereas the lowest (6.67) was in *A. procera* at treatment T_{20}.

Nodule number

Observation revealed that nodule number was increased with the increases of harvest interval. The nodules of *A. auriculiformis* were significantly increased in both control and treatment where the rate of increment was higher in treatment. For *A. procera* there was no significant variation in nodules both in control and treatment. Nodule number of *A. lebbeck* was significantly increased in treatment but not in control. The greatest number of nodules was recorded in *A. lebbeck* at treatment T_{60} while the lowest was found in *A. auriculiformis* in control C_{20} (Table 2).

Nodule size

Table 3 represents the variation of nodule size (mm) of selected legumes with the increase of harvest interval. From the data it was evident in most cases that nodule sizes were significantly increased with the increases of harvest interval in both control and treatment. In case of *A. procera* nodule size was varied significantly in control but not in treatment. However, nodule size was greater in treatment than in control. The biggest nodules were found in *A. procera* at treatment T_{80} while the smallest was observed in *A. auriculiformis* at treatment T_{20}.

Table 2. Number of leaves and nodule number of *A. auriculiformis, A. lebbeck* and *A. procera* at different harvest intervals (days) in control and treatments (fertilized soil) under nursery conditions

Species	Number of leaves							
	Harvesting at 20the day		Harvesting at 40th day		Harvesting at 60the day		Harvesting at 80the day	
	C_{20}	T_{20}	C_{40}	T_{40}	C_{60}	T_{60}	C_{80}	T_{80}
A. auriculiformis	9.67b*	11.0b	27.67a	23.3ab	13.0b	30.0a	20.0ab	31.6a
A. lebbeck	11.0ab	11.3ab	13.33a	12.6a	9.33b	8.00b	9.00b	11.0ab
A. procera	7.00b	6.67c	8.00b	7.67bc	9.67b	10.3b	15.0a	14.0a
Species	Number of nodule							
	Harvesting at 20the day		Harvesting at 40th day		Harvesting at 60the day		Harvesting at 80the day	
	C_{20}	T_{20}	C_{40}	T_{40}	C_{60}	T_{60}	C_{80}	T_{80}
A. auriculiformis	10.67b*	16.33c	18.33ab	31.67b	32.6a	19.33bc	27.00ab	56.67a
A. lebbeck	27.00a	38.33ab	38.33a	59.00a	33.33a	66.67a	41.67a	21.67b
A. procera	37.33a	16.00a	31.67a	37.33a	32.3a	33.3a	11.67a	26.6a

Notes: *Values in the columns followed by the same letter (s) are not significantly different ($p<0.05$) according to Duncan's Multiple Range Test (DMRT)

Table 3. Nodule size (mm) of the species grown in control and treatments (fertilized soil) under nursery conditions

Species	Nodule size (mm)							
	Harvesting at 20the day		Harvesting at 40th day		Harvesting at 60the day		Harvesting at 80the day	
	C_{20}	T_{20}	C_{40}	T_{40}	C_{60}	T_{60}	C_{80}	T_{80}
A. auriculiformis	1.90b*	1.85b	3.15a	3.12a	2.37b	2.00b	3.23a	2.33ab
A. lebbeck	3.12b	2.47b	3.13b	3.57a	3.90a	2.10b	3.58a	3.57a
A. procera	2.05b	4.27a	2.98ab	3.85a	4.00a	4.67a	2.90ab	5.80a

Notes: *Values in the columns followed by the same letter (s) are not significantly different ($p<0.05$) according to Duncan's Multiple Range Test (DMRT)

Discussion

Our experiment clearly revealed that the application of P-fertilizer significantly enhanced the seedling growth of selected agroforestry tree species in nursery which varies with different harvesting intervals. During the study overall growth rate of the selected agroforestry tree seedlings was increased in most cases. The growth was found more pronounced in *A. auriculiformis*, whereas it was not apparent and showed depressed growth in case of *A. lebbeck*. Therefore, it can be understood from the study that, with few exceptions, the growth parameters of the selected agroforestry tree seedlings is dependent on the application of P-fertilizer i.e. growth was more as P-fertilizer applied.

The result of this study is in accordance with the findings of Totey (1992) and Sundralingam (1983), who have also found the significant positive effect of P-fertilizers on *Tectona grandis*. Bhuyiyan *et al.* (2000); Sanginga *et al.* (1989) and Bhatnagar (1978) have reported the acceleration of growth parameters on the application of P-fertilizer, particularly on *Casuarina* spp. The significant effects of P fertilizers on plant height, collar dia, root length etc are also evident from the study of Verma *et al*. (1996) on *Dalbergia sissoo* and Sundralingam (1983) on *T. grandis*. An excess of application of P-fertilizers also reduce the seedling growth of *A. lebbeck* which may hamper the seedling growth by the initiation of toxic effects. This supported the findings of Van der Driessche (1980), who reviewed both the positive and negative effects of nursery fertilizer application on subsequent seedling growth and survival. Negative effects of commercial fertilizers on seedling growth was also observed by Kadeba (1978), who reported that, the addition of excess fertilizer on *Pinus caribaea* depressed growth and increased mortality of the seedlings.

Another finding of the study was the positive effect of P fertilizers on the nodulation of selected agroforestry tree seedlings. It was found that nodulation was significantly increased in terms of number and size in P fertilizations in comparison with the control (without P fertilizations). Similar findings were reported by Munns (1997); Hicks and Loynachan (1987) and Gates and Wilson (1974), who had also found the increase in nitrogen fixation with the application of P fertilizer on *A. mangium* seedlings; Sanginga *et al*. (1989) who reported that, the application of P fertilizer in *Leucaena leucocephala* improved the seedling biomass and nitrogen fixation. Though nitrogen fixing tree (NFT) species are of great importance in traditional agroforestry system, a detailed field investigation is therefore recommended to ensure the long term growth performance of selected NFT species in response to P fertilizer application in natural stands.

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