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RESEARCH PAPER

Effects of inorganic fertilizers on biological nitrogen fixation and seedling growth of some agroforestry trees in Bangladesh

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Abstract: The effects of different inorganic fertilizers (Urea and Triple Super Phosphate (TSP)) on seedling growth and nodulation capabilities of four agroforestry tree species (*Albizia chinensis*, *A. saman*, *Acacia nilotica* and *Sesbania sesban*) were compared. The nodulation of these seedlings were treated with different fertilizer treatments (at the rate of urea 40 kg·hm^{-2}, urea 80 kg·hm^{-2}, TSP 40 kg·hm^{-2}, TSP 80 kg·hm^{-2}, (urea+TSP) 40 kg·hm^{-2}·and (urea+TSP) 80 kg·hm^{-2}) after one month of seed germination. The results revealed that the seedling growth was enhanced significantly with moderate fertilizer treatment. In some cases, the higher levels of fertilizers reduced the seedling growth. The study also revealed that the nodulation in nodule number and size was significantly inhibited by the application of N fertilizer (Urea), while it was increased significantly with the application of P fertilizer (TSP). This study improved our understanding and provided insights that would be useful to the farmers in their efforts to amend the soil with inorganic fertilizers in order to enhance plant growth and biological nitrogen fixation.

Keywords: inorganic fertilizer; urea; Triple Super Phosphate (TSP); agroforestry; *Albizia chinensis*; *A. saman*; *Acacia nilotica*; *Sesbania sesban*

Introduction

Albizia chinensis (Osbeck) Merr., *Albizia saman* (Jacq.) Merr., *Acacia nilotica* (L.)Willd. *ex* Del. (Das et al. 2001) and *Sesbania sesban* (L.) Merr, (Domingo 1983), are commonly used as agroforestry tree species in Bangladesh because the four tree species can improve the soil condition through atmospheric N_2 fixation (Uddin 2003).

The steady declines in food production prompt farmers to improve the soil with different fertilizers in order to enhance plant growth and increase crop yield (Reijnties et al. 1992). The high global population and the corresponding need for plant products have also stimulated fertilizer utilization, especially nitrogen and phosphorous containing fertilizers (Stamford et al. 1997). Urea with 46% of nitrogen and TSP (Triple Super Phosphate) with 48% of P_2O_5 are commonly used as inorganic fertilizers in Bangladesh. The application of these commercial fertilizers accelerates the seedling growth and nodulation capabilities for many agroforestry tree species (Uddin et al. 2007; MacDicken 1994; Walker et al. 1993; Sanginga et al. 1989).

Biological nitrogen fixation is an important part of many agroforestry and land rehabilitation practices (Danso et al. 1992; Kang et al. 1990). A tremendous potential for contribution of fixed nitrogen to soil ecosystems exists among the legumes (Brockwell et al. 1995; Peoples et al. 1995; Tate 1995). Nitrogen-fixing agroforestry tree species are also ideal in nitrogen deficient soils for their ability to thrive in degraded soil (MacDicken 1994). The fertility of degraded soil is to be maintained either by supply of inorganic fertilizers or by planting tree species that regularly fix atmospheric N_2 (Huda et al. 2007). Although inorganic fertilizers are expensive to use over vast plantation areas, they greatly influence growth and formation of nodules (Pankaj et al. 1998).

Few studies have so far been conducted to evaluate the effect of fertilizer on seedling growth and nodulation capabilities of different tree species (Uddin et al. 2007; Hossain et al. 2003; Hossain et al. 2001; Bhuiyan et al. 2000). There are a few reports available on the effects of fertilizers on some traits in seedling growth and nodulation capabilities. In addition, no detailed experiment about effects of inorganic fertilizers on biological nitrogen fixation has been conducted yet on the agroforestry tree species, particularly in respect to application of N and P fertilizer. Therefore, the present study intended to report the effects of N and P fertilizer on seedling growth and nodulation capabilities of *Albizia chinensis, A. saman, Acacia nilotica,* and *S. sesban* in

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nursery condition.

Materials and methods

The entire experiment was carried out in nursery polybag (6 inch×4 inch in size) with mean monthly maximum temperature of 29.75 ºC and a minimum temperature of 21.14 ºC. In the area, an average annual rainfall of 2500–3000 mm mostly takes place from June to September. Polybags were filled with soil of similar composition containing forest top soil and sand in a ratio of 1:1. Six-month-old seedlings of four potential agroforestry leguminous tree species, i.e. *A. chinensis*, *A. saman*, *A. nilotica* and *S. sesban*, were used as receptor species for the experiment. Seedlings were collected from the nursery, maintaining their phenotypical uniformity as far as possible.

Urea with 46% of nitrogen and; TSP (Triple Super Phosphate) with 48% of P_2O_5 were applied as treatment at each polybag [(@ 40kg·hm^2 in level 1 and @ 80 kg·hm^2 in level 2]. No fertilizer was used in the controls. Fertilizers were applied after 5 weeks of seed germination, when the seedlings were established. The experiment has the following treatments;

T_0: no Fertilizer (Control);
T_1: urea 40 kg·hm^{-2} per polybag;
T_2: urea 80 kg·hm^{-2} per polybag;
T_3: TSP 40kg·hm^{-2} per polybag;
T_4: TSP 80kg·hm^{-2} per polybag;
T_5: urea 40kg·hm^{-2} + TSP 40kg·hm^{-2} per polybag;
T_6: urea 80kg·hm^{-2} +TSP 80kg·hm^{-2} per polybag.

A randomized complete block design with four replicates was adopted for this study. Each species was subjected to seven different treatments. In total of 280 polybag seedlings (70 seedlings of each species) were used in the experiment, involving seven treatments and four species combinations. The seedlings were allowed to grow altogether for three months from the time of seed sowing. Final harvesting was done after two months of fertilizer application. And seedlings from each treatment were measured for physical parameters. The recorded parameters were as follows: shoot and root length, collar diameter, root diameter, number of nodules and their size, relative elongation ratio of shoot to root length, etc.

The recorded data were calculated by a single factor analysis of variance (ANOVA) for significant differences between treatment means and then compared with the control treatment using Dun-can's multiple range test (DMRT). Relative ratios (shoot length and root length) were calculated as suggested by Rho et al. (1986):

$$R = Mt/Mc \times 100 \quad (1)$$

where, R is the relative ratios, Mt theMean data of tested plant, and Mc is the mean data of control.

Results

Shoot length

The shoot lengths of four selected tree seedlings treated with different fertilizers were investigated in Table 1. The study revealed that shoot lengths were significantly different among the different fertilizers. In most of the cases, it was found that the shoot length increased with the application of fertilizers. The maximum shoot length (125.00 cm) was observed in *S. sesban* at T_5 treatment followed by *Acacia nilotica* (73.40 cm) and *Albizia chinensis* (61.2 cm) at T_3 and T_4 treatment respectively whereas the lowest shoot length (20.26 cm) was observed in *Albizia chinensis* at T_0 treatment (Table 1). The highest relative elongation ratio (RER) of shoot (301.9%) was observed in *A. chinensis* at T_4 treatment while the lowest (81.2 %) was in *A. nilotica* at T_2 treatment (Fig. 1).

Table 1. Shoot length (cm) of different agroforestry tree seedlings treated with different fertilizers

Species	T_0	T_1	T_2	T_3	T_4	T_5	T_6
A. Chinensis	20.3e	26.7de	35.9cd	54.6ab	61.2a	45.8bc	48.8b
A. saman	32.3bc	37.5b	48.5a	36.8b	37.0b	37.5b	29.0c
A. nilotica	65.70ab	66.50ab	53.40b	73.40a	70.00a	71.10a	67.70ab
S. sesban	71.45c	100.20b	116.60ab	83.10c	116.60ab	125.00a	115.00ab

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).

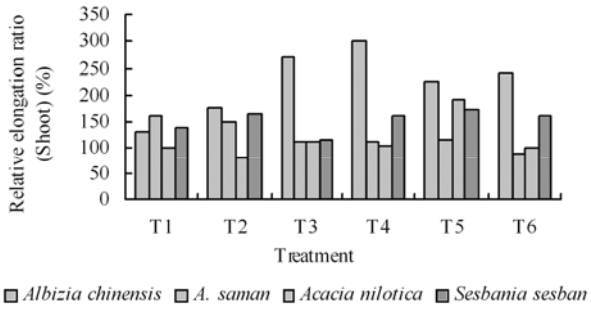

Fig. 1 Relative elongation ratio (RER) of shoot treated with different fertilizers

Root length

There was a positive increase in root lengths with fertilizer treatments except in case of *Albizia saman* (Table 2). The highest root length (40.80 cm) was recoded in *S. sesban* at T_1 treatments. Maximum relative elongation ratio (RER) of root (167.9 %) was found in *Albizia chinensis* at T_3 treatment while the lowest (53.8%) was in *A. saman* at T_4 treatment (Fig. 2).

Table 2. Root length (cm) of different agroforestry tree seedlings treated with different fertilizers

Species	T_0	T_1	T_2	T_3	T_4	T_5	T_6
A. chinensis	15.60bc	18.50abc	19.50abc	26.20a	24.50ab	15.80bc	12.95c
A. saman	20.00a	17.5a	18.50a	13.50b	10.75b	11.00b	13.50b
A.. nilotica	33.10ab	37.00a	24.2b	25.05b	26.72ab	31.05ab	23.37b
S. sesban	30.10ab	40.80a	26.00b	26.20b	38.20ab	28.90ab	38.80ab

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).

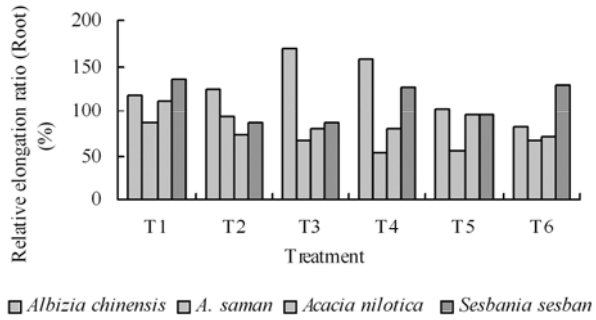

Fig. 2 Relative elongation ratio (RER) of root treated with different fertilizers

Collar diameter

The fertilizer applications had significant effect on the collar diameter increment (Table 3). The maximum effect was found at T_5 treatment in case of *S. sesban* while the lowest response of diameter growth to fertilizers was found at T_2 treatment in case of *Acacia nilotica***.**

Table 3. Collar diameter (mm) of different agroforestry tree seedlings treated with different fertilizers

Species	T_0	T_1	T_2	T_3	T_4	T_5	T_6
A. chinensis	2.57e	2.91de	3.56cd	4.93a	4.70ab	3.87bcd	4.50abc
A. saman	4.18abc	4.56abc	4.95a	3.87bc	4.53abc	4.73ab	3.72c
A.. nilotica	3.78ab	3.56abc	3.07c	3.97ab	3.72ab	3.42bc	4.06a
S. sesban	3.98d	5.44c	5.73bc	3.78d	6.31bc	8.02a	6.75b

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 diameter

With some little exception, the selected species of this study were significantly response with fertilizers (Table 4), resulting on the increment of root diameter in most of the cases. The highest root diameter (7.50 cm) was recorded in *A. saman* at T_2 treatment whereas the highest root diameter of *A. nilotica* was the smallest (1.30 cm).

Table 4. Root diameter (cm) of different agroforestry tree seedlings treated with different fertilizers

Species	T_0	T_1	T_2	T_3	T_4	T_5	T_6
A. chinensis	3.75b	3.82b	5.10ab	5.60a	5.80a	5.20ab	4.09ab
A. saman	6.75a	6.50a	7.50a	5.00b	5.25b	5.25b	4.75b
A. nilotica	1.93cd	2.38bc	1.30d	3.00a	2.73ab	1.82cd	2.04bcd
S. sesban	4.11c	6.33ab	5.73b	4.58c	6.06ab	6.06ab	7.02a

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).

Nodule number

The nodulations was found to be significantly sensitive to the application of N and P fertilizers on the selected tree species (Table 5). The P fertilizer treatments (T_3 and T_4) formed the highest number of nodules in most of the species. Except for *A. chinensis* the lowest number of nodules for rest of the species was recorded at N fertilizer treatments (T_1 and T_2). Number of nodules per plant was maximum in *A. chinensis* (30.20) at T_3 treatment. All the treatments produced significantly higher number of nodules compared to N fertilizer treatment (T_1 and T_2). Applications of nitrogen fertilizers inhibited the nodulation. No nodules were observed in few cases. Among the species *Acacia nilotica* was poorly nodulated.

Table 5. Nodule number of different agroforestry tree seedlings treated with different fertilizers

Species	T_0	T_1	T_2	T_3	T_4	T_5	T_6
A. chinensis	8.00d	8.00d	7.50d	30.20a	29.50b	25.20c	5.90e
A. saman	9.00f	15.00e	5.00g	19.00a	15.00d	15.00c	18.00b
A. nilotica	.00g	.00f	.00e	.00d	3.50a	.00c	.00b
S. sesban	5.45d	5.00e	1.000E-01f	10.00c	12.00b	12.00b	15.00a

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).

Nodule size

The nodule sizes of selected agroforestry tree seedlings are shown in Table 6. It was observed that the fertilizer treatments had the positive impact on the increment of the nodule in sizes. The highest nodule in size (5.75 mm) was found at T_5 treatment in case of *A. saman* while the lowest (1.21mm) was found in case of *A. chinensis* at T_6 treatment.

Table 6. Nodule size (mm) of different agroforestry tree seedlings treated with different fertilizers

Species	T_0	T_1	T_2	T_3	T_4	T_5	T_6
A. chinensis	2.7a	2.05b	2.05b	2.21b	2.62a	2.50a	1.21c
A. saman	4.58bc	3.21d	3.87cd	3.69cd	3.58d	5.75a	4.98ab
A. nilotica	.00b	.00b	.00b	.00b	1.70a	.00b	.00b
S. sesban	2.67c	2.71c	2.48c	2.43c	3.06c	4.41b	5.17a

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

This study clearly revealed that the fertilizers have their effect on the improvement of growth parameters for leguminous agroforestry tree seedlings in nursery condition. The results of this study were supported by the results of some researchers (Bhuiyan et al. 2000; Walker et al. 1993; Sanginga et al. 1986), who reported the acceleration of growth parameters on the application of fertilizers in *Casuarina* spp. Moreover, some researchers (Heilman and Fu-Guang 1993; Maze et al. 1993) reported the increment of seedling growth on the application of N fertilizers. Our findings were also agreed with the findings of Verma et al. (1996) who reported the positive effect of phosphorus fertilizers on the seedling growth of *Dalbergia sissoo*.

In some cases, we found that the higher doses of fertilizers

reduced the seedling growth by the initiation of toxic effects. This result was supported by the findings of Van den Driessche (1980), who reviewed both the positive and negative effects of fertilizer application on subsequent seedling growth and survival in nursery condition.

Our study also revealed that different fertilizers had their different effects on nodulation. It was found that N fertilizers influenced the nodulation of leguminous agroforestry tree seedlings in nursery condition. In most of the cases, N fertilizers inhibit the nodulation (nodule numbers/plant) of agroforestry tree seedlings. But in few cases, nodulation was found to be promoted by the low doses of N fertilizers. These findings coincide with the findings of some researchers (Zahran 1999; Arreseigor et al. 1997; Abdul-Wahab et al. 1996; Sanginga et al. 1996; MacDicken 1994). This result is also consistent with the findings of Solaiman (1999) who found the suppression of nodulation in agroforestry crops due to nitrogen fertilization.

P fertilizers had positive effect on the nodulation of agroforestry tree seedlings. Results showed that nodulation was significantly increased in both levels of phosphorous fertilizations in comparison to the control (without P fertilizer). Similar findings were reported by Munns (1997), Adu-Gyamfi et al. (1989) and Jasper et al. (1989), who found that growth and nitrogen fixation were increased in *Acacia mangium* with P fertilizer application.

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