Growth Performance and Species Interactions in a Young Mixed Plantation of Acacia Auriculiformis and Swietenia Macrophylla

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Abstract—*A study was carried out in the nursery of the Institute of Forestry and Environmental Sciences, Chittagong University (IFESCU), Bangladesh to assess the effects of mixed plantings of Acacia auriculiformis (A) and Swietenia macrophylla (S) on initial growth and biomass production during February to November, 2015. The treatments consist of two pure planting plots of A. auriculiformis and S. macrophylla (100% A and 100% S) and five mixed planting plots (1A:1S, 1A:2S, 1A:3S, 2A:1S and 3A:1S) of the two common forest plantation tree species. Seeds were sown in a randomized blocks with three replicates of seven treatment plots in the nursery. Periodic increments on height (cm), collar diameter (cm) and leaf/phyllode (number) of the seedlings was taken in every month and continued up to 10 months. At the age of 10 months of the experiment, it was found that S. macrophylla seedlings were significantly tallest (90.43 cm) when planted with A. auriculiformis in a proportion of 1A: 3S, whereas A. auriculiformis seedlings were tallest in the pure 100% Acacia plot, with an average mean height of 135.4 cm. Maximum collar diameter (1.14 cm) was recorded for S. macrophylla in the mixed plot 2A:1S. Fresh and dry weight of shoots and roots of the seedlings were found significantly ($p<0.05$) highest in 1:1 mixed plot for S. macrophylla. S. macrophylla showed highest quality index when mixed with Acacia in a proportion of 1:1, with an average value of 6.06. The findings suggested that mixed species young plantations of Acacia auriculiformis and Swietenia macrophylla had the potential and significantly ($p<0.05$) better growth, biomass yield to improve stand productivity over that of respective monocultures. The early results of both the nitrogen fixing and non-nitrogen fixer species in different mixing ratios may be projected for further field plantations.*

Keywords*: Bangladesh, biomass, mixed plantations, periodic increment, species interactions*

1. INTRODUCTION

Tropical forests of Bangladesh are unique and irreplaceable ecosystems with their incomparable variety of plant and animal species [1]. But, massive failures of established plantations and land degradation have resulted in continuous depletion of forest resources. In order to save natural forests from further degradation, it is important to expand forest area through mixed plantations of native and exotic species. Conservation of forest resources along with mixed plantations is also vital to mitigate climate change [2]. To reduce the gap between demand and supply of forest products and manage plantations more successfully, it is an urgent need to increase the yields of such plantations. A mixed plantation with suitable species combination can help to solve these problems [3]. Species mixture can produce a greater amount of biomass per unit area of land because competition between individuals is reduced and the space is utilized more effectively [4]. Nitrogen fixing trees in tropical environments appear to offer both high growth rate and soil enrichment [5]. There is a wide range of nitrogen fixing plants that have been used in forestry with an objective of raising soil nitrogen levels and subsequently improving the growth of the non–nitrogen fixing forest species [6]. But still research on nitrogen–fixing species in general has lagged behind that on food, feed, and forage crops. For tropical evergreen forests estimate of nitrogen fixation are extremely rare and highly variable (Cleveland et al., 1999). *A. auriculiformis*, a nitrogen fixing tree species, has becoming a common plantation tree in the eco-park, Botanical gardens, protected forests of Bangladesh and provide considerable economic and social benefits (Hossain, 2008). Nitrogen fixing *A. auriculiformis* and *Swietenia macrophylla* (non–nitrogen fixing species) are two exotic species extensively planted in forests, marginal lands, institutes, roadsides, railway sites, field borders and homesteads of Bangladesh (Hossain, 2008). The present study was aimed to investigate the effects of mixed plantings of nitrogen fixing tree species (*A. auriculiformis*) with a non-nitrogen fixing tree (*S. macrophylla*) on their growth and biomass.

2. MATERIALS AND METHODS

Experimental plot design

Seedlings were raised in a randomized blocks with three replicates of seven treatment plots. Two pure planting plots of *A. auriculformis* and *S. macrophylla* along with five mixed planting plots of two species (*Acacia*× *Swietenia)* were established. The treatment details were Two pure planting plots – P_1 (100% A), P_2 (100% S) and five mixed planting

plots – M_1 (1A:1S), M_2 (3A:1S), M_3 (1A:3S), M_4 (2A:1S), M_5 (1A:2S) were established. Each plot was 200 cm × 60 cm in size with 30 seedlings at a spacing of 20 cm × 20 cm (seedling to seedling distance: 20 cm).

Measurement of growth parameters in the nursery

The seedlings were allowed to grow for ten months from the time of seed sowing. Five representative seedlings from each species were selected from each replication of a treatment for measuring physical parameters.

Harvesting and growth data collection in the seed research laboratory

Five randomly selected seedlings of each species were uprooted carefully from each mix plot and ten seedlings from each pure plantation plot at 10 months after germination. The uprooted seedlings were than washed to clear the root region off all soil particles. The data on shoot length, shoot diameter, branch number, leaf number, tap root length, lateral root length, tap root diameter, and number of lateral roots were recorded. Fresh weight of the stem, root and leaves were measured after removal of all water from the root portion of the washed seedlings. The samples were oven dried at 70°C for 72 hours and after that oven dry weight of shoot, root and leaf of the seedlings were measured. The quality index (QI) to quantify seedlings morphological quality was calculated [9] as follows:

Determination of interspecies competition

The effect of interspecies competition was determined by comparing aboveground plant biomass for individual species in pure and mixed plots. The effect of competition on changes in plant biomass (PB_{diff}, expressed in g per plant) for a given species when mixed with other tree species was calculated using the following equation [10]:

$$PB_{diff} = PB_{mix} - \frac{1}{2} PB_{pure}$$

Where,

PB_{mix}= Plant Biomass (g per plant) of species grown in mixture with another species,

PB_{pure}= Plant Biomass (g per plant) of the same species grown in pure stand.

$$QI = \frac{Seedling\ dry\ weight\ (g)}{[Height\ (cm)/\ Diameter\ (mm) + Shoot\ dry\ weight\ (g)/\ root\ dry\ weight\ (g)]}$$

3. RESULTS

Initial growth performance

Results from periodic measurement of height and collar in the all plots, the order of periodic increment for *A. auriculiformis* was $P_1 > M_2 > M_1 > M_5 > M_3 > M_4$ and for *S. macrophylla* was $M_3 > M_2 > P_2 > M_5 > M_4 > M_1$

Seedling morphological character

The result of variance analysis for seedling morphological character after 10 months of *A. auriculiformis* revealed that the effect of planting patterns was significant ($p < 0.05$). After 10 months, significantly ($p< 0.05$) highest mean shoot length (163. 27 cm) was observed in mixed plot M_5 followed by M_3 (149.97 cm) and P_1 (149.53 cm). Significantly ($p< 0.05$) highest mean shoot length (103. 56 cm) for *S. macrophylla* was observed in mixed plot M_5 followed by P_2 (100.1 cm) and M_3 (96.7 cm).

Biomass productivity

At the time of *A. auriculiformis* seedling harvest, the highest fresh weight (113.91g) was recorded in M_3 followed by 105.83g in M_2 and 103.07g in P_1. Compared with pure plot, the fresh weight of stem, root and leaves were also significantly higher in mixed plots. The result of variance analysis for fresh weight of *S. macrophylla* revealed that the effect of planting pattern was significant ($p< 0.05$). Mean comparison using Duncan multiple range test (DMRT) showed that the highest amount of yield for fresh weight obtained in mixed plot (M_1). At the time of *S. macrophylla* seedlings harvest, the highest fresh weight was recorded 156.03 g in M_1 followed by 135.67g in M_2 and 134.24g in M_5.

Effects of Inter–species competition

The effect of interspecies competition was determined by comparing aboveground plant biomass. Biomass yield differed significantly among mixed plots **(Fig.1).** The highest biomass production (33.72 g) was obtained in mixed (M_1) plot while the least (14.81 g) was obtained in M_3 plot. *A. auriculiformis* biomass per tree was positively affected by mixing with *S. macrophylla* in M_1–M_5 plots. The shoot biomass production for *S. macrophylla* was decreased (14.82 g) when mixed with *A. auriculiformis* in 1A:3S proportion.

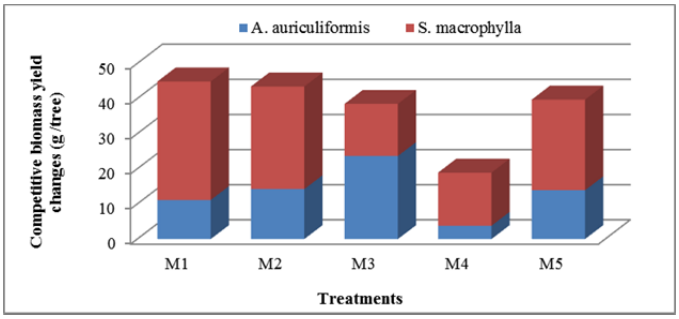

Fig. 1: Effect of competition on aboveground biomass in mixed plotsQuality Index (QI)

The present study revealed that at the time of harvesting the quality index was highest for *S. macrophylla* (6.06) followed by *A. auriculiformis* (1.75)**.**Maximum quality index (1.75) was calculated for *A. auriculiformis* in M_3 followed by P_1 (1.66), M_1 (1.56) and M_2 (1.52). Highest quality index (6.06) was

calculated for *S. macrophylla* in M_1 followed by M_2 (4.98) and M_4 (4.57) **(Table-1).** *S. macrophylla* was showed better morphological quality through quality index in the mixed plots than in pure plots.

Table 1: Quality Index of *A. auriculiformis* and *S. macrophylla* in pure and mixed plots at ten months after germination

Species	Treatment	Seedling dry weight	Height (cm)	Collar dia. (mm)	Ht (cm)/ Collar dia (mm)	Shoot dry weight (g) [S.D.W.]	Root dry weight (g) [R.D.W.]	S.D.W./ R.D.W.	Ht/Coll.dia.+ S.D.W./R.D.W.	QI
Acacia	P_1	50.79	149.53	11.4	13.13	40.74	10.07	4.07	30.59	1.66
	M_1	39.13	143.4	13.1	10.94	31.48	7.64	4.12	25.05	1.56
	M_2	45.41	135.17	9.7	13.93	34.58	10.82	3.19	30.04	1.51
	M_3	53.36	149.97	12.7	11.80	44.02	9.34	4.71	30.65	1.75
	M_4	31.85	130	12.1	10.74	24.16	7.70	3.14	22.07	1.44
	M_5	43.54	163.27	12.37	13.19	34.25	9.29	3.68	28.62	1.52
Swietenia	P_2	58.14	100.1	11.3	8.87	48.13	10.02	4.80	13.69	4.21
	M_1	70.83	86.57	11.9	7.28	57.78	13.05	4.43	11.71	6.06
	M_2	65.12	103.56	12.1	8.56	53.27	11.87	4.49	13.06	4.98
	M_3	46.96	96.7	11.3	8.56	38.89	8.08	4.81	13.38	3.51
	M_4	50.31	95.07	12.7	7.48	39.18	11.12	3.52	11.01	4.57
	M_5	60.48	95.24	12.2	7.81	49.85	10.64	4.68	12.49	4.84

4. DISCUSSION

The initial growth performance of *A. auriculiformis* and *S. macrophylla* in the experiment showed that both the species performed better in combinations than in pure plantations. Compared with pure plantation, performance of *S. macrophylla* was significantly higher when it was planted with *A. auriculiformis* in a proportion of 1:1. *S. macrophylla* also showed best performance in the mixture with *A. auriculiformis* in 3:1 and 1:3 ratios which was similar to Aryal et al. (1999). A study conducted by Aryal et al. (1999) reported that performance of non-nitrogen fixing *Eucalyptus camaldulensis* was significantly higher when it was planted with *Albizia procera* in a proportion of 50:50 (1:1).

In this research, the effects of mixed plantations on growth and biomass of two common plantation tree species (*A. auriculiformis* and *S. macrophylla*), and the root and stem development of these species were investigated. In this respect, it has been determined that there were significant differences between growth performance of the seedlings ($p<0.05$).

Accordingly, it has been found that the growth performance of the non-nitrogen fixing *S. macrophylla* seedlings exposed to various patterns of mixed plantations with *A. auriculiformis* were much higher than the growth performance of the *S. macrophylla* seedlings in pure plantations.

These findings would be useful for successful afforestation/plantation programs. But, these results are based on 10–month old saplings only. So, it is too early to assess the exact performance of these species and the inferential power of the results is limited.

5. CONCLUSION

The initial results of present investigation showed enhanced growth and biomass in mixed plantations in comparison to pure plantations. Further study needs to be conducted to compare growth performance, and biomass increase between mixed and pure plantations.

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