Early growth performance of some tree species on water logged sites in Nepal's Terai

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A species elimination trial was established in June 1991 on waterlogged site at Shankarnagar, Rupandehi District of the terai region.The aim was to compare the survival and growth of selected species so that a recommendation could be made for tree species suitable for planting on waterlogged sites in the terai region. Seedlings of *Albizia chinensis*, *Albizia procera*, *Anthocephalus chinensis*, *Salix tetrasperma*, *Syzygium cumini*, *Terminalia belerica*, *Terminalia chebula* and *Trewia nudiflora*, were planted on mounds of 30 x 30 x 30 cm size which were prepared one month before planting.The cost of mound preparation is 33% more than that of the cost of pitting, which is not significantly higher regarding the cost of planting.There was highly significant difference in height and diameter growth of tested tree species at 3.5 years ($P<0.01$). Among the eight tested tree species, the height growth of *Albizia chinensis* (height=10.1m, diameter=12.3cm) was heighest followed by *Albizia procera* and *Anthocephalus chinensis*. *Terminalia chebula* has the poorest growth followed by *Syzygium cumini*. *Terminalia chebula* was repeatedly browsed by goats and *Syzygium cumini* by insects due to which their survival was poor. *Salix tetrasperma* failed to grow.

Keywords: growth performance, *Albizia chinensis*, *Albizia procera*, *Anthocephalus chinensis*, *Salix tetrasperma*, *Syzygium cumini*, *Terminalia belerica*, *Terminalia chebula and Trewia nudiflora*, water-logged sites, terai

The limitation and /or excess of water are the important plant stress variables in many parts of the world (Chaturvedi *et al.* 1984). Acquiring knowledge on water requirements of different tree species becoms important to select suitable tree species for water-logged sites and thereby increasing the productivity of land.

The terai has a sub-tropical type of climate. The large amount of rainfall and lack of drainage in these areas lead to the formation of several ponds, ditches and temporary to perennial water bodies. Certain tree species can perform well or even tolerate waterlogged site. To test this hypothesis a Species Elimination Trial was established by the Forestry Research Division at Shankarnagar, Rupandehi District in 1991. The objective was to compare the survival and early growth of some species suitable for waterlogged areas in Nepal's terai. The tree species for the present experiment were *Albizia chinensis*, *Albizia procera*, *Anthocephalus chinensis*, *Salix tetrasperma*, *Syzygium cumini*, *Terminalia belerica*, *Terminalia chebula* and *Trewia nudiflora* (seed source is given in Annex).

Materials and methods

The study was conducted at Shankarnagar (about 4km south-east of Butwal town) at Rupandehi District, Western Region of Nepal. Its altitude is about 205m above msl. Its

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latitude and longitude are 27° 42' N and 83° 28' E respectively. The site has a typical sub-tropical monsoon climate with more than 90% of the rainfall occurring between June to October. The site generally remains dry from November to May, except for occasional light shower during winter.

The trial was established in 0.18 hectare. Seedlings were planted on mound (30 cm x 30 cm x 30 cm) prepared one month before planting. For the first three years plants were weeded manually two times a year during September and March .

Plantation was done just at the beginning of monsoon rain. A randomized complete block design (RCBD) with 3 replications and 8 species (treatments) was used. A sub-plot had 5 x 3 plants. Spacing between plants was 2 x 2 m. One row of *Albizia chinensis* was planted around the plot boundary.

The first reading on survival was recorded just after planting and the second reading after six months. The heights were also measured after six month and thereafter at an interval of one year for three and half consequetive years. Analysis of variance (ANOVA) and Tukey's test were used to analyse the data.

General observation

On 26.09.93, some leaves of *Albizia chinensis* were found damaged by insects. Self-pruning was observed in this species. Most *Albizia procera* trees had multi-stems. *Salix tetrasperma* survived up to one year, then the upper parts of stems started drying up leading ultimately to death and thus was dropped from the experiment.

Syzygium cumini had scorched leaves due to attack of insects which appeared on the middle of July, 1993 which disappeared on the last week of October 1993. Such incidence also occurred during 1992 and 1994. Some trees of *Terminalia belerica* and *Terminalia chebula* were browsed by goats. On 30.05.1995, again *Syzygium cumini* were heavily attacked by larva of unidentified insects due to which a few plants died.

Results and discussion

The survival percentage and mean heights taken at three different periods are presented in table 1. Three species, namely *Albizia chinensis, Albizia procera* and *Anthocephalus chinensis* showed a relatively faster height growth and better survival percentage. The analysis of variance (see Table 2) revealed that there was highly significant in height growth of seven tree species ($P < 0.01$).

Table 1: Survival percent (5%) and mean height of species at 5, 19 and 32 months.

Species	Age (Months)					
	5		19		32	
	Mean Ht. (cm)	S (%)	Mean Ht. (m)	S (%)	Mean Ht. (m)	S (%)
Albizia chinensis	70	100	3.7	100	7.1	100
Albizia procera	59	100	2.9	100	5.5	100
Anthocephalus chinensis	79	100	2.7	100	5.3	100
Syzygium cumini	79	84	1.0	76	1.3	76
Terminalia belerica	86	100	1.3	100	2.5	93
Terminalia chebula	66	95	1.1	96	1.7	87
Trewia nudiflora	69	99	1.4	78	2.5	78

The results showed that the height growth of three species, namely, *Albizia chinensis, Anthocephalus chinensis,* and *Albizia procera* were significantly different with *Syzygium cumini, Trewia nudiflora, Terminalia belerica* and *Terminalia chebula* (Table 2).

Lower survival of *Syzygium cumini* might be due to the repeated attack of insects whereas

the same for *Terminalia chebula* and *Terminalia belerica* might be due to repeated browsing by goats. Since, these species grew very slowly in the early stage as compared to *Albizia chinensis*, *Anthocephalus chinensis* and *Albizia procera* which were easily outreached from goats. *Anthocephalus chinensis* had the most uniform height growth followed by *A. procera* and *A. chinensis* (Table 1). However, *T. chebula* had larger variation in height growth that may be due to the damage by goats.

Table 2: Survival percentage, mean height, standard error of mean and coefficient of variation of seven tree species at 3.5 years.

Species	S (%)	Mean ht (m)	SE of Mean (m)	CV (%)
Albizia chinensis	98	10.1	0.22	16.3
Albizia procera	100	8.0	0.15	13.9
Anthocephalus chinensis	100	7.6	0.07	6.60
Syzygium cumini	22	1.6	0.07	16.7
Terminalia belerica	78	4.3	0.15	23.8
Terminalia chebula	44	1.3	0.28	106.3
Trewia nudiflora	76	4.3	0.25	36.1

Means followed by the same letters do not differ significantly ($P < 0.01$).
Tukey's value = 2.636

Considering the mean height and survival percentages at 3.5 years of age, *Albizia chinensis* has performed the best growth on waterlogged areas followed by *Albizia procera and Anthocephalus chinensis.*

Diameter at breast height (DBH) of *T. chebula* and *S. cumini* were not measured at 3.5 years, because of negligible growth. The cause of the mortality of *Salix tetrasperma* is not clearly known. However, rooted cuttings used for planting might have been rotten due to excess of water.

A significant difference in diameter growth of *Albizia chinensis* with *Trewia nudiflora, Terminalia belerica, Anthocephalus chinensis* and *Albizia procera* was observed at 3.5 years. *Anthocephalus chinensis* also showed significant difference with all other four species. The highest diameter growth(12.3 cm) was found in *Albizia chinensis.* The results of mean DBH, standard error of mean, coefficient of variance and Tukey's results are given in table 3.

Table 3: Mean DBH, standard error of mean and coefficient of variation of seven tree species at 3.5 years

Species	Mean DBH (cm)	SE of Mean	CV (%)
Albizia chinensis	12.3	0.5	26.8
Albizia procera	7.7	0.3	28.1
Anthocephalus chinensis	9.9	0.4	24.6
Terminalia belerica	4.4 a	0.2	29.7
Trewia nudiflora	5.1 a	0.3	27.0

Means followed by same letters do not differ significantly ($P < 0.05$).
Tukey's value = 1.457

These species may have a low priority in getting quick return particularly to private growers. However, these species have higher value for house construction than other tested species. So, they can be used for block planting in the waterlogged sites.

The present study suggests that *Albizia chinensis, Albizia procera* and *Anthocephalus chinensis* could be used for planting on the waterlogged sites of terai under different rotations. The importace of *Terminalia belerica* and *Trewia nudiflora* cannot be ignored, if considered for match splints, planking and packing cases. Further research is needed for rotation period of these species.

The cost of mound preparation is 33% more than that of the pitting. So the overall cost of planting is not so much higher than the usual planting. The benefit would be more if the products could be harvested within short time from the poor marginal lands. The fast growth rate of *Albizia chinensis, Albizia procera*, and *Anthocephalus chinensis*, indicates higher

biomass production - a positive aspect for planting these species.

This trial terminated at 3.5 years. This period is not good enough to confirm and compare the growth performance and survival of these species. Establishment of trial of all the tested species in large blocks is suggested to observe the growth and survival pattern on waterlogged areas.

Utilisation of the tested species

Albizia chinenesis is good for light furniture and planks. It has fodder value also (Napier and Robbins, 1988). It weighs 300 to 550 kg m^{-3}, so it is rather light to be a good fuelwood. Its timber is soft and not durable (Jackson, 1994).

Albizia procera is good for firewood and fodder; furniture and general construction (Napier and Robbins, 1988). Rotation of 3.5 years could be applied for firewood production for this species, however, rotation for furniture and construction need to be similar to *A. chinensis*. It has a calorific value of 26, 800 kJ kg^{-1} and good for charcoal production also. Its density (heartwood) is 640 kg m^{-3} (Jackson, 1994). A higher coppicing capacity of this species is advantageous for firewood production. Further study is therefore needed on growth and utility value of furniture and construction for these species.

Anthocephalus chinensis has calorific value of 23,000 kJ kg^{-1} (air-dried). It burns slowly except occasional cracking. It is a medium quality fodder. Other uses are for veneer corestock, matches splints and paper pulp. Its density is about 600 kg m^{-3} (Jackson, 1994). It can coppice well. Management of this species for firewood and pulpwood production could be done.

Terminalia belerica could be used for firewood, planking, packing cases and sometimes for house construction, fodder, tannin and medicines. It has a density of 770 kg m^{-3}. *Trewia nudiflora* has light wood (density 460 kg m^{-3}). It is mainly used for planking, packing cases and wood carving, match splints and fodder. Further research is needed to find out the appropriate rotation to get most of the above uses for these two species.

Syzygium cumini has a calorific value of 20,100 kJ kg^{-1} and density 770 kg m^{-3}. It is used for firewood, posts beams, rafters, agricultural implements, fruits and fodder. *Terminalia chebula* has density of 920 kg m^{-3}. It is used for furniture, carts, agricultural implements, house construction and fodder (Jackson, 1994).

Conclusion and recommendations

Selection of the suitable tree species for planting on waterlogged areas demands a great care. Considering the 3.5 years' data, the remarkable growth of *Albizia chinensis*, indicated higher biomass accumulation which could be used for furniture wood in short rotations. The three species, *Albizia chinensis*, *Albizia procera* and *Anthocephalus chinensis* need to be used for planting in the water logged areas. Further research is needed for *Albizia procera* and *Anthocephalus chinensis* and *Albizia chinensis* to find out the rotation period for pulp wood production, furniture and construction purpose.. In addition to it, utility value and its preference by furniture makers should also be studied.

Due to higher coppicing ability and growth rate, *Albizia procera* and *Anthocephalus chinensis*, the rotation of 3.5 years need to be applied for fire wood production. The frequency of coppicing ability of these species could be the other research area for these species are good for planking, packing cases and for making match splints. Based on the results of 3.5 years, planting of *Terminalia belerica* and *Terminalia nudiflora* could be done if market of these products were available. *Syzygium cumini* and *Terminalia chebula* have slow growth and hence are not recommended for afforestation programme on waterlogged areas. However, these species have higher value for construction and these can be planted in large blocks to get the products in the long term.

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Annex

S. No.	FRD Seedlot number	Species	Seed/cuttings source
1	1226	*Albizia chinensis*	Hetauda, Makawanpur District
2	1690	*Albizia procera*	Hetauda, Makawanpur District
3	1734	*Anthocephalus chinensis*	Belbari, Morang District
4	------	*Salix tetrasperma**	Tarahara, Sunsari District
5	1730	*Syzygium cumini*	Tarahara, Sunsari District
6	1748	*Terminalia belerica*	Tarahara, Sunsari District
7	1743	*Terminalia chebula*	Tarahara, Sunsari District
8	1669	*Trewia nudiflora*	Belbari, Morang District

* Cuttings were collected at Tarahara.