SHORT NOTES

Preliminary findings on provenance trial of *Azadirachta indica* in western Terai, Nepal

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Azadirachta indica (neem) - an attractive evergreen tree (deciduous in drier areas) is native to the Indian Sub-continent. It is cultivated throughout Southeast Asia, Australia, East and Sub-Sahelian Africa, Fiji, Mauritius and many countries in Latin America. In Nepal, it is found both in wild and in homesteads gardens of the Terai and Inner Terai regions up to an elevation of 900 m (Karki and Karki, 1994). But, its commercial plantations have not been established by any institutions in Nepal. It is believed to be an exotic species by most researchers, its adaptive nature to Nepal's eco-physical conditions (Stainton, 1982, Jackson, 1994) and Kayastha, 1985), has rendered its availability in almost every village in the Terai.

Considering the multipurpose importance of this species participants (of the first consultation meeting on neem improvement which was held in Bangkok, 18-22 January, 1993), including the main countries of the natural range of the species, agreed to undertake an International Neem Improvement Programme coordinated by a panel formed by CIRAD- FORET (France), Danida Forest Tree Seed Centre (DFSC, Denmark), Forestry/Fuelwood Research and Development Project (F/FRED, Bangkok) and FAO. The second consultation on neem improvement at Jodhpur, India, 28 February to 4 March, 1994, examined the results of the encouraging pilot activities and progress made. The International Neem Network was established and decided to establish Neem provenance trials in participating countries, using seeds from world over. Nepal was also one of the participant country for this work.

In countries, which are located outside the natural range of this species, the genetic materials used for plantation research is very narrow. The provenance trials would therefore, help selecting the best possible provenance for establishing Government/ community/private plantations for those areas. This would also help in breeding programmes.

In this connection, to support the long-term objective of the International Neem Network (INN) on improving the genetic quality and adaptability of neem, and to increase its utilisation in the related countries with emphasis on meeting the needs of rural people, the present experiment aims:

a) to test the adaptability of 23 neem provenance in the western Terai of Nepal; and

b) to identify the best provenance in terms of health , stem form and productivity.

Materials and methods

The provenance trial was established at Shankarnagar (27° 42' N and 83° 28' E; alt. 205 m) , which lies in the western Terai/Bhabar region of Nepal. The site has well-drained loamy soil (depth > 100 cm) without gravel on the top. The mean annual rainfall of the area is 2452 mm with mean maximum and minimum temperatures 30°c and 20°c respectively. April and May are the hottest months whereas January is the coldest (source: Department of Hydrology and Meteorology).

The site has originally sal (*Shorea robusta*) forest with tree associates like *Terminalia alata, Terminalia belerica, Lagerstroemia parviflora* and Shrubs like *Hollarbena antidyscentrica.* About 1.7 hectare of land including 0.7 hectare of patch with coppicing *Shorea robusta* was also used for this trial.

Pitting (Pit size 30 x 30 x 30 cm) of the site was done on the first week of July 1996, and soil was refilled in each pit. Nine to 15 months old stumps of neem provenance (Tibbia Laran, Multan, Ghati Subramanya, Chitradurga and Kuliyapitiya) were brought from Attaria nursery, about 430 km to the west of Butwal town. Plantation of their stumps was done on 13th of July 1996, and the other seventeen provenance brought from Hetauda nursery (about 300 km to the east of Butwal) were planted on the 16th. There was a lot of moisture in the soil. Beating up was done in September 1996.

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Randomised complete block design with three replicates was selected for 23 provenance (Annex 1). The plot size consisted of 30 stumps, the core plot being of 12 stumps with spacing being plant to plant 2 m and row to row 4 m. In the third replicate of the trial, some provenance were washed away by rain water, and hence, assessment was not done in this replicate after 1.5 years. Every possible measures were taken to protect the plot from animals. Fire line was also maintained every year.

Survival rate and height of plants were recorded on a yearly basis. DBH, diameter at 30 cm were measured. Health assessment and straightness of stems were done using the score. The number of stems at or below 1.3 m was counted at 4.5 years. Differences among provenance were established by analysis of variance (ANOVA) using MINITAB. Whenever the differences were significant in the ANOVA, the means were separated using the Tukey's Honestly Significant Difference (HSD) test ($P < 0.05$). Data on survival percent was subjected to arcsin transformation in order to normalise the variance (Fowler and Cohen 1990).

Results and discussions

After four and half years more than 75 percent stumps survived in six provenance viz., Rammana Gudu (India), Yezin (Myanmar), Sunyani (Ghana), Sagar Chanatoriya (India), Annur (India) and Lamahi (Nepal). Those survived between 70 to 80 % were Doitao (Thailand), Allahabad (India), Geta (Nepal), and Tibbia Laran (Pakistan). Except four provenance (Ban Bo, Tuang Luang, Ghati Subramanya, and Kuliyapitiya), all other 19 had the survival percentage more than 60 (Table 1), which is quite satisfactory. No significant difference ($P < 0.05$) was found in arcsin (angular) transformed mean survival of 23 neem provenance at this period.

Only four provenance (Eosin, Sunni, Lama and Band) that performed well had the mean heights higher than 2.5 at 3.5 years (Table 2). For them, the trend of height growth was similar even at 4.5 years (Table 3).

Some of the promising provenance in terms of height growth at 4.5 years, were Yezin, Sunyani, Lamahi, Ghati Subramanya, and Bandiya which attained the average heights more than 3 m. Some of the provenance Chamwino, Ramanna Gudu, Balharshah, Allahabad, Annur, and Kuliyapitiya had the heights in a range of 2 to 2.9 m (Table 3). There was no significant difference in mean height of 23 neem provenance tested ($P < 0.05$).

Yezin, Sunyani, Lamahi (local provenance), and Bandiya provenance performed better in diameter growth than other provenance, all of which had the D30 (diameter at 30 cm) more than 4 cm. Other provenance, which attained D30 (cm) between 3 to 3.9 cm, were Chamwino, Doitao, Ramanna Gudu, Balharshah, Ghati Subramanya and Kuliyapitiya at 4.5 years.

Doitao, Yezin, Sunyani, Annur, Lamahi and Bandiya provenance attained the DBH higher than 2.5 cm at 4.5 years with the highest DBH being for Sunyani (Ghana) provenance (Table 3). No significant differences were observed in diameter growth (dbh or D30 cm) of 23 neem provenance.

The average value of crown diameter in Ramanna Gudu, Yezin, Sunyani, Bandiya and Kuliyapitiya was higher than 1.5 m. Ten provenance attained average crown diameter less than 1 m (Table 3). There was highly significant different in crown diameter of 23 neem provenance ($P < 0.01$) at 4.5 years. Tukey's test showed that only Sunyani and Mandore neem provenance significantly differed in crown diameter.

The Mandore provenance had no forked stems at or below 1.3 m, and the three provenance from Thailand (Ban Bo, Tuang Luang, and Doitao), Vientiane, Chitradurga and Ghati Subramanya had less forked stems in comparison to others (Table 3).

Assessment of health of all provenance was done at 3.5 years. Provenance such as Ban Bo, Tuang Luang, Doitao, Vientiane, Ramanna Gudu, Yezin, Sunyani, Balharshah, Annur and Kuliyapitiya were found healthier than the others. Leaves were dry in the winter and trees were almost leafless. Branch, stem and barks were damaged to some extent by wild animals (deer, rabbit) and termites. In 10 provenance's such as Chitradurga, Tibbialaran, Multan, Lamahi, Kuliyapitiya, Sagar, Allahabad, Myene, Chamwino, and Yezin, leaves were affected by cold. Some healthy neem provenance at 4.5 years were Ban Bo, Tuang Luang, Doitao, Myene, Ghati Subramanya, Bandiya, Kuliyapitiya, Yezin , Vientiane and Sunyani. Most of these provenance had full green leaves during the assessment in March, 2001, however those in some provenance were slightly dry due to cold.

Table 1: Survival percentages of neem provenance in different months

Provenance	Country	Survival percent in different months					
		7	18	30	42	54	Rank
Ramanna Gudu	India	96	92	92	92	92	1
Sunyani	Ghana	96	96	96	92	92	1
Sagar Chanatoriya	India	96	96	96	92	92	1
Lamahi	Nepal	92	92	92	88	92	1
Annur	India	92	92	88	92	88	2
Yezin	Myanmar	96	88	79	79	79	3
Myene	Myanmar	92	83	54	79	75	4
Geta	Nepal	92	88	83	75	75	4
Doitao	Thailand	88	75	75	75	75	4
Allahabad	India	92	71	71	71	71	5
Tibbia Laran	Pakistan	83	75	75	63	71	5
Mandore	India	92	71	67	63	67	6
Chamwino	Tanzania	92	71	71	67	67	6
Balharshah	India	83	63	63	63	63	7
Multan	Pakistan	96	71	63	63	63	7
Ban Nong Rong	Thailand	96	67	67	67	63	7
Vientiane	Lao	96	67	67	63	63	7
Ban Bo	Thailand	92	58	58	58	58	8
Bandia	Senegal	79	63	79	63	58	8
Chitradurga	India	79	63	63	54	54	9
Tuang Luang	Thailand	96	58	54	54	54	9
Kuliyapitiya	Srilanka	83	54	54	50	50	10
Ghati Subramanya	India	71	54	54	42	42	11

Table 2: Mean height of 23 neem provenance in different months

Provenance	Country	Average height (m) in different months			
		7	18	30	42
Ban Bo	Thailand	0.25	0.37	0.9	1.2
Chamwino	Tanzania	0.31	0.76	1.4	2.1
Tuang Luang	Thailand	0.25	0.38	0.7	1.1
Doitao	Thailand	0.29	0.55	1.2	1.7
Ban Nong Rong	Thailand	0.29	0.56	1.1	1.5
Vientiane	Lao	0.24	0.54	1.0	1.5
Ramanna Gudu	India	0.35	0.87	1.7	2.2
Yezin	Myanmar	0.42	1.15	2.4	3.1
Sunyani	Ghana	0.32	0.71	2.0	2.7
Sagar Chanatoriya	India	0.38	0.87	1.5	2.2
Myene	Myanmar	0.31	0.89	1.9	1.8
Balharshah	India	0.26	0.48	1.4	2.0
Allahabad	India	0.29	0.69	1.7	2.2
Mandore	India	0.19	0.45	1.0	1.1
Annur	India	0.23	0.62	1.0	2.0
Geta	Nepal	0.26	0.83	1.5	2.1
Lamahi	Nepal	0.31	1.10	1.7	2.7
Tibbia Laran	Pakistan	0.25	0.53	1.1	1.4
Multan	Pakistan	0.32	0.82	1.6	2.1
Ghati Subramanya	India	0.26	0.70	1.4	2.4
Chitradurga	India	0.27	0.81	1.1	1.8
Bandia	Senegal	0.23	1.05	1.4	2.6
Kuliyapitiya	Srilanka	0.24	0.67	1.4	2.2

Table 3: Mean height, DBH, diameter at 30 cm, crown diameter, and number of stems at or below 1.3 m of 23 neem provenance at 4.5 years

Provenance	Mean height (m)	SE of mean height (m)	Mean DBH (cm)	SE of DBH (cm)	Diameter at 30 cm (cm)	SE of D30 (cm)	Crown diameter (m)+	SE of CD (m)	No. stems a below m
Ban Bo	1.8	0.3	3.1*	0.40	2.8	0.55	0.8ab	0.16	1.2
Chamwino	2.5	0.2	2.2	0.34	3.0	0.36	1.0ab	0.17	1.7
Tuang Luang	1.6	0.2	1.9*	0.43	2.3	0.40	0.6ab	0.14	1.3
Doitao	2.5	0.2	2.7	0.26	4.0	0.44	1.0ab	0.09	1.3
Ban Nong Rong	1.9	0.2	2.3	0.26	3.0	0.43	0.7ab	0.15	1.5
Vientiane	2.1	0.2	1.8	0.22	2.9	0.41	0.9ab	0.13	1.2
Ramanna Gudu	2.7	0.2	2.4	0.30	3.5	0.30	1.6ab	0.14	1.4
Yezin	3.6	0.2	4.0	0.38	4.7	0.33	1.9ab	0.16	1.7
Sunyani	3.5	0.2	4.3	0.39	5.4	0.42	2.1ab	0.16	1.9
Sagar Chanatoriya	2.3	0.2	1.6	0.17	2.7	0.19	0.8ab	0.06	1.6
Myene	2.4	0.2	2.0	0.26	3.0	0.23	1.1ab	0.13	1.8
Balharshah	2.5	0.2	2.2	0.47	3.1	0.38	1.4ab	0.18	1.7
Allahabad	2.9	0.2	2.3	0.33	3.6	0.38	1.4ab	0.18	1.8
Mandore	1.2	0.2	1.5*	0.35	1.4	0.22	0.4a	0.09	1
Annur	2.7	0.2	2.7	0.40	3.5	0.35	1.6ab	0.18	1.7
Geta	2.2	0.2	2.2	0.22	3.0	0.26	0.9ab	0.11	1.5
Lamahi	3.1	0.2	3.0	0.43	4.2	0.42	1.4ab	0.18	1.5
Tibbia Laran	1.9	0.2	1.5	0.25	1.9	0.23	0.6ab	0.13	1.4
Multan	2.3	0.3	2.1	0.39	2.9	0.41	0.7ab	0.09	1.6
Ghati Subramanya	3.1	0.2	2.3	0.29	3.3	0.30	1.4ab	0.12	1.3
Chitradurga	2.1	0.3	1.9	0.47	2.4	0.38	0.7ab	0.14	1.3
Bandia	3.4	0.3	3.4	0.47	4.5	0.52	1.8ab	0.21	1.7
Kuliyapitiya	2.7	0.3	2.5	0.53	3.3	0.48	1.8ab	0.24	1.5

* DBH calculation is from one replicate only.
+ crown diameter was estimated in leafless trees on the basis of spreading branches.
Tukey's value for crown diameter = 1.6
Mean crown diameter followed by the same letters do not vary significantly.

Sagar Chanatoriya, Allahabad, Geta, Multan, and Chitradurga provenance were almost leafless during the assessment period. The proportion of the effect of cold on leaves for the rest neem provenance varied slightly to moderately. It indicates the variation in resistance of cold of the tested provenance.

Ban Bo, Tuang Luang, Doitao, Ban Nong Rong, Vientiane, Ramanna Gudu, Mandore, and Bandiya had straight or almost straight stems. Such provenances could be of significant use in agroforestry practices in Nepal.

Conclusion

Considerable variation was found in survival, growth and other parameters like crown diameter, straightness and health in 23 neem provenance. Generally, two neem provenance Sunyani (Ghana) and Yezin (Myanmar) have shown better performance in survival, growth (height and diameter), crown diameter and health at 4.5 years. However, these provenance have low ranking in respect of number of stems at or below 1.3 m. Mandore is the best provenance as it has no forked stems at or below 1.3 m. Three provenance from Thailand (Ban Bo, Tuang Luang, and Doitao), Vientiane, Chitradurga and Ghati Subramanya have less forked stems in comparison to other provenance. The stems of three neem provenance from Thailand (Ban Bo, Dirt, and Ban Nong Rong) are straighter than other provenance tested. Although some provenance have shown encouraging results, it is still premature to identify the best one.

References

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Annex 1: Detailed of neem provenance

S. No.	Id. No	Provenance	Country	Altitude (m)	Latitude	Longitude
1	1918	Ban Bo	Thailand	150	16°17' N	103°35' E
2	1919	Chamwino	Tanzania	1030	06°20' N	35°50' E
3	1920	Tuang Luang	Thailand	4	09°09' N	99°07' E
4	1921	Doitao	Thailand	300	17°57' N	98°41' E
5	1922	Ban Nong Rong	Thailand	40	14°05' N	99°40' E
6	1925	Vientiane	Lao	180	18°00' N	102°45' E
7	1935	Ramanna Gudu	India	250	19°50' N	83°49' E
8	1936	Yezin	Myanmar	100	19°51' N	96°16' E
9	1937	Sunyani	Ghana	950-1000	07°21' N	02°21 W
10	1938	Sagar Chanatoriya	India	527	21°51' N	78°45' E
11	1943	Myene	Myanmar	76	22°03' N	95°13' E
12	1945	Balharshah	India	250	19°52' N	79°25' E
13	1947	Allahabad	India	320	25° N	82° E
14	1949	Mandore	India	224	26°18' N	73°08' E
15	1952	Annur	India	360	11°17' N	77°07' E
16	1953	Geta	Nepal	170	28°46' N	80°34' E
17	1954	Lamahi	Nepal	350-440	27°52' N	82°31' E
18	1956	Tibbia Laran	Pakistan	115	28°24' N	70°18' E
19	1957	Multan	Pakistan	150	31°11' N	71°29' E
20	1963	Ghati Subramanya	India	950	13°22' N	77°34' E
21	1964	Chitradurga	India	615	14°02' N	76°04' E
22	1965	Bandia	Senegal	15	14°35' N	17°02' W
23	1966	Kuliyapitiya	Srilanka	100	7-8° N	80-81° E