Monitoring growth of Uttis *(Alnus nepalensis)* at a plantation cite at Dhankuta, Nepal

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A long-term growth monitoring experiment on Uttis (*Alnus nepalensis*) was conducted in the permanent sample plots of the Agricultural Research Station (ARS) Pakhribas, Dhankuta for 10 years (1992-2001). The average annual increment was diameter at breast height 2.14 cm in 8th year, and was 0.13 cm at 16th year of planting. The trees grew 44 cm to 130 cm per year irrespective of the age. The highest growth rate correspondend with higher rainfall during summer (March-April). Estimated biomass of stem and branches increased by 2-2.5 times within the 10 years period. Thinning and felling every year indicated need for timely management of the plantation to provide better growing environment. The data would be useful for growth modelling and proper management of Uttis plantation in Nepal .

Key words: Nepalese alder vs Uttis, height, diameter, biomass, Pakhribas.

Alnus nepalensis commonly known as Uttis in Nepal, few parts of India, Pakistan and Bangladesh, is an important multipurpose tree species. It grows in the cooler and moist areas of the northern temperate region of South-East Asia, China, Japan, and in South America. In Nepal, it is distributed from 900 to 2700 m (Lamichhaney, 1995) above sea level associated mainly with *Prunus* and *Saurauria* sp. in higher elevation and with *Schima* and *Castanopsis* sp. in the lower elevation. It is a pioneer species of degraded lands and is moderately shade tolerant (Storrs and Storrs, 1984) and colonizes well in gravel slip prone slopes (Jackson, 1987). As a nodule-forming non-legume, it has the ability to fix atmospheric nitrogen and improve soil. Its leaf alone can add 100 kg N $ha^{-1}yr^{-1}$ to the soil (Postgate, 1978).

Endemic to Nepal (Burley and Stewart, 1985) and other mountain countries, Uttis is one of the most preferred forest tree species by the hill communities. It is fast growing, commonly used for fuel-wood, timber, furniture and leaf litter. It is also used for fodder and shade to large cardamom (Ghimire, 1985) and teas (PAC, 1985) in the eastern hills and for industrial purposes (ply, match, tanning, chest for tea etc).

According to PAC (currently ARSP) annual record (1995), Uttis accounted for more than 50 per cent of the tree seedlings distributed from Pakhribas forest nursery for planting in the Koshi hills. Over the past 25 years, this species has been extensively planted throughout Nepal (Lamichhaney, 1984 and 1995).

In spite of extensive plantings, there is little information on silvicultural management of this species. There is no record on thinning regimes or appropriate final plant spacing (Lamichhaney, 1995). Therefore, to quantify growing rates on yearly basis, need of a long-term growth monitoring trial was felt and that was established for regular measurements. The information is useful for community forest users and forest managers in planning and management of Uttis in private and community forests. Such information will enable estimation of current annual increment, mean annual increment and to derive suitable rotations.

Materials and methods

The permanently established (planted in 1984 at 2x2m in collaboration of Forest Research Division) sample plots of Uttis (*Alnus nepalensis*, D. Don) in the north farm of ARS Pakhribas, Dhankuta at the elevation of 1900 m was used for growth monitoring trial. Three squared plots of 32 m x 32 m (0.1 ha) were selected and laid-out in February 1992. Block I and block III were located in slops, south facing, in upper and lower part or elevation respectively. Block II was in moderately slop between the above blocks but it was facing southeast. The trees within the boundaries and edge trees in the plots were marked and demarcated. Location map and plot chart showing each tree and identity number, site description (altitude, topography, slope, drainage, soil texture, natural vegetation etc.) of each plot developed.

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Periodic measurements (once every year in January) of diameter, and tree height were carried out in the trial blocks.

Diameter at breast height (DBH) measured over bark for all trees in each block (replication), while top heights were measured in 10 fattest selected trees/ block. DBH was measured before felling. The number of standing trees and felled trees are given in Annex 1. Height of trees and girth of logs were measured and wood yield was estimated. Volume was calculated on the basis of mid-diameter of 3m logs. The biomass of the harvested trees was also recorded. The data on major parameters were taken since 1992 and continued for 10 years. Fresh weight was converted into dry weight by multiplying with 0.41-a relationship derived by Levenson (1979): $Y = 3.87 + 0.26\ a$,

Where, y = dry weight yield (kg), and $a = dbh^2$ (cm).

Similarly, volume of stem was calculated according to volume equation (Sharma and Pukkala, 1990):

$Ln\ (V) = (a+b)\ ln\ (dbh) + c \times Ln\ (h)$,

Where V is total stem volume with bark (dm^3),
a = -2.7761, b = 1.9006, and c = 0.9428
d is diameter (in cm) and h is height (in m).

The number of stock trees and removed trees in each block was recorded every year. Up to 50% trees based on height, canopy close, DBH and density were thinned. Permanent ring was painted in each tree at the breast height. Renumbering was also done where necessary. The tree growth rate and ratio were calculated every year. In 1995, the bushes were partially cleared as there was difficult to move and take measurements. Tree height and DBH were measured that year in mid February only. In 1999, data were taken one week later than previously (first week of February).

Results and discussion

The major growth parameters like diameter and height were recorded from 1992 to 2001 and presented in Table 1 and Table 2 respectively.

Diameter at breast height-The average DBH increased from 17.23 to 28.00 cm over the ten years period (Table 1). The DBH was measured in all trees selected in each block. The average increment rate was from 0.13 to 2.14 cm (Table 1). The higher rates were during the initial period, when the trees were small. The data showed that Uttis trees had gradual increase up to the final year of observation (2001), however the differences were found in decreasing trend.

Average tree height - The average height of Uttis varied from 15.73 to 22.40 m over the 10 years. Likewise, the average increment rates or differences were 0.44-1.30 m for different years (Table 2). The trees attained 5 to 6m during the 9 years period. Unlike diameter, growth rates found higher during later period than the initial period. The heights were measured in the same 10 fattest trees, where the DBH were measured. The detail of measurement record is given in Annex 2.

According to 1995 records, average number of trees ha^{-1} after thinning was 673.8, 546.9 and 439.5 in Block I, II and III respectively. Normal stand is considered to 900 trees ha^{-1} after thinning. A closer spacing might give a higher yield.

The biomass was calculated based on the given table (Kharel and Mulder, 1984). Biomass of stem, branch and leaf are estimated separately (Table 3). The data revealed that stem and branches could produce similar yield (around 40 kg $tree^{-1}$ each at 8^{th} year and above 100 kg $tree^{-1}$ in 16^{th} year of planting). Leaves had smaller quantity of dry weight (5-11 kg/tree) at 12% moisture.

Table 1. Average diameter increment from 1992 to 2001
North Farm, ARS Pakhribas, Dhankuta

Year	Diameter, cm				Average increment/year
	Block I	Block II	Block III	Mean	
1992	17.1	14.1	20.5	17.23	-
1993	19.5	15.8	22.8	19.37	2.14
1994	20.9	17.6	24.5	21.00	1.63
1995	22.4	19.3	26.3	22.67	1.67
1996	23.6	20.7	27.9	24.07	1.40
1997	24.9	21.9	29.5	25.43	1.36
1998	26.0	22.9	31.1	26.67	1.24
1999	27.4	23.3	31.5	27.40	0.73
2000	27.7	23.9	32.0	27.87	0.47
2001	27.4	24.5	32.2	28.00	0.13

Table 2. Average height increment (m) of 10 fattest trees from 1992 to 2001
North Farm, ARS Pakhribas, Dhankuta

Year	Block I	Block II	Block III	Mean	Increment rate
1992	17.5	12.0	17.7	15.73	-
1193	17.7	12.9	17.9	16.17	0.44
1994	18.0	13.3	18.6	16.63	0.46
1995	19.3	14.3	18.9	17.50	0.87
1996	19.8	14.6	19.8	18.07	0.57
1997	20.5	15.0	20.5	18.67	0.60
1998	21.2	15.7	21.0	19.30	0.63
1999	22.8	16.8	22.2	20.60	1.30
2000	24.6	17.2	22.8	21.53	0.93
2001	25.3	18.4	23.5	22.40	0.87

Table 3. Biomass of Uttis (kg/tree) estimated according to DBH Table
ARS Pakhribas, Dhankuta

Year	DBH	Biomass		
		Stem	Branch	Leaf
1992	17.23	41.5	39.5	5.4
1193	19.37	52.7	51.0	6.4
1994	21.00	61.9	62.4	7.3
1995	22.67	69.5	70.0	8.0
1996	24.07	78.6	79.3	9.0
1997	25.43	86.8	87.0	9.8
1998	26.67	91.6	92.2	10.4
1999	27.40	95.5	96.3	10.8
2000	27.87	97.2	98.1	10.9
2001	28.00	100.0	101.0	11.0

In Ilam, wood yield of Uttis was estimated to obtain 7.0 t/ha/yr from a 15-year rotation grown on a moist site. In Kaskikot a 6-year old plantation was estimated to yield 6.0 t/ha/yr of fuel-wood (Kharel and Mulder, 1984).

Various researchers had assessed growth measurement of Uttis in the past at different parts of the country. A summary of the result is presented here (Table 4) for comparison with the present result. It is obvious that most of the data are close to the current findings. The DBH of the trees varied from 0.3 to 3.0 cm and the height from o.6 to 2.7 m, where the duration and age of trees are not identical. Lamichhaney (1984 and 1995) emphasized the need of provenance identification within Nepal. Provenances from east Nepal showed taller height than that of far-western region (Clark, 1985).

Volume/Wood production

The volume or wood production was recorded from typical selected trees in Block I and Block II of the experimental plot. The mean data showed that there

Table 4. Annual average diameter and height increased per year in Uttis at different sites*.

Site	Altitude	DBH (cm) per year	Duration, year	Height (m) per year	Duration, year	Reported by, in
Banepa , Kavre	1975m	1.5	16	1.4	16	Lamichhaney, 1981
Nagarkot, Bhaktapur	2150 m	1.1	7	1.5	2.5	NAFP, 1980
Godawari, Lalitpur	1540 m	0.3	4	2.0	2.5	NAFP, 1980
Chalnakhel, Kathmandu,	1500 m	3.0	9	2.7	9	Lamichhaney, 1981
Thankot, Kathmandu	1630 m	2.2	17	1.5	17	Lamichhaney, 1981
Jayakot, Kaski	918m	2.2	7	1.6	7	Lamichhaney, 1984
Palpa		-	-	0.6-1.0	4.5	Fonzon, 1986
Trisuli		-	-	7-10	5	-

Source: (Lamichhaney, 1995)

Table 5. Wood production (in kg, average of 3 trees)
ARS Pakhribas, Dhankuta

	Block I			Block II		
	Trunk	Branch	Total	Trunk	Branch	Total
	129	24	153	106	11	117
	147	23	170	135	10	145
	58	4	62	115	26	141
Mean	111	17	128	119	16	134

Data recorded in 2000

was 128 and 134 kg (Table 5) of total wood per tree and the ratio of trunk and branch was 6-7:1. Similarly, volume was calculated based on the diameter and height of the trees. The result showed both positive and negative figures (Table 6).

Conclusion

The long-term growth monitoring data permit to draw the following conclusion and recommendations.

- DBH increment rate decreased with the tree age.
- No definite trend is followed in the rate of height increment. It may vary with growing environment.
- Better growth could be obtained preferably with regular and high precipitation during summer months.
- Diameter and height increment are inversely propotional.

Recommendations

- Thinning should be done in plantations with 2x2m spacing after 5-6 years.
- Thinning and felling of undesired as well as slow growing plants should be done regularly at an interval of 2-3 years.
- Study on the effect of thinning on diameter, height and volume of Uttis is suggested to conduct for data confirmation.

Acknowledgements

The author would like to acknowledge and extend sincere gratitude to the station chiefs (Dr. K R Regmi and Mr. P L Karna) and Ex-Director (Mr. F. E. Tollervy of the then PAC) for their continuous support. Thanks are due to all officers and staff of the Station, who were directly involved in the conduction of this long-term experiment. Lastly, I would like to thank Mr. C M Bhusal, who worked for the second half period of the research and involved in thinning, management, measurement and data recording. Likewise, Mr. H B Thapa, Scientific Officer of the DFRS is thanked for helping analyse tree volume.

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Uttis Permanent Sample Plot, ARS Pakhribas

Annex 1. DBH and Height of 10 Fattest Trees

Measured on : 6-7/ 2/ 1999

Block I Tree No.	DBH (cm)	Tree height (m)	Block II Tree No.	DBH (cm)	Tree height (m)	Block III Tree No.	DBH (mm)	Tree height (m)
4	28	24.53	120	28	15.55	75	37	25.82
5	31	23.46	143	25	17.48	79	33	23.91
34	28	23.20	105	23	15.68	117	34	21.78
37	29	21.03	107	24	18.10	18	32	21.70
52	32	23.16	39	26	15.88	2	37	22.86
86	27	25.18	13	24	18.77	19	32	21.69
82	28	22.85	70	23	17.26	129	28	21.62
118	29	23.62	103	23	16.00	78	29	22.21
120	27	22.44	141	22	16.64	174	27	20.77
143	31	20.86	177	21	18.23	164	26	20.47

Annex 2. Description of the numbers of trees in different blocks

Block No I

Description	Observation Years									
	1992	'93	'94	'95	'96	'97	'98	'99	'00	2001
Total trees from previous year	219	111	79	69	69	59	47	38	35	35
No. of trees for removal	108	32	10	0	10	12	9	3	0	2
No. of existing trees	111	79	69	69	59	47	38	35	35	33
Removed trees, %	49.3	28.8	12.7	0	14.5	20.3	19.1	7.9	0	5.7
Avg. diameter (cm)	11.6	14.1	15.7	16.8	17.6	19.2	20.5	21.4	23.3	25.5
Wood extraction (kg)	2212	2580	2078	not thinned	1914	2212	2139	-	-	-

Block No II

Description	Observation Years									
	'92	'93	'94	'95	'96	'97	'98	'99	2000	2001
Total trees from previous year	179	87	64	56	56	47	40	35	35	32
No. of trees for removal	92	23	8	0	9	7	5	0	3	3
No. of existing trees	87	64	56	56	47	40	35	35	32	29
Removed trees, %	51.4	26.4	12.5	0	16.1	14.8	12.5	0	8.6	9.4
Avg. diameter (cm)	9.9	11.5	13.6	14.9	15.8	17.6	18.5	19.4	22.3	23.5
Wood extraction (kg)	1849	864	1702	not thinned	1603	1685	1784	-	-	-

Block No III

Description	Observation Years									
	'92	'93	'94	'95	'96	'97	'98	'99	2000	2001
Total trees from previous year	174	82	53	45	45	38	29	22	22	22
No. of trees for removal	92	29	8	0	7	9	7	0	0	2
No. of existing trees	82	53	45	45	38	29	22	22	22	20
Removed trees, %	52.9	35.4	15.1	0	15.6	23.7	24.1	0	0	9.1
Avg. diameter (cm)	12.1	14.4	17.5	19.2	20.3	22.3	24.7	26.9	30.0	31.3
Wood extraction (kg)	2277	2439	1718	not thinned	1860	2035	1699	-	-	-