Growth and climate relationship in *Cedrus deodara* from Joshimath, Uttar Pradesh

A. Bhattacharyya & R. R. Yadav

Bhattacharyya, A. & Yadav, R. R. 1990. Growth and climate relationship in *Cedrus deodara* from Joshimath, Uttar Pradesh. *In* : Jain, K. P. & Tiwari, R. S. (eds)—*Proc. Symp. 'Vistas in Indian Palaeobotany', Palaeobotanist* **38** : 411-414.

Tree-ring analysis of 12 cores of *Cedrus deodara* collected from Joshimath, Uttar Pradesh has shown clear annual rings with year to year high variability. The statistics of tree ring data exhibits mean sensitivity 0.317, standard deviation 0.33 and first order auto-correlation 0.312 indicating suitability for climatic analysis. Response function analysis reveals that the growth of this tree is inversely related to the maximum temperature of previous summer (July, August and September) and the current summer, but directly related with precipitation of March, April, July and August of the current year.

Key-words—Dendrochronology, Dendroclimatology, *Cedrus deodara*, Himalaya (India).

A. Bhattacharyya & R. R. Yadav, Birbal Sahni Institute of Palaeobotany, 53 University Road, Lucknow 226 007, India.

सारॉंश

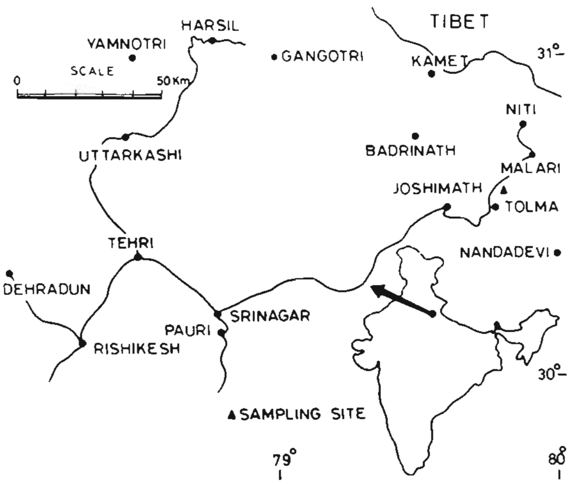
उत्तर प्रदेश में जोशीमठ से सिड्रस देवदारा की वृद्धि एवं जलवायु में अन्तरबन्धुता

आमलव भट्टाचार्य एवं रामरतन यादव

उत्तर प्रदेश में जोशीमठ से एकत्र 12 क्रोड़ों के वृक्ष-वलयों में प्रत्येक वर्ष की स्पष्ट वार्षिक वलय प्रेक्षित की गई हैं। वृक्ष-वलय आँकड़ों अर्थात् 0.317 औसतन संवेदनशीलता, 0.33 मानक विचलन तथा 0.312 प्रथम स्व: सहसम्बन्धन से जलवायवी विश्लेषण के लिए उपयुक्तता प्रदर्शित होती है। अनुक्रिया कार्य विश्लेषण से व्यक्त होता है कि इस वृक्ष की वृद्धि पिछली गर्मी की ऋतु तथा इस गर्मी की ऋतु के तापक्रम के व्युत्क्रमानुपाती है परन्तु इस वर्ष मार्च, अप्रैल, जुलाई एवं अगस्त की वर्षा से इसकी वृद्धि का सीधा सम्बन्ध इंगित होता है।

IN India, besides the temperate trees, about 25 per cent of the tropical trees are also known to produce growth rings, though these are formed annually or not is uncertain (Chowdhury, 1964). The formation of an annual ring is controlled by various environmental factors during and prior to the growing season. With the rapid advancement of tree ring science it is now possible to understand which climatic variables are significantly involved in tree growth through a type of multivariate statistical analysis known as Response Function (Fritts, 1976). Here we have discussed the climate relationship with the growth of *Cedrus deodara* considering the available data on phenology and environmental variables regulating physiological activity. Phenology of this tree has been studied in detail by Troup (1921) and Maheshwari and Biswas (1970) but their publications hardly provide information on the effect of various environmental variables on various physiological activities of this tree.

The utility of tree ring study in India has so far been to determine the productivity of a tree and a site. Science of dendrochronology has recently been introduced in India. Recent researches emphasize the selection of suitable sites and conifer species for climatic reconstruction (Pant & Borgaonkar, 1984; Ramesh *et al.*, 1985; Hughes & Davies, 1987; Bhattacharyya *et al.*, 1988). In contrast to conifers, the broad leaved taxa are less explored. They constitute a major part of the Indian forest but their potentiality in dendroclimatic analyses are yet to be established. Many of these trees producing growth rings have large number of false, missing and anastomosing rings which make them difficult or



Text-figure 1—Map showing the site of samples collection.

Table 1—Sample and chronology statistics of Deodar, Joshimath, U.P.

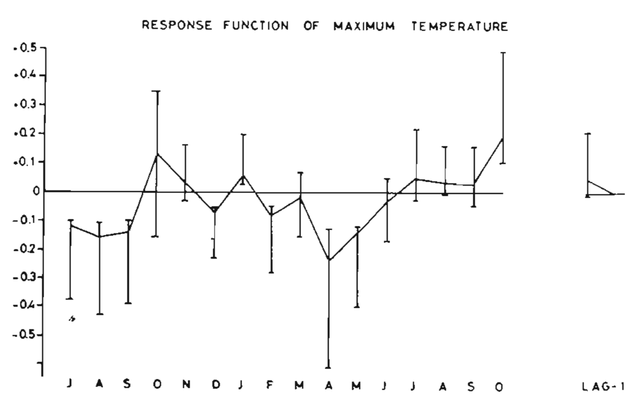
Number of tree cores	12
Time span of analysis	1917-1985
Mean ring width	1.466
Analysis of variance	
Common variance % Y	51.63%
Cross correlation	
Mean correlation between trees	.519
Chronology statistics	
Time range	1806-1987
First order autocorrelation	0.312
Standard deviation	0.330
Mean sensitivity	0.317

impossible to date (Yadav & Bhattacharyya, 1988). So far, only *Tectona grandis* has been found to have the potential for the reconstruction of precipitation from Thane, Maharashtra (Pant & Borgaonkar, 1983; Ramesh *et al.*, 1989).

The cores of *Cedrus deodara* have been collected from the village Tolma (30° 31′ N : 79° 45′ E) in Dhauli Valley near Joshimath (Text-fig. 1) at elevation ranging from 1,800 to 2,400 m. It remains covered with dry temperate conifer mixed broad leaved taxa with *Cedrus deodara* as its dominant constituent. Other associated taxa are *Juniperus macropoda* and *Quercus ilex* at its lower level and *Pinus wallichiana* at the higher level. Cores were taken at about breast height of trees through increment corer of 40 cm in length. Generally two increment cores per tree in opposite directions were collected except in a few cases only one core from one side of the trunk was taken where the other side was difficult to approach due to steep slope.

The samples were processed and growth rings were dated to the calendar year of their formation using skeleton plot method (Stokes & Smiley, 1968). Most of the samples are dated between 1806-1987 except few which go back to around 1287 A.D. The ring widths of dated samples were measured by using Bannister tree ring measuring machine. The data analysis has been done only on 12 cores for the period of 1917-1985 which have common time range.

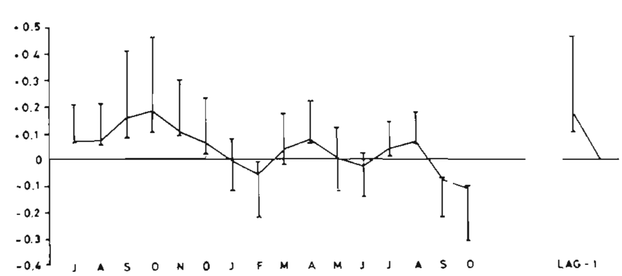
The chronology considered suitable for climatic analysis should have low first order auto-correlation, high standard deviation and high mean sensitivity (Fritts & Shatz, 1975). The studied chronology of *Cedrus deodara* exhibits first order auto-correlation 0.312, standard deviation 0.330 and mean sensitivity 0.317. The analysis of variance of the standarized data for the period 1917-1985 indicates a common variance of 51.63 and mean correlation between trees 0.519 (Table 1). These features clearly indicate the suitability of it for climatic analyses.



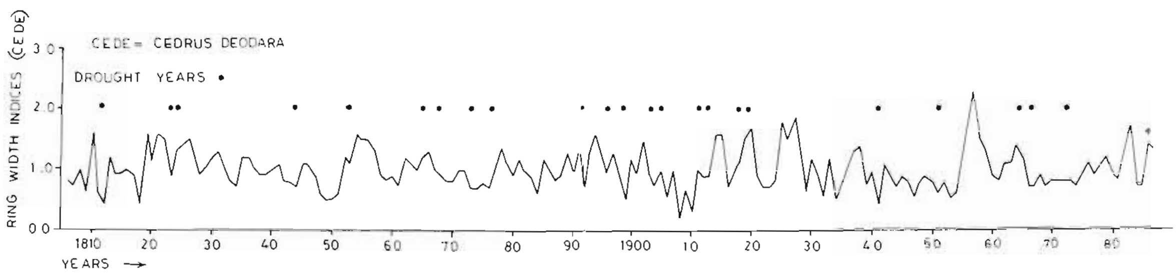
Text-figure 2—Response function plot against maximum temperature from July of the previous year to October of the current year.

RESPONSE FUNCTION ANALYSIS

Response function analysis was computed for *C. deodara* utilizing the computer programme



Text-figure 3—Response function plot against precipitation from July of the previous year to October of the current year.



Text-figure 4—Chronology of Deodar showing matching with drought years and low ring width indices.

'Respons' of Tree Ring Research Laboratory, Tucson, USA. Climatic data of monthly mean maximum temperature and total average monthly precipitation extending from 1920 to 1976 A.D. are used from Joshimath which is the nearest meteorological station from the sampling site. Sixteen values each of temperature and precipitation beginning from July to December of prior year and January to October of current year along with ring width indices for one year prior to current ring year were used as variables. Later has been used to measure the effect of previous growth on current growth. The response function plot for both maximum temperature and average monthly precipitation has been shown in Text-figures 2 and 3.

A positive correlation has been observed between ring width (growth) and maximum temperature during October-November of prior year and October of the current year but a inverse relationship exists during summer, both prior and current years (July, August and September of prior year and April, May and June of current year). This positive relationship might be due to continued higher photosynthetic activity during the later part of the growing period with the increasing temperature. The inverse relationship during summer is perhaps the result of enhanced evapo-transpiration causing water stress at higher temperature.

With precipitation, high growth has been observed during September, October and November of the prior year and also with March, April, July and August of current year. The existence of enough soil moisture due to high precipitation during the end of the growing season of the prior year and the beginning of the growing season of the current year promotes photosynthetic activity. This increased photosynthate enhances initiation of the cambial activity during March and April. The precipitation during summer reduces evapo-transpiration resulting an increase in the photosynthetic activity. However, inverse relationship during September and October might be due to low temperature associated with increased precipitation. The low temperature may also reduce the ability of roots to absorb water and nutrients from the soil.

CONCLUSION

The response function of *C. deodara* growing near Joshimath in Uttar Pradesh Himalaya indicates that growth exhibits an inverse relationship with summer temperature but a positive relationship exists with precipitation during both summer and winter. These climatic variables seem to be potentially reconstructable by tree ring analysis. A cross matching observed between most of the recorded drought years and low ring width indices (Text-fig. 4) suggests that the tree ring chronology seems to have great potential in the reconstruction of drought from the western Himalayan region. Some trees of *C. deodara* have been dated over 700 years old from this region, which indicate the possibility of a long term climatic reconstruction.

ACKNOWLEDGEMENTS

Authors express their sincere gratitude to Dr B. S. Venkatachala, Director, BSIP, Lucknow, for his constant encouragement during the course of this study. Thanks are also due to Drs G. B. Pant and K. Rupa Kumar, I.I.T.M., Pune for providing the meteorological data and running the computer programme. We are grateful to Mr H. C. Raizada, Chief Conservator of Forests, Uttar Pradesh for his kind help during the collection of samples.

REFERENCES

Bhattacharyya, A., Telewiski, F. & LaMarche, V. C. 1988. Dendrochronological reconnaissance of the conifers of north-west India. *Tree-Ring Bull.* **48** : 21-30.

Chowdhury, K. A. 1964. Growth rings in tropical trees and taxonomy. *J. Indian bot. Soc.* **43** 334-343.

Fritts, H. C. 1976. *Tree-rings and climate.* Academic Press, London.

Fritts, H. C. & Shatz, D. J. 1975. Selecting and characterizing tree-ring chronologies for dendroclimatic analysis. *Tree-ring Bull.* **35** : 31-40.

Hughes, M. K. & Davies, A. C. 1987 Dendroclimatology in Kashmir using tree-ring widths and densities in subalpine conifers. *In*: Kairiukstis, L., Bednarz, Z. & Feliksik, E. (eds)—*Methods in dendrochronology-I: east-west approaches*, pp. 163-175. International Institute for Applied System Analysis. Polish Academy of Sciences.

Maheshwari, P. & Biswas, P. 1970. *Cedrus*. C.S.I.R., New Delhi.

Pant, G. B. & Borgaonkar, H. P. 1983. Growth rings of teak trees and regional climatology (an ecological study of Thane region). *Envir. Mgmt. Allahabad Geogr. Soc., Univ. Allahabad* : 153-158.

Pant, G. B. & Borgaonkar, H. P. 1984. Growth rate of Chir-pine (*Pinus roxburghii*) tree in Kumaon area in relation to regional climatology. *Himalayan Res. Dev.* **3** : 1-5.

Ramesh, R. R., Bhattacharyya, S. K. & Gopalan, K. 1985. Dendrochronological implications of isotope coherence in trees from Kashmir Valley, India. *Nature* **317** : 802-804.

Ramesh, R., Bhattacharyya, S. K. & Pant, G. B. 1989. Climatic significance of δ D variations in a tropical tree species from India. *Nature* **337** : 149-150.

Stokes, M. A. & Smiley, T L. 1968. *An introduction to tree-ring dating*. Univ. of Chicago Press, Chicago.

Troup, R. S. 1921. *The silviculture of Indian trees*, **3**. Oxford.

Yadav, R. R. & Bhattacharyya, A. 1988. Non-synchronity in the formation of terminal parenchyma in *Michelia* L. *J. Tree Sci.* **6** : 101-105.