STUDIES ON THE ENVIRONMENTAL INFORMATION IN TREE RINGS OF SOME TREE SPECIES GROWING IN NORTH-EAST INDIA

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Dedicated to
The loving memory of my
Grandfather
& my beloved parents

THE NORTH-EASTERN HILL UNIVERSITY

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DECLARATION

I, Nongthombam Dhirendra Singh, hereby declare that the subject matter of the thesis is the record of the work done by me, that the contents of this thesis did not form basis of the award of any previous degree to me or to the best of my knowledge to anybody else, and the thesis has not been submitted by me for any research degree in any other University/ Institute.

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CONTENTS

CHAPTER-1

Introduction

The vascular tissue of higher plants has been an object of continuous detailed study since the invention of light microscope. Vascular tissue provides the long-distance transport system for water and nutrients within the plant, and an understanding of the structure and developmental pathways within it is essential for an understanding of growth in all higher plants, including crop plants. The whole of xylem and fibres of the phloem have been in high demand commercially for their unique properties and as the only renewable (energy source) structural material on earth.

The development of the xylem is controlled by a wide variety of factors both exogenous and endogenous, including hormones and by interaction between them. Relatively little work has been done on growth rings in dicotyledons since the early survey of Jost (1891) except for the often cited work of Chowdhury (1934, 1936, 1939, 1940a, b, 1947, 1958, 1964) and the key to ring-porous woods by Record (1919a). Chowdhury, in his papers described in detail the growth rings of eleven Indian tree species to all relevant factors: temperature, light, rainfall, relative

humidity, foliar development, locality (e.g., microclimates) and "internal factors" (e.g., growth-promoting substances, hormones, reserve food materials etc.). He then attempted to compare growth rings in these species. Chowdhury concludes that factors are interrelated, and one obtains no clear cut picture of which factors are primary and which are secondary in the initiation and differential events within a growth ring. However, Chowdhury's studies were undertaken in a tropical area (but seasonal); more marked results might be obtained in a temperate area with more sharply defined seasonal events. Moreover, there are many physiological measures not included by Chowdhury that one would ideally want: transpiration rates, xylem tension, and water availability (soil moisture). Gilbert's (1940) idea that ring-porosity (growth rings demarcated by much larger vessels in earlywood) is a phylogenetically derived condition and should not be accepted as a generalization, although it may be true in particular ecological conditions. His idea that ring porosity is limited to the Northern Hemisphere has been disproved many times; that idea was merely an artifact of the lack of Southern Hemisphere wood in collections at that time.

The vascular cambium has been the subject of intense study ever since its importance in building up the plant body was felt. We owe a lot to the pioneering efforts of Karl Gustav Sanio, the great German botanists in this connection (Sanio 1872, 1873). His was perhaps the first exhaustive and methodical study on cambial activity (Carlquist 1975; Timell 1980a). Besides establishing the so-called "Sanio's laws" governing the variations in the dimensions of the cambial derivatives within a tree (Bailey and Shepard 1915), Sanio was also responsible for the detailed description of the sequence of derivation of xylem and phloem cells from the uniseriate cambial initial layer. The group of four cells, consisting of an initial, a mother cell and two daughter cells, first observed by Sanio, is now known as "Sanio's Four" (Mahmood 1968). Subsequent to Sanio, Bailey and his school added considerable wealth of information on the cytology of cambial cells and the mechanism of cell division in cambial tissue (Bailey 1919, 1920a, 1920b, 1920c, 1923, 1930; Bailey and Kerr 1934). These works described the seasonal changes in the vacuolation pattern in the fusiform initials and also elucidated the mechanism of additive and multiplicative cell divisions in the cambium. So accurate were the observations of Bailey that later examinations of cambium with

sophisticated techniques and instruments confirmed his descriptions admirably. In the recent past, our knowledge of cambial cytology has been greatly extended by the several studies using the techniques of transmission electron microscopy (Srivastava 1966; Srivastava and O'Brien 1966; Kidwai and Robards 1969; Robards and Kidwai 1968; Evert and Deshpande 1970; Mia 1970; Murmanis 1970, 1971, 1977; Itoh 1971; Barnett 1973, 1975; Timell 1973, 1979, 1980b; Catesson 1974; Tsuda 1975; Farooqui and Robards 1979; Barnett 1992; Farrer and Evert 1997). More information has been provided on the seasonal changes in cambial activity in relation to environmental factors, the mechanism of cell plate formation and its extension and the change during differentiation of vascular elements.

Studies on seasonal variations of cambial activity and annual rhythm of xylem and phloem differentiations in tropical trees, semi-arid and arid regions have been studied in quite a number of plants (Coster 1927; Chowdhury 1939, 1940, 1941; Koriba 1958; Alvim 1964; Reinders-Gouwentak 1965; Philipsion et al. 1971; Fahn et al. 1968; Amobi 1974; Ghouse and Hashmi 1978; Denne and Dodds 1981; Venugopal 1986; Venugopal and Krishnamurthy 1986, 1987, 1989, 1994;

Creber and Chaloner 1990; Priya and Bhat 1999; Borchart 1999; Rao and Rajput 2001). In spite of these studies, there is a lacuna in the knowledge on cambial activity, organization, cytology and duration of wood production of the trees growing in sub-tropical moist forest. Another aspect that needs to be studied in detail is about the dendroclimatic studies of Indian tree species, especially of eastern Himalayan region which will provide the environmental information on Himalayan tree ring data. Such studies will be beneficial to the scientific community (climatologist, ecologist, policy makers of both national and international level as well as public will be informed by vulgarization efforts of deforestation etc.).

The characteristic features of growth ring are affected by the activity of the vascular cambium and in turn the activity of the vascular cambium is controlled by many factors, both internal and external. Climatic factors play a significant role in the activity of cambium. Thus, based upon the relationship between the activities of cambium and the growth-ring formation, the climatic conditions of a particular site could be determined by analysis of the yearly ring-width pattern with climatic factors.

Tree ring patterns results from fluctuating cambial activity, which is sensitive to environmental changes. The Tibetan plateau, with its elevation of about five kilometers above the sea level plays a crucial role by influencing the pressure gradient which regulates the monsoon climatic regime of Indian subcontinent. It should be checked to what extent the Himalayan ecosystem reflects changes in India. A promising method is the analysis of environmental information in patterns of tree-ring width pattern, as trees are stationary living organisms responding to environmental factors during their life span. The ever-changing environmental stimuli are transformed in permanent tree structures and as such recorded over periods as long as the life time of trees (Schweingruber 1983). Thus, dendroclimatlogy should receive a lot of public attention nowadays, only a few investigations have been published sporadically in India (Pant 1979; Hughes 1992; Bhattacharyya et al. 1988 etc.)

Therefore in this thesis, three gymnospermous trees viz. *Cedrus deodara* Loudon, *Cryptomeria japonica* D.Don, *Pinus kesiya* Royle ex. Gordon and two angiospermous species viz. *Michelia champaca* Linn. and *Shorea robusta* Gaertn.f. were studied with reference to the following aspects.

1. To study the response behaviours of the above mentioned tree species in relation to climatic factors.

2. To study the relationship between previous years ecological conditions and growth ring formation.