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Full Length Research Paper

Effect of cement dust pollution on the vascular cambium of *Juglans regia* (L.)

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Woody trees increase in girth by the activity of meristematic tissue called vascular cambium. The vascular cambium comprises fusiform and ray initials, which give rise to vertically oriented elements that is, vessels, fibers, tracheids etc. and horizontally oriented elements that is, rays. The present study reveals that there is reduction in dimensions and proportions of fusiform and ray initials in *Juglans regia* growing under impact of cement dust pollution.

Key words: Vascular cambium, cement dust pollution, *Juglans regia*.

INTRODUCTION

The activity of vascular cambium is not uniform throughout the year and is determined by the interaction of internal and external factors (Philipson et al., 1971; Larson 1994; Iqbal 1994; Grotta et al., 2005). With rapid industrialization the environment is degrading day by day effecting air, water and soil. The forests are in no way lagging behind in such activity. Trees are mostly affected by the air pollution as it changes internal physiology leading to growth inhibition and cause visible injury and death of plant.

Number of worker have studied the vascular cambium of trees (Dave and Rao, 1982; Ghouse and Iqbal 1975, 1977; Ghouse et al., 1980; Han and Woong, 1993; Iqbal 1990; Khan et al., 1988; Khan, 2001; Paliwal and Yadav, 1999; Paliwal et al., 2002; Rao and Rajput, 1999; Rao et al., 1996) but little is known about the activity of vascular cambium in trees growing under pollution (Berlyn and Battey, 1985; Creber and Chaloner, 1990; Khan, 1982) though a few attempts have been made to explain the formation of xylem in conditions affected by air pollution (Bauch, 1986; De Kort, 1986; Evertsen et al., 1986; Ghouse et al., 1984a; b; Kottzenburg and Knigge, 1987; Mahmooduzzafar and Iqbal, 1993; Mahmooduzzafar et al., 1986; Wahimann et al., 1986). Keeping in view the above observations an attempt was made to study the effect of cement dust pollution on the Vascular cambium of *Juglans regia*. It is one of the most important temperate dry fruit trees of J and K state, spread over an area of 599.00 ha. Producing 83, 399 metric tones of fruit annually (Anonymous, 2001). Besides its fruit production, almost every part of tree is useful. The wood is highly prized, used in making of high quality furniture, carving items, cabinets, musical instruments and in rifle butts (Gamble, 1972).

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MATERIALS AND METHODS

Cambial sample along with some bark and sapwood of 1 to 2 inch^2 size were collected from main trunk of *J. regia* belonging to family Juglandaceae growing under the environmental stress of cement dust pollution near Khrew Cement Plant, Khrew, District Pulwama, Kashmir, India while healthy plants growing in natural conditions from Wahab Sahaib, Shar, District, Pulwama, Kashmir. The geographical location along with other characteristics of the selected sites and material are shown in Table 1. Twenty samples were taken from 5 trees of comparable age and vigour under one environmental conditions in the same month of the year. Samples were fixed on spot in formalin aceto-alcohol (F.A.A) and then transferred to 70% ethanol after 72 h for preservation. Samples were sectioned in tangential plane at a thickness of 10 to 15 µm. Sections were stained in tannic acid, ferric chloride (Foster, 1934) and mounted in Canada balsam (Sass, 1958). Measurements of cambial initials were carried out from tangential longitudinal sections with the help of an ocular micrometer scale under the specific magnification of compound microscope. An average of 500 measurements was

Table 1. The geographical location along with other characteristics of the selected sites and material.

Factor	Site I (Khrew) experimental	Site II (Shar-i Shali) control
North latitude	30º 12´	30º 10´
East longitude	75º 35´	75º 30´
Elevation (m)	1750	2000
Soil	Sandy clay	Sandy clay
Age in years	10- 13	10- 13

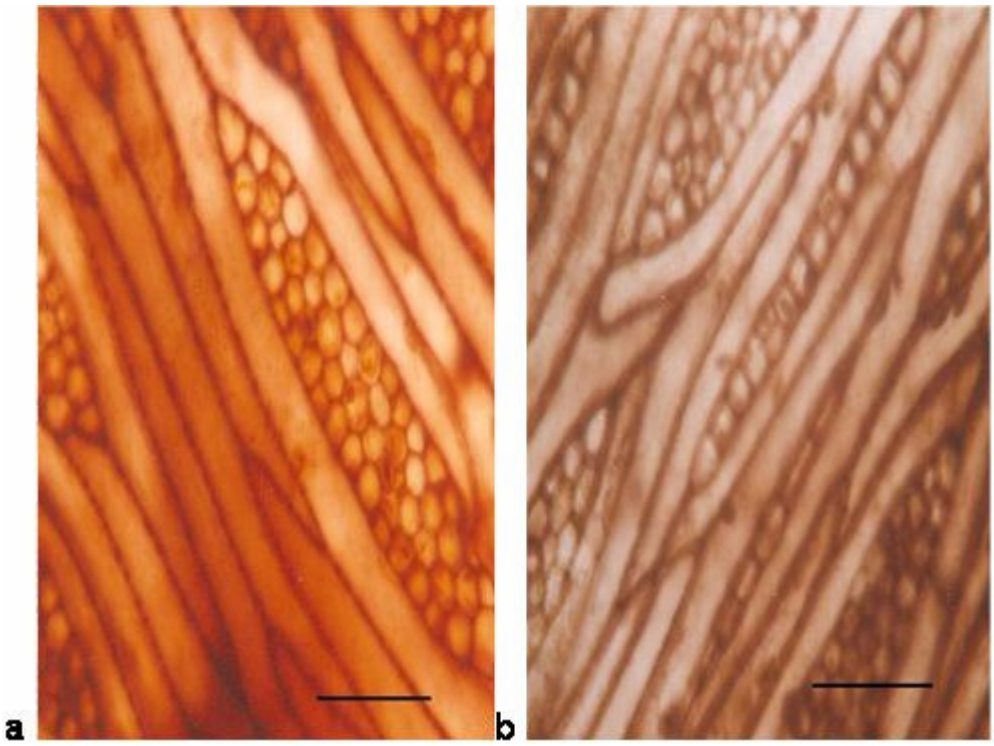

Figure 1. A: T. L.S of *J. regia* in normal environmental conditions showing non- stratified cambium. B: T.L.S of *J. regia* growing under cement dust pollution.

taken on random basis. The mean of cell dimensions were determined after pooling the readings obtained from different samples. The ratio of ray and fusiform initials was calculated by Ghouse and Iqbal (1975).

RESULTS

The Vascular Cambium of presently investigated species of *J. regia* is made up of two type's initials that is, fusiform and ray initials. The fusiform initials were elongated-spindle shaped elements which overlap with one another at considerable distance thus rendering the cambium non-stratified. The walls of the fusiform initials bear primary pit fields and have distinct plasmodesmata connections with the contiguous elements, especially with the ray initials. The radial walls of fusiform initials are slightly thicker than the tangential ones and appear distinctly beaded during dormancy (Figure 1a). The length of fusiform initials ranges from 363 to 414 µm under normal growth conditions and 327 to 378 µm under cement dust pollution. The width of these cells is found to vary from 16 to 21 µm and 14 to 20 µm, respectively (Table 2). The ray initials which occur in distinct groups generally form cambial rays which vary in width and height to a considerable extent in the different environmental conditions (Figure 1). Two or more cambial rays often fuse together to form complex aggregates running to a great height and covering the length of one or more fusiform initials. A fusiform initial can also intrude into a unit of ray initials by apical intrusive growth thus splitting it into two parts.

The size of ray initials also varies in different environmental conditions. The anticlinal and periclinal diameter of these initials ranges from 24/30 - 24/33 µm in normal

Table 2. Dimensions of cambial initials under different environmental conditions.

		Fusiform initals		Ray initials		
		Length	Width	Anticlinal	Periclinal	Ratio of fusiform initals to ray
	Condition	µm	µm	µm	µm	µm
Range	Normal	363-414	16-21	24-30	24-33	78/22
	Pollution	327-378	14-20	23-30	22-31	76/24

trees while in cement dust pollution, it ranges from 23/30 - 22-31 µm (Table 2). Depending on the cambial make-up the ratio of ray and fusiform initials differ in different conditions of environment. In normal trees, the ray initials constitute about 22% and that of fusiform initials constitute about 78% while in trees growing in cement dust pollution it constitute about 24 and 76%, respectively.

DISCUSSION

Air pollutants, responsible for vegetation injury and crop yield losses, are causing increased concern (Fuji, 1973). Air pollution has become a major threat to the survival of plants in the industrial areas. Rapid industrialization and addition of the toxic substances to the environment are responsible for altering the ecosystem (Ara et al., 1991; Ahmad et al., 1986). The cement industry also plays a vital role in the imbalances of the environment and produces air pollution hazards. The cement production process is accompanied with the emissions of considerable amounts of dust which causes changes in the growth conditions of forest trees. Dust falling from the atmosphere to the forest ecosystem is deposited mostly on leaves (Parn, 2006), and effect photosynthesis, stomatal functioning and productivity (Nanos and Ilias, 2007). The reduced photosynthetic activity retards cambial activity and consequently xylem and phloem production (Wahlmann et al., 1986). Transpiration rate decreases and assimilation processes are starved of minerals (Halbwachs, 1970). The activity of cambium depends on the availability of water, starch, soluble sugars, minerals and growth hormones etc. (Berlyn and Battey, 1985; Iqbal, 1995; Riding and Little, 1984. In the presently investigated plants, arrangement of cambial initials depicts a clear non-stratified structure as in the majority of vascular plants (Figure 1). In this type of arrangement, the fusiform initials overlap with one another at considerable distance, thus rendering the cambium non-stratified e.g. *Salix, Populus, Eucalyptus* (Dwivedi, 1982).

Bailey (1923) found that the length of fusiform initials in non-stratified form vary from 460 ti 4440 um. The present observations regarding this aspect do not agree with the limits of Bailey's above observations. Bartwal et al. (1983); Ghouse and Iqbal (1975); Ghouse et al. (1980); Khan (1980); Khan (2001); Mahmood (2001) and Wani and Khan (2008; 2009) have found the length of fusiform initials to fall shorter than the limits for the non –stratified cambium. Among the plants of *J. regia* investigated in the present study, those growing under the influence of cement dust pollution has been found to possess comparatively short fusiform initials than those growing normal conditions. The shortening of fusiform initials is due to decreased transpiration, because water content is reduced in the stem and fusiform initials readjust their dimensions to decrease in size. The short size of fusiform initials is coupled with structural shortening of other features of the bark and wood namely, the size and structure of sieve tube members, vessel elements, xylem and phloem rays and the amount and distribution of parenchyma so as to support the capillary action in the lumen (Esau, 2002; Fahn, 1997). The present findings go in agreement with earlier workers (Creber and Chaloner, 1990; Ghouse et al., 1985, 1989; Iqbal et al., 1987a; b; Khan, 1982; Mahmooduzzafar et al., 1986; Yunus and Iqbal, 1996).

The analysis of dimensions of ray initials in the present study indicates that they undergo a decrease in the polluted environmental conditions as compared to healthy trees. While, the relative proportion of the ray initials to the fusiform initials has been observed to increase from 22% in normal condition to 24% under cement dust pollution. This clearly shows an increase in the number of ray initials with decrease in their anticlinal and periclinal diameters under the polluted environment (Creber and Chaloner, 1990; Romberger et al., 1993; Yunus and Iqbal, 1996). Earlier workers show that the fusiform initials constitute more than 90% of the cambial cylinder (Bailey, 1923; Butterfield, 1972; Margaris and Papadogianni, 1977). But this report goes in agreement with Bhat et al. (2005); Ghouse and Iqbal (1975; 1977); Khan et al. (1979; 1982; 1983); Khan and Siddiqui (2007a-d); Wani and Khan (2008; 2009).

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