SEMIMATURE-TISSUE NEEDLE BLIGHT OF EASTERN WHITE PINE AND LOCAL WEATHER

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Weather strongly influences the establishment and geographical distribution of disease in forest trees. Extensive studies have been carried out in the Maritime provinces on the relationship between temperature and rainfall and the spread of "birch dieback".[1] In Wisconsin, forest pathologists studied the role microclimate played in the infection of white pine by the blister rust fungus, Cronartium ribicola Fischer[2]. Trees mechanically wounded by high winds, sleet, hail and lightning may have their wood exposed to provide infection courts for decay fungi. Further, the foliage of trees is subject to severe damage by drought and extremes of temperature.

The disease, needle blight of eastern white pine, is characterized by an orange-red discoloration of the distal portions of needles of the current year. Diseased trees may also display small leaves and twigs, premature defoliation, reduced height and diameter growth, and poorly developed root systems. All ages of white pines, both planted and naturally reproduced, may be affected. Diseased trees have been reported throughout the entire range of eastern white pine[3, 4, 5].

Although outbreaks of needle blight on white pine trees were observed often during the first 50 years of this century, the development of the foliar symptoms was little understood. It was believed that the disease affected the tips of needles first, followed by a progressive dieback. However, it was found in 1957 that needle blight started in semimature-tissues and that the injury then spreads distally throughout adjacent,

[1] Presented at Forest Microclimate Symposium, September 28-October 1, 1965, Chalk River, Ontario

more mature, tissues[6]. On the basis of this new finding, the name of the disease has been changed to semimature-tissue needle blight (abbreviated to SNB).

The initial injury of SNB occurs as faint, pinkish spots on stomata-bearing faces of needles in semimature-tissues (about three weeks old). The spots develop into orange-red bands which spread acropetally to the needle tips. The injury was never observed to spread from semimature-tissue to the immature-tissue located proximally. Further, the initial needle blight injury was never observed in immature- or mature-tissues.

Histological examination revealed that semimature-tissue in white pine needles is characterized by the start of suberization of the radial and transverse walls of the endodermal cells. Suberization does not begin until the needles are about three weeks old, starting at the tips and developing basipetally. Suberization continues to develop on endodermal cell walls at approximately the same distance from the basal meristems of the needles for about seven weeks. Early in August when meristematic activity ceases, suberization of the endodermis proceeds proximally to the bases of the needles and by the latter half of August the new needles are completely mature. Thus there is approximately a nine-week period that new needles on white pine trees are susceptible to the onset of SNB symptoms.

In 1957 and 1958 a series of permanent sample plots was established in young white pine stands at the Petawawa Forest Experiment Station, Chalk River, for the purposes of determining the annual incidence of SNB and the times of attack each year. Data on the atmospheric conditions which occurred immediately prior to and during each outbreak of SNB were taken from the daily weather records maintained by the ecology section of the Department of Forestry at the Petawawa Forest Experiment Station.

A total of 13 SNB outbreaks occurred at the Experiment Station during the period 1957 to 1964. Four occurred in late June, five in early July, three in late July and one in early August. Nine of the 13 outbreaks occurred during the last week in June and the first two weeks in July. Outbreaks of SNB occurred infrequently during any one growing season, with different numbers of trees affected each time, but in most cases trees that had been affected before again displayed the foliar symptoms.

The annual incidence of SNB was expressed as per cent affected trees in the total number of living trees on the sample plots. At the Petawawa Forest Experiment Station, disease incidence was extremely high in 1957 and in 1958, fell sharply in 1959, increased to moderate levels during 1960-1963, and then fell to lowest levels ever encountered in 1964. The annual occurrence of the disease fluctuated uniformly on the widely separated sample plots located at the Experiment Station.

Various climatic conditions such as a late spring frost[7], a wet spring followed by a dry early summer[8], a summer of excess moisture[9], a summer drought[10, 11, 12, 13], a decrease in rainfall during the period June 15-July 15[14], a wet period followed suddenly by a continuous sunny period[5, 6], a dry summer in the previous year followed by a wet summer[15], and a drought in the previous year followed by a wet spring and a sudden hot, dry period during needle growth[16] have been postulated to contribute to the occurrence of outbreaks of white pine needle blight.

Clinton[7] believed late frosts in the spring were responsible for needle blighting of white pines. However, at the Petawawa Forest Experiment Station in 1958 a year of extremely high SNB incidence there were five days in May with temperatures below 32°F, whereas in 1959 a year of very low SNB incidence there were six days in May with freezing temperatures. There were no days with freezing temperatures in the month of June in either 1958 or 1959.

Ham and Eggertson[14] concluded that an increase in rainfall during the period June 15 to July 15 in 1950 compared to 1949 was responsible for the decrease in needle blight incidence from 1949 to 1950. However, at the Petawawa Forest Experiment Station, a decrease in rainfall during the period June 15 to July 15 in 1959 compared to 1958 coincided with a sharp decrease in SNB incidence from 1958 to 1959.

Baldwin[15] believed that a drought in the previous year followed by a wet summer in 1954 contributed to an outbreak of white pine needle blight in New Hampshire. At the Petawawa Forest Experiment Station, however, there was no drought in either 1956 or 1957, whereas in the years immediately following, 1957 and 1958, extremely high incidences of SNB occurred.

It is apparent that some of these earlier observations, that certain weather conditions were related to outbreaks of needle blight, were merely coincidental, since it was found at Petawawa Forest Experiment Station that the same weather conditions may occur during years of low SNB incidence, and that during years of high SNB incidence they may not occur at all.

The relationship between local weather and outbreaks of SNB is better understood when facts about the occurrence of SNB are taken into consideration. During an SNB outbreak, many susceptible white pines which occur sporadically throughout an area are affected simultaneously, indicating that some atmospheric factor at that particular time is operative. Outbreaks of SNB each year at Petawawa Forest Experiment Station during the period 1957 to 1964 occurred twice, once, no times, four times, twice, twice, twice and no times respectively. Possibly a general prevailing climate in the previous year or in the same year conditioned the susceptible trees to break down, but in order for outbreaks to occur at distinct and different times during each summer, some particular weather pattern prevailing during the time of the outbreak must be contributory.

The records of the atmospheric conditions which occurred immediately prior to and during each outbreak of SNB at the Petawawa Forest Experiment Station were examined. In 1957, a total of 3.32 inches of rain fell at Chalk River on the last four days in June. On July 1 and 2 almost continuous sunshine occurred and the initial symptoms of SNB appeared ubiquitously in the area. During several outbreaks of SNB in the following years, a sudden change in weather conditions occurred, mostly of the type in which a wet period was followed suddenly by a continuous sunny period. Exceptions occurred, of which an outbreak on June 29, 1963 is an example. In this case an outbreak of SNB occurred following ten days of extremely hot, dry weather. However this drought in late June followed a cool wet period of about two weeks. In 1959 and in 1964 the years of no SNB outbreaks the weather was generally warm and dry in June and July, but interspersed with brief wet periods, and no extremes of weather succeeded one another.

Studies on the etiology of the disease have shown that fungi are not responsible for the initiation of SNB. With the discovery of the manner of symptom development of SNB[6], and the knowledge that susceptible trees in a local area are simultaneously affected, consideration was given to the role of atmospheric constituents in inciting SNB. Injury to tobacco leaves, called "weather fleck" was found in 1958 to be caused by high concentrations of atmospheric ozone[17]. During the field seasons of 1960, 1961 and 1962 at the Petawawa Forest Experiment Station the daily average concentrations of naturally occurring atmospheric ozone were determined, and these values were correlated with the times of SNB outbreaks in the area. Seven outbreaks of SNB occurred during the period investigated, and no outbreaks coincided with a peak level of daily ozone occurring either on the same day or on the day previous to an SNB outbreak. Peak concentrations of daily ozone were recorded several times during periods that white pines were susceptible to SNB but no outbreaks occurred at these times.

In conjunction with the forest meteorology project started at Petawawa Forest Experiment Station in 1964 by the Canada, Department of Transport and the Canada Department of Forestry, a one-tenth acre plot containing 179 white pine seedlings was established adjacent to the Department of Transport's 200 ft. weather tower. These seedlings are examined every day during the growing season for the appearance and development of the symptoms of SNB. In addition, a Mast ozone meter and remote recorder has been set out beside the seedling plot to continuously monitor the concentration of atmospheric ozone. It is anticipated that the combined information on the times of SNB outbreaks, the concentrations of atmospheric ozone, and the data on forest microclimate obtained by the Department of Transport will provide the clearest picture to date of the relation between local weather and the initiation of semimature-tissue needle blight of eastern white pine.

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