CHLOROTIC DWARF IN EASTERN WHITE PINE

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Eastern white pine (Pinus strobus L.) is one of the most important conifers in northeastern forests. But this species is attacked by numerous diseases that destroy or reduce its commercial and aesthetic values.

Among those diseases that damage white pine are the physiogenic needle disorders, which are well known but not well understood. Within the last few years several of these diseases have received considerable attention, and their etiology is nearing solution. Among these physiogenic disturbances is chlorotic dwarf, a widespread foliar disorder of white pine in the midwestern and eastern states.

Within the past 60 years, there has been much confusion about chlorotic dwarf's etiology, symptoms, and relation to other white pine needle blights.

Chlorotic dwarf has been attributed most frequently to drought, natural competition and suppression, moisture imbalances, nutrient deficiencies, poor planting practices resulting in root balling, a possible physiological genetic complex, fungus root rot, feeding by sucking insects, lack of root mycorrhizae, and a viral infection. None of these concepts has ever been proven experimentally and chlorotic dwarf has continued to be an enigma.

Our course of investigation of chlorotic dwarf has been to delineate its symptomatology, determine its cause, and propose measures for its control. As a result of our investigations, we found that air pollution, through its harmful action on the foliage of genetically susceptible white pine trees , is responsible for chlorotic dwarf.

SYMPTOMS

Trees affected by chlorotic dwarf are characterized by stunted roots and tops, short and mottled needles , and premature shedding of foliage. New foliage is light green upon emergence but soon becomes mottled with chlorotic spots and is often yellowed by early summer as spots coalesce. Current needles of highly susceptible individuals are thin, curled, and twisted. They may further exhibit tipburn after extended drought in summer or winter. Older foliage is usually shed before current needles have reached full development.

Although diseased trees may occur in young naturally regenerated stands, chlorotic dwarf is primarily a problem in 3 to 12 year old white pine plantations.

White pines vary in their susceptibility to chlorotic dwarf. Affected trees exhibit symptoms that range from a mild yellow mottling of the needles to severe stunting of all plant parts. Needle length and shoot growth may vary from near normal to needles and shoots less than an inch long. In 10 to 15 year old plantations, typical chlorotic dwarf specimens are usually not more than 2 to 3 feet tall. On such trees , both size and the number of branch buds are decreased.

Root systems are reduced in proportion to the size of the top. On highly susceptible trees fibrous roots are few; and primary roots are coarse, stubby, and twisted.

An unusual characteristic of chlorotic dwarf is the seemingly unchanging symptom pattern. Symptoms on individual trees remain remarkably constant from year to year, with little change in shoot growth or in needle mottling and length. Even highly susceptible individuals may survive for a number of years if open grown under normal climatic conditions. For example, of 250 diseased trees held under observation for 6 years , only 9 have died. And of these nine, only four have expressed symptoms severe enough to account for their death. Only when the canopy of a young pine plantation begins to close in do the most severely affected individuals tend to die off at an increasing rate. This appears to be due more to competition for light and nutrients than to disease intensification.

Chlorotic dwarf is found on young white pine in pure and mixed plantings and in natural stands occurring over a wide range of growing conditions. Infected trees are found at random both on dry sites and on moist sites, on clay and sandy loam soils, and on various slopes and aspects. The incidence of disease is fairly uniform within plantings, but may fluctuate markedly among plantings in different localities .

CAUSE

A number of possible causal agents, including insects, fungi, malnutrition, virus, moisture stress, and air pollution were concurrently investigated. As a result of these investigations, we found that air pollution, through its harmful action on foliage of genetically susceptible white pines, is primarily responsible for causing chlorotic dwarf .

Results from intergrafting diseased and healthy pines demonstrated that susceptibility to chlorotic dwarf is controlled by inherited factors and that the disease is due to a causal agent acting directly upon the foliage rather than on other parts of the tree. This work and data from other studies strongly suggested an aerological agent and supported the supposition that tree-to-tree variation in susceptibility is controlled by genetic characteristics .

Support for this concept included simulation of chlorotic dwarf symptoms by artificial defoliation of healthy white pines; a high frequency of infected trees near industrial pollution sources; recovery of affected trees when transplanted to a pollution-free environment, followed by initiation of typical symptoms when returned to their original sites near industrial centers; failure of fungicidal and insecticidal treatments to improve the condition of diseased pines in plantations; apparent absence of tree-to-tree spread; and observations of affected pines that showed that symptoms on individual trees, whether mild or severe, remained fairly constant each year.

Strong evidence that air pollution is the primary causal agent of chlorotic dwarf was obtained when diseased field trees , enclosed in special chambers, recovered when gaseous dispersoids were filtered from the atmosphere.

CONTROL

Because chlorotic dwarf is caused by the continued irritation of atmospheric toxicants upon the foliage of susceptible individuals, several approaches to control are suggested.

The most obvious solution to noxious fumes lies primarily in the modification of emission sources, either by completely eliminating these injurious materials or by reducing their phytotoxicity and concentrations below harmful limits. But, at present, the feasibility and practicality of this approach avail little immediate hope or promise to today's forest managers.

Economic returns from white pine plantings limit any intensive program of control through the use of antipollutant sprays or removal of diseased trees from the stand. Such procedures are costly and rarely applicable for most growers.

Control measures directed towards developing genetically resistant white pines to use in pollution areas could be one of the most promising approaches towared permanent removal of susceptible trees .

Although breeding for resistance is expensive and time consuming, the inherent resistance of many white pine trees to air pollution damage promises success in this venture. Possibly a long breeding program could be circumvented if seedlings or seed were obtained from areas known to have high levels of pollution. In such areas, cross-pollination among surviving pollution-resistant white pines should result in a larger quantity of seed immune to aerological damage than in pollution-free areas where seed production would occur between resistant and susceptible white pine trees.

Vegetative propagation of resistant clones is possible but of limited value, since white pine cuttings are difficult to root, particularly when cuttings are obtained from older trees. Grafting resistant scions to seedling root stock results in a high percentage of successful unions, but the cost would be high and little is known about latent incompatibility.

We now are assessing the effects of parentage, juvenile characteristics , and site on white pine nursery seedlings that become diseased when outplanted in Ohio plantations. If correlations are established between seedling characteristics and the occurrence of diseased plantation trees , early detection of latent chlorotic dwarfs may be possible in the nursery. And thus infected trees may be easily culled during normal grading practices. Initial results from this work are promising.