DISEASES OF INTENSIVELY CULTURED HYBRID POPLARS:

A SUMMARY OF RECENT RESEARCH IN THE NORTH CENTRAL REGION

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Abstract.--Several potentially damaging diseases of hybrid poplars have been identified in the north-central United States. Among the most serious are leaf and stem diseases caused by Melampsora, Marssonina, and Septoria. Short-term chemical controls are of limited usefulness. The most practical control strategy appears to be the use of resistant clones obtained through local screening, combined with various cultural measures, and integrated into overall management plans.

Introduction

The increasing demand for economical wood fiber and energy, together with the competition for land has created an interest in establishing short-rotation, intensive tree culture systems to maximize biomass yield per unit area. Recent research in the north-central United States has concentrated on the use of hybrid Populus and the application of agronomic practices to establish and manage high yielding plantations on short rotations to provide raw material for industrial and energy uses. Populus appears well-suited for management under such a system because of its rapid growth, genetic diversity, ease of vegetative propagation, and coppice regeneration. However, past experience with growing hybrid poplars in Europe, Canada, and the southern and northeastern United States indicates that pathogens and insect pests can severely limit the productivity or lower the quality of affected trees. Because plantations are costly to establish and maintain, they must be protected from serious damaging agents. This paper will summarize the major findings of recent research into the potential impact and control of diseases of intensively cultured hybrid poplars in the north-central region.

Disease Detection and Pathogen Identification

Foliage Diseases

Poplar leaf rust, caused by Melampsora medusae, was the first disease recognized as having the potential to severely reduce biomass yields (Schipper and Dawson 1974). Rust reduced wood volume of susceptible clones up to 42 percent in research plots in Wisconsin, Minnesota, and Iowa (Widin and Schipper 1981). Impact from rust is most severe on poplars planted within the natural range of Larix, its alternate host, where poplars are infected early in the growing season. Other virulent races of M. medusae may also be present (Singh and Heather 1982). In addition, other rust species could infect previously resistant poplars. Fungicides will protect trees, but screening and selecting rust-resistant clones is the best control strategy.

Insects and pathogens affecting 32 clones of hybrid poplars were detected and identified in 13 small plantations planted throughout the north-central region in 1976 and 1977 (Ostry 1979). Data were collected on the prevalence and severity of damaging agents several times during each growing season through 1982.

Several foliage diseases, some of them potentially serious, were identified. Poplar leaf rust was of lesser importance in the southern plantations than in the north where premature defoliation of susceptible clones was common. Phyllosticta leaf spot, a

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disease of minor importance except on young trees, was most severe in southern Illinois and rarely found north of Iowa. Septotinia podophyllina was found only in the northern region. It causes a leaf spot in the lower crown late in the season but may be of periodic importance on young trees. Venturia macularis causes a leaf and shoot blight that kills terminal portions of trees, reduces growth, and deforms trees. It was most severe on young trees in the northern region.

Marssonina brunnea causes a leaf spot and lesions on the current year's stem growth and was present throughout the region. Highly susceptible P. X euramericana clones were prematurely defoliated by Marssonina, resulting in reduced growth. Other reductions in root growth and depletion of root starches may predispose defoliated trees to environmental stresses and other diseases (Bassman and Dickmann 1982).

Marssonina was of minor importance until it reached epidemic proportions at Rhinelander, Wisconsin, in 1978 and at Rosemount, Minnesota, in 1980, illustrating how disease impact can change in poplars when inoculum levels increase and conditions for spore dispersal and infection of susceptible clones exist. Marssonina infection decreased in 1981 at Rosemount largely because most of the susceptible trees were more than 8 m tall and their lower live crowns were 3-4 m above the ground. Moisture dries more quickly on leaves at this height, reducing conditions favorable for infection. From observations in our research plots, it appears that Marssonina is most damaging on young trees grown at close spacings.

To better understand the life history of Marssonina and other pathogens, we placed spore traps in and around poplar plantations in Michigan, Wisconsin, Minnesota, and Iowa from 1980-1982. Weather data also were collected. Disease symptoms and tree phenology were recorded throughout the growing season. We found that Marssonina conidia or ascospores of its perfect state (Drepanopeziza) are liberated throughout the entire season (Figure 1).

In 1977 leaf spot caused by Septoria musiva was found on poplars in all plantations except Rhinelander, where it was not found until 1980. It was, however, present on native P. balsamifera in this area. Premature defoliation of trees of several highly susceptible clones reduced their growth and predisposed them to other pathogens and environmental stresses, resulting in extensive dieback. Infection of poplar leaves in spring results from ascospores of Mycospharella populorum, the perfect state of S. musiva, being liberated from infected leaf debris on the ground (Figure 1).

Stem diseases

Deer browsed heavily on trees in northern Minnesota and Michigan. Diseases such as Venturia and heavy weed competition prevented many trees from outgrowing the reach of deer and Cytospora dieback was common on these trees. Vigorously growing trees in larger plantations could outgrow the deer hazard.

Branch and stem diseases other than Cytospora were rare on trees until after 1978, when cankers caused by Dothichiza populea and S. musiva became important. Cankers caused by Dothichiza were most severe at Rosemount. Stem breakage at these cankers began in 1981. Susceptibility varied by clone and species perhaps because of the difference in clonal rooting depth (Haywood and McNabb 1979). The perfect state of Dothichiza, Cryptodiaporthe populea, was present on infected trees--the first report of the perfect state in the United States. The ascospores of this perfect state may be important in the spread of the fungus within plantations. Field testing to select trees for drought resistance may be warranted to reduce the incidence of this disease as well as Cytospora and Phomopsis dieback. To guard against stress related diseases, clones should be matched to sites they will occupy.

Septoria cankers were first recorded in 1978 near Ames, Iowa, and at Rosemount. Poplar stems inoculated in a greenhouse with isolates of Septoria obtained from leaf spots resulted in the typical sunken cankers observed in the field. Canker severity remained high at these two locations, and stem breakage began in 1979 as a result of multiple cankers on stems of highly susceptible clones. Many of these trees have resprouted and died back repeatedly from subsequent cankering. In contrast, trees of these same clones growing at Rhinelander remained healthy until late summer, 1981, when Septoria canker was first observed. Cultivation was more frequent and thorough at Rhinelander than at other study sites and may have been a factor in reducing overwintering inoculum. Cultivation was discontinued when tree size made it difficult to operate machinery in the plantings and spore trapping confirmed an increase in inoculum within plantings.

Susceptibility to Septoria varies, necessitating local screening of poplar clones before large acreages are planted. In

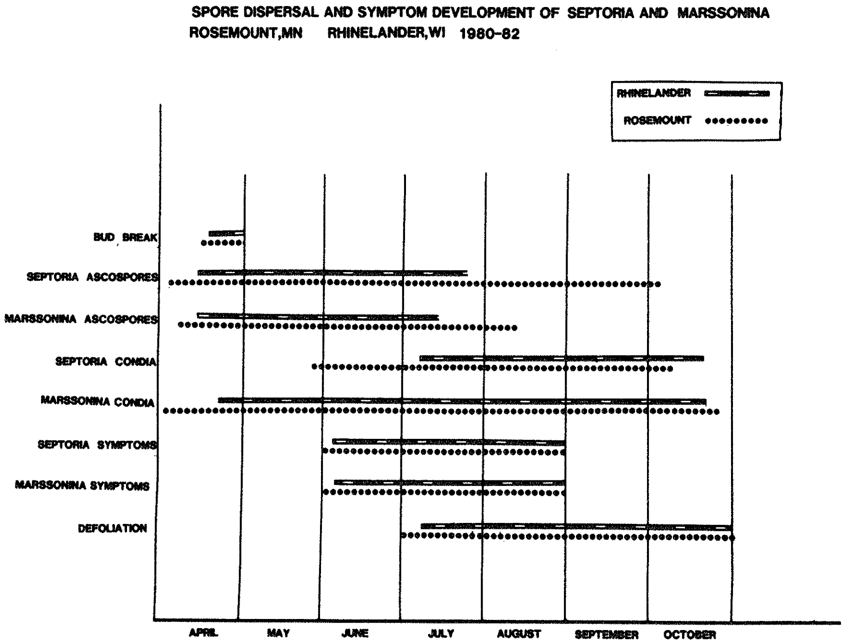

Figure 1.--Spore dispersal and symptom development of *Septoria* and *Marssonina* at Rosemount, Minnesota and Rhinelander, Wisconsin 1980 - 1982.

one area where this was not done, trees of many susceptible clones were propagated in a nursery and outplanted. Heavy cankering by Septoria resulted in early failure of several plantations and many clones were removed from the nursery (Moore et al. 1982).

Root Diseases

Armillariella mellea causes a root and butt rot usually, but not always, of weakened trees. A late spring frost in 1981 at Rhinelander killed flushed leaves and cambium of trees of several clones that were also highly susceptible to foliage disease. A. mellea was found on these trees and together with other pathogens resulted in the decline and eventual death of the trees. Root rots may become increasingly important in older plantations and stands of coppice regeneration.

Screening for Resistance

Three plantations, each containing more than 500 species and clones of poplars were planted in 1978 to screen many genotypes for field resistance to Melampsora, Marssonina, and Septoria. Plantations were located at Rosemount, Rhinelander, and near Ames. Resistance to the diseases caused by the major pathogens varied widely. As in the previously described plantings, identical clones planted at Rosemount and near Ames were heavily infected by Septoria, but those clones were free from cankers until 1981 at Rhinelander. Cultivation again was much more thorough at Rhinelander than at the other sites and is thought to be responsible for less Septoria infection. Melampsora defoliated highly susceptible clones at Rhinelander more than a month before symptoms appeared on the same clones at Ames. Tree growth and winter hardiness also varied by clone and location. At this time, 104 of the clones planted are disease resistant at all 3 locations. A total of 130 clones are too susceptible to Septoria canker to be recommended for planting at any of the locations (Ostry, unpublished data).

Results of this screening study revealed the importance of field testing clones for disease resistance. Repeated observations of disease development over the growing season detected clones that became heavily infected with rust or Marssonina late in the season in contrast to highly susceptible clones that became infected early in the season. Some clones moderately susceptible to Melampsora at Rhinelander could be safely planted near Ames. Genotype-environmental interactions and variation among clones in susceptibility to diseases underscore the importance of "tailoring" planting stock for each site and area within the region. In the future it may be desirable to screen clones at the spacing at which they will be grown, to judge their relative competitiveness and disease susceptibility at that spacing (McNabb et al. 1982a).

Impact of Septoria Canker

Impact of Septoria canker on a mixed hybrid poplar plantation planted at 10,000 trees/ha was studied in central Iowa from 1977 through 1981. Biomass production of the first rotation was determined from a cut made in the winter, 1979-80. The mixture included clones with high and moderate susceptibilty as well as resistant hybrids of similar biomass production potentials (Table 1). The resistant hybrid produced three times more biomass by weight than did the highly susceptible clone. In addition, 30 percent of the resulting stumps failed to resprout in the highly susceptible hybrid compared to only 3 percent failure for each of the other 3 clones (McNabb et al. 1982b). In pulping studies, cankered wood, either as the sole source or in mixtures with healthy wood where it exceeded 25 percent by dry weight, proved unsatisfactory for pulp fiber used in kraft paper production (Holt et al. 1981). Cankered wood had higher lignin and extractive content than uncankered wood. Paper produced from this pulp stretched significantly further, and it had lower tensile and bursting strength, burst factor, and breaking length.

Chemical and Cultural Control Trials

Short-term chemical disease control is needed, especially in propagation nurseries, to ensure that only healthy stock is produced and used in establishing plantations. Fungicides also may be appropriate to reduce inoculum in plantations, but long-term controls using cultural treatments in addition to resistant clones are more desirable.

The Central Iowa plantation used to assess impact of Septoria also was used to test the effectiveness of three fungicides for managing S. musiva. During the first rotation an early and midseason spray of captafol, as well as bimonthly sprays, controlled Septoria canker near the level of the resistant clone (Table 1) (McNabb et al. 1981).

Septoria canker is a serious problem in nursery cutting beds and coppiced stands

Table 1. Results of *Septoria* canker control trials

Clone No. [a]	Ames, IA (plantation) Unsprayed check	Ames, IA (plantation) Captafol spray: early & midseason	Ames, IA (plantation) Captafol spray: bimonthly	Freesoil, MI (nursery) Unsprayed check	Freesoil, MI (nursery) Benomyl spray: early season	Freesoil, MI (nursery) Benomyl spray: bimonthly	Freesoil, MI (nursery) cultivation
	Canker rating [b]			Canker index [c]			
NE 1	5.1	0.9	0.8	.46	.00	.00	.45
NE 299	3.6	0.9	0.6				
NE 298				.00	.00	.00	.07
NE 387	2.9	0.6	0.5	.15	.06	.00	.10
NE 19	0.3	0.0	0.2	.00	.00	.00	.00

[a] NE 1 = *Populus nigra* L. X *P. laurifolia* Ledeb. 'Strathglass' (highly susceptible)

NE 299 & NE 298 = *P. nigra* var. *betulifolia* Torr. X. *P. trichocarpa* Torr. and Gray (moderately susceptible)

NE 387 = *P. candicans* Ait. X *P.* X *berolinensis* Dippel (moderately susceptible)

NE 19 = *P. nigra* cv. *charkowiensis* X *P. nigra* var. *caudina* Tenore (resistant)

[b] Canker Rating = 0 - no cankers; 0.1-9.9 - increasing numbers of branch and stem cankers; 10-tree breakage and death

[c] Canker Index = Number of infected stumps/number planted

(Moore et al. 1982, McNabb et al. 1982b). Chemical control of this disease was tested in Minnesota in 1980 and 1981. Trees were cut yearly to simulate a nursery cutting bed. Four fungicides and four spray schedules including check plots were randomized within the plots. Benomyl applied monthly or bimonthly at 1 lb. active ingredient per 100 gallons of water resulted in less cankering than any of the other treatments.

On the basis of these preliminary results, we began a control study in 1981 at the poplar nursery of the Packaging Corporation of America near Manistee, Michigan. The objective of this study was to compare clone resistance, and chemical and cultural controls to disease incidence. A 30x300-foot length of a nursery bed was planted with four clones variously susceptible to *Septoria* (Table 1). Four treatments were randomly assigned among the plots except for the plots designated to be cultivated. These plots were on one end of the nursery bed to facilitate use of nursery equipment. Plots were cultivated as soon as the ground was workable in the spring through the end of May. Benomyl was sprayed on some of the remaining plots either once at the beginning of the season or bimonthly throughout the season; other plots were left unsprayed as checks. Disease data were recorded from the center trees of each plot and the other trees served as buffers between treatments.

No significant results were obtained at the end of 1981 because leaf disease was light on all plots and no cankers were present. All plots were harvested along with the production nursery beds in early winter.

The same treatments were applied in 1982 and data were recorded in September. Leaf disease was greater than in 1981 and stem cankers were present. Previous experience had shown us that *Septoria* canker prevalence increases as inoculum on fallen infected leaves increases. In addition, greater infection in 1982 also was caused by increased density of stems resulting from multiple sprouts on each stump. Both chemical spray schedules were effective in reducing cankering of susceptible clones (Table 1). Cultivation, however, failed to reduce disease. Clones previously known to be resistant or only moderately susceptible were either healthy or lightly infected.

Spore trapping indicated generally low inoculum levels in the nursery. However, the proximity of the cultivated plots to unsprayed susceptible plot trees provided inoculum that may have caused failure of cultivation to reduce disease. Cultural controls may only be effective in reducing disease if done thoroughly and then only if inoculum from outside sources is absent or light.

Benomyl, as was shown earlier with captafol, was effective in preventing disease development in even the most susceptible clone tested. But, the impact that *Septoria* canker can have in plantations where chemical controls may not be feasible dictates that only resistant clones be planted where this disease is known to be a hazard.

Intensive Culture Versus Disease Development and Management Implications

Silvicultural systems developed for rapid production of wood fiber can favor the development of disease in some instances. Growers must be aware that conditions that maximize tree growth may increase disease incidence or severity so that production gains over natural stands are severely reduced or completely lost.

Populus, as a genus, is host to many insects and pathogens. Many poplar species and hybrids now being planted are not native to our area. Introduction of exotics has resulted in instances where an endemic pathogen in native poplar stands has caused serious disease problems. For example, *S. musiva* causes minor leaf spotting of native poplars. In contrast, on many hybrids between the sections Aigerios and Tacamahaca, this fungus not only causes premature defoliation of highly susceptible trees, but also causes cankers on stems and branches. Industrial and research plantings examined thus far in Michigan, Wisconsin, Minnesota, and Iowa have revealed that hybrids involving *P. trichocarpa*, *P. laurifolia*, and *P. maximowiczii* are especially susceptible to cankering. Species of *Marssonina* are periodically important on native poplars. However, *M. brunnea* causes a serious leaf disease of many *P.* X *euramericana* clones. Susceptible clones can be prematurely defoliated and predisposed to other diseases and to winter injury, especially in the northern portion of the north central region.

We only need to look at modern agriculture and the chemical and cultural treatments needed to control diseases to see the potentially serious risk involved in growing trees in a monoculture at close spacings. Use of clones means that all trees of a susceptible clone can be affected in a disease outbreak. Dense plantings create many conditions that can increase disease severity (Schipper 1976). Density influences air movement, leaf wetness, and humidity within a plantation--important factors in the infection and development of pathogens (McNabb et al. 1982a). Proximity of trees to each other within a plantation influences rate of spread of pathogens and subsequent development and severity of diseases. Even-age management similarly can increase disease severity because all trees may be equally susceptible to a particular disease at their stage of development.

In the vegetative propagation of poplars, serious disease agents may be moved along with cutting or rooted stock. Viruses, detected in many poplar clones being used, threaten vegetatively propagated poplar monocultures, and steps should be taken to eliminate them from planting stock (Berbee et al. 1976, Van der Meer et al. 1980). We have found that unrooted hardwood cuttings taken from clonal nurseries in the Lake States can be infected with Septoria, Marssonina, and Dothichiza. These serious pathogens can be moved to areas of previously uninfected trees. Fungi that are weakly parasitic on poplars such as Cytospora and Phomopsis can weaken improperly stored cuttings so that they produce plants susceptible to other stresses (Ostry and McNabb 1982).

Cultural treatments such as plowing, discing, and irrigation also can influence disease development. Thin-barked poplars can be easily wounded by implements, creating entrances for canker and decay fungi. Plowing may kill or reduce soil microbiota such as saprophytic fungi that would otherwise limit soil-borne pathogen populations. Irrigation, especially overhead systems, may increase foliage diseases because of possible increased spore dispersal and infection resulting from longer periods of leaf wetness.

Poplars growing in an agroecosystem are subject to conditions much different from those in a natural, dynamic ecosystem. Intensive culture systems can create an imbalance, resulting in rapid development and multiplication of pathogens. We are growing a susceptible host on which several potentially damaging pathogens are present. Manipulating the environment around these trees can be extremely important because the environment is a controlling influence on pathogens as well as on the host. Vigorous trees can generally tolerate greater incidence of pathogens and insect pests. Tree vigor, disease incidence, and pathogen and insect populations must be monitored under the various cultural systems used to guard against an imbalance that may cause an insect or disease problem to develop.

Summary and Conclusions

Many pathogens of hybrid poplars have been identified in the north-central region. Some have no apparent impact on tree growth or quality. Other pathogens may be of periodic importance. These need to be monitored so that control actions, either in the current rotation or the next, can be taken to minimize damage. Diseases can increase to unacceptable levels in the event of a change in the host, environment or pathogen. A few pathogens are, however, usually destructive to susceptible trees, reducing tree growth, quality and survival. The risks associated with these pathogens must be considered in any planting plans. Of importance is management's objective in growing the trees: what will be the use of the wood produced?; are quantity, quality, or both important?; how long will the trees be grown?; will the stand be coppiced? These are important questions to consider in terms of diseases impact and disease control. Some of the fastest growing trees we have studied are also the most susceptible to one or more diseases. These diseases pose some threat to trees grown on short rotations, but they may cause serious problems for trees grown on longer rotations. Septoria, for example, may or may not adversely affect management's objectives. Defoliation and growth loss from the disease are severe on only the most susceptible clones, and cankering of plantation trees usually is serious 3-4 years after planting. Therefore, susceptible clones can be grown on mini rotations, but not in shelterbelts or on longer rotations. Wood fiber quality of cankered trees is satisfactory for fuelwood or lower quality paper, but not for high-quality paper. Septoria infection is much more severe in coppiced stands so coppicing highly susceptible clones is highly risky.

Proper planning before planting, including selection of clones with resistance to important diseases, and good management aimed at maintaining high tree vigor will avoid many future problems. Integrating disease control into silvicultural practices is the most promising strategy. Higher economic returns from intensively managed hybrid poplar plantations in the future will justify disease and insect control and give managers more flexibility in dealing with pest problems.

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